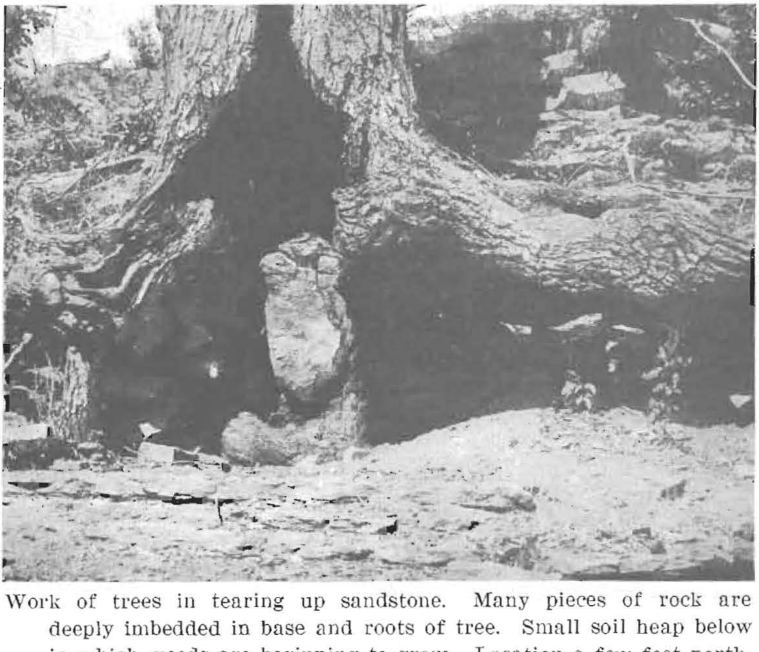
Showing structure and effects of weathering in the upper sandstone of the Huron formation. Young growth of trees and shrubs getting a foothold in the new made soil. Near center of Sec. 33 just north of Tobinsport, Perry County, Ind. See p. 304.



Work of trees in tearing up sandstone. Many pieces of rock are deeply imbedded in base and roots of tree. Small soil heap below in which weeds are beginning to grow. Location a few feet northwest of the upper view.

INDIANA.

DEPARTMENT

OF

Geology and Natural Resources.

THIRTY-THIRD ANNUAL REPORT.

W. S. BLATCHLEY,

STATE GEOLOGIST.

1908.

INDIANAPOLIS:
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING
1909

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
February 27, 1909.

Received by the Governor, examined and referred to the Auditor of State for verification of the financial statement.

OFFICE OF AUDITOR OF STATE,
INDIANAPOLIS, April 28, 1909.

The within report has been examined and found correct.

J. C. BILLHEIMER,
Auditor of State.

April 28, 1909.

Returned by the Auditor of State, with above certificate, and transmitted to Secretary of State for publication, upon the order of the Board of Commissioners of Public Printing and Binding.

MARK THISTLETHWAITE,
Secretary to the Governor.

Filed in the office of the Secretary of State of the State of Indiana.

FRED A. SIMS,
Secretary of State.

Received the within report and delivered to the printer April 30, 1909.

A. E. BUTLER,
Clerk Printing Bureau.

State of Indiana,
Department of Geology and Natural Resources,
INDIANAPOLIS, IND., February 27, 1909.

HON. THOMAS R. MARSHALL, *Governor of Indiana:*

DEAR SIR—I have the honor to transmit to you herewith the manuscript of the Thirty-third Annual Report of the Department of Geology and Natural Resources. It comprises in the main papers of economic importance relating to the coal fields and soils of southern Indiana, together with an extended paper on the Mammals of Indiana, which is something that has long been needed for use in our public schools. It also embraces the reports of the State Mine Inspector and the State Supervisor of Natural Gas for the calendar year 1908.

Yours very truly,

W. S. BLATCHLEY,
State Geologist.

ASSISTANTS.

George H. Ashley	Chief Field Assistant
Edward F. Lines	Field Assistant
Chas. W. Shannon	Field Assistant
L. C. Snider	Field Assistant
R. E. Lyons	Chemist
Walter L. Hahn	Zoologist
James Epperson	Inspector of Mines
Jonathan Thomas	Assistant Inspector of Mines
Robert Irving	Assistant Inspector of Mines
Wellington O'Connor	Assistant Inspector of Mines
Albert Sams	Assistant Inspector of Mines
B. A. Kinney	Supervisor of Natural Gas
Isadore Kessler	Clerk
Millard Gilliam	Messenger and Janitor

TABLE OF CONTENTS.

	PAGE.
INTRODUCTORY. By W. S. Blatchley	9
THE COAL DEPOSITS OF INDIANA: A SUPPLEMENTAL REPORT TO THE ONE ISSUED IN 1898. By George H. Ashley	13
REPORT OF THE STATE MINE INSPECTOR FOR THE YEAR 1907. By James Epperson	153
A SOIL SURVEY OF DUBOIS, CRAWFORD AND PERRY COUNTIES. By Chas. W. Shannon	277
A SOIL SURVEY OF DAVIESS COUNTY. By L. C. Snider	343
THE PETROLEUM INDUSTRY IN INDIANA IN 1908. By W. S. Blatchley	361
REPORT OF THE STATE SUPERVISOR OF NATURAL GAS FOR THE YEAR 1908. By B. A. Kinney	385
THE STRATIGRAPHIC AND FAUNAL RELATIONS OF THE WALDRON FAUNA IN SOUTHERN INDIANA. By E. M. Kindle and V. H. Barnett	395
THE MAMMALS OF INDIANA. By Walter L. Hahn	417

DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES,

INDIANAPOLIS, INDIANA.

W. S. BLATCHLEY, State Geologist.

Please Acknowledge Receipt of this Volume.

In return, Scientific Books, Fossils and Implements
of the "Stone Age" are Acceptable.

State Museum, Room 126, Third Floor, State House.
Open to the Public from 8 a. m. to 5 p. m., except on Sundays
and legal holidays. Admission free.

Office of State Geologist, Room 89, Third Floor,
State House.

INTRODUCTORY.

The principal paper in the present volume is the one which embodies the results of the field work carried on during the summer of 1908 in co-operation with the United States Geological Survey on the coal fields of western Indiana. The paper was prepared by Dr. George H. Ashley, of Washington, D. C., now one of the coal experts of the United States Survey. Dr. Ashley was the author of the large volume on Indiana coal issued as the Twenty-third (1898) volume of the Indiana Department of Geology. It was that volume of 1,740 pages which first showed in detail by text, maps and charts, the full extent and value of the great coal veins of western Indiana and which led to such development that the output of coal increased from 5,146,920 tons in 1898 to 13,250,715 tons in 1907.

Since the former volume was issued hundreds of bores have been sunk to test the thickness and character of the coal in different parts of the area, and many new mines have been opened up in the development of the industry. Much new data was, therefore, available which has been gathered and compiled by Dr. Ashley and his assistants for the paper in mention. New maps and charts have been prepared and the nomenclature of the different veins corrected where necessary on account of the more available and enlightening data. The paper as presented therefore shows with accuracy the location, character and extent of each of the great workable veins of the State's chief mineral resource. Taken in connection with the former volume, to which it is offered as a supplement, it furnishes to investors, operators and users a fund of available information regarding the coals of Indiana, such as is possessed by few states and excelled by none.

Since it relates to the same subject, the report of the State Mine Inspector, James Epperson, of Linton, Indiana, follows next in order. Mr. Epperson and his four deputies have given careful attention to the duties which they are empowered to perform and have enforced impartially all laws relating to the mining industry. In his report are very full and complete tables of statistics relating to the coal industry for the year, from which have been compiled the following general summary showing the relative rank of the fourteen coal-producing counties of the State, with the output of each in tons and the amount of wages paid in each.

Tons of Coal Produced and Wages Paid to Miners in 1908 by Counties.

COUNTIES.	*Tons Produced.*	*Wages Paid.*
Vigo	2,617,915	$2,239,464 83
Sullivan	2,585,993	2,193,550 85
Greene	2,257,646	1,767,935 38
Vermillion	1,139,669	1,012,142 99
Clay	1,029,161	997,286 65
Parke	602,945	639,925 52
Knox	427,999	298,959 11
Pike	424,965	345,966 06
Warrick	424,053	299,663 21
Vanderburgh	253,774	266,235 22
Gibson	170,421	163,179 24
Daviess	43,185	58,073 21
Fountain	15,849	18,468 20
Perry	3,729	4,018 97
Totals	11,997,304	$10,304,869 65

The table shows a decrease in output for the year of 1,253,411 tons, or 9.4 per cent, under that of 1907. This decrease was due almost wholly to the commercial and manufacturing depression brought about by the monetary panic of 1907-08. Of the coal produced 852,960 tons were block coal and the remainder bituminous. The block coal, mined in Clay and Parke counties, is used almost wholly for domestic purposes and its output was not, therefore, much affected by the stringency in money matters. This is shown by the fact that there was a loss of but 22,273 tons in its output. The amount paid for the mining of the block coal was $1,035,947.

The third paper in the volume, a continuation of those in the preceding report on the Soils of Southern Indiana, is by Chas. W. Shannon and L. C. Snider. In it the soils of Dubois, Crawford, Perry and Daviess counties are classified and the area covered by each of the soil types shown on accompanying maps. The authors give the use to which each of these type soils is best adapted, the kind of fertilizer most needed and much other information which will doubtless be of value to the land owners of the counties mentioned.

The fourth paper is one entitled "The Petroleum Industry in Indiana in 1908," in which is given the principal facts and statistics relating to that industry for the year.

The closely-related but almost exhausted resource, Natural Gas.

is next treated briefly by B. A. Kinney, the State Natural Gas Supervisor, in his annual report.

Next in order is a short paleontological paper, by E. M. Kindle and V. H. Barnett, treating of the fossil forms occurring in the Silurian rocks of Waldron, Shelby County.

The final paper, as is the usual custom, is one relating to Natural History, being "A Descriptive Catalogue of the Mammals Occurring in Indiana in Recent Times," by Dr. Walter L. Hahn, an Indiana man now teaching in South Dakota. Mr. Hahn has for years made a special study of the shrews, moles, bats, squirrels, foxes and other furred and hairy animals of the State, and in his paper has given keys, full descriptions and an account of the habits of each of the species. This information should be of especial value not only to those students in the various schools and colleges who are interested in the natural history of the State, but also to farmers and residents of the country, who come in almost daily contact with these smaller fellow-creatures.

SUPPLEMENTARY REPORT

(to Report of 1898)

ON THE

COAL DEPOSITS OF INDIANA.

BY GEORGE HALL ASHLEY.

ACCOMPANIED BY A

CHART OF INDIANA COAL AND MINING.

BY EDWIN F. LINES.

AND TWO APPENDICES:

A. Recent Analyses of Indiana Coal.

B. Descriptive Notes on the Stratigraphic Chart.

In Coöperation with the

UNITED STATES GEOLOGICAL SURVEY,

George Otis Smith, Director.

LETTER OF TRANSMITTAL.

Department of the Interior,

United States Geological Survey.

Washington, February 23, 1909.

Mr. W. S. Blatchley, State Geologist, Indianapolis, Ind.:

Sir—I have the honor to submit herewith my supplemental report to my 1898 report on the Coal Deposits of Indiana, based on field work in 1908. The revision in the field was confined mainly to the area of commercial mining. In the office the stratigraphy and distribution of the coals over the eastern part of the field has been reveiwed in the light of our better knowledge of the general stratigraphy.

While intended primarily simply as a supplement to the coal report, this paper has taken the form of a brief restatement of the geology of the coal deposits as a whole, with notes on the recent developments in the use of Indiana coal.

The time in the office devoted to the review of the eastern part of the coal field, now largely undeveloped commercially, while throwing a great deal of light on that area, left many problems unsolved, and cut seriously into the time available for the preparation of the report.

The writer was assisted in the field by Mr. E. F. Lines, and for a short time by Jno. Udden, Jr. In the office Mr. Lines prepared the chart of Indiana coal and mining.

Very respectfully submitted,

GEO. H. ASHLEY,
Geologist, U. S. G. S.

In charge geologic work in Northern Appalachian and Eastern Interior Coal Fields.

CONTENTS.

	PAGE
Letter of transmittal	14
A quiz on general facts on Indiana coal and coal deposits	17
CHAPTER I.—Coal industry of Indiana and geologic work in the coal fields	26
CHAPTER II.—Indiana coal	33
Kinds of coal	33
Description of kinds of coal	33
Physical properties of Indiana coal	34
Chemical properties of Indiana coal	35
Commercial and economic character of Indiana coal	41
Experimental tests by the U. S. Government	43
Results of actual experience	45
Smokeless combustion	45
Domestic use	47
Use of Indiana coal in the producer-gas plant	49
Weathering of Indiana coal	53
CHAPTER III.—Indiana coal measures	54
General character and relation	54
Naming and grouping of the coals and rocks	55
Generalized section in Sullivan and Greene counties	59
Coal measures above Coal VII north from Sullivan County	61
Coal V to Coal VII inclusive north from Sullivan County	61
Coals and rocks above Coal VII south from Sullivan County	63
From Coal V to Coal VII inclusive south from Sullivan County	64
Coal III to base of Coal V from Sullivan and Greene counties northward	70
Coals below Coal III north of Sullivan County	75
Coals below Coal V from Greene County southward	78
CHAPTER IV.—The coal beds	91
Number of coal beds	91
Thickness of coal beds	91
Extent of coal beds of Indiana	91
The coal chart	91
Coal VII	97
Coal VI	101
Coal V	103
Coal IV	106
Coal III	107
Minshall coal and Coal II	109
Upper Block coal	112
Lower Block coal	113
Cannelton-Shoals coal	115
CHAPTER V.—Distribution of coal in Indiana by counties	117
Warren County	117
Fountain County	118
Parke County	120

PAGE
Vermillion County 122
Putnam and Owen counties 123
Clay County 123
Vigo County 124
Greene County 125
Sullivan County 126
Martin County 126
Daviess County 127
Knox County 128
Orange and Crawford counties 128
Dubois County 128
Pike County 129
Gibson County 130
Perry County 130
Spencer County 130
Warrick County 131
Vanderburgh and Posey counties 131
CHAPTER VI.—Structure of the Indiana coal field 132
CHAPTER VII.—The amount of coal in Indiana 135
APPENDIX A.—Recent analyses of Indiana coal 144
APPENDIX B.—Descriptive notes on the stratigraphic chart 145
Descriptions of sections 145

LIST OF ILLUSTRATIONS.

Plate I. Chart of Indiana coal and mining, by E. F. Lines.
Plate II. Stratigraphic chart.
Plate III. Coal chart.
Plate IV. Structure chart.
Figure 1. Skeleton section showing principal coals.

CHAPTER II.

INDIANA COAL.

As is well known, coal is a rock occurring in beds in the earth. It is composed largely of the element, carbon, with some oxygen, hydrogen and a few other elements, and is economically important as fuel. It is usually black, massive or bedded, has a hardness of 1.2 to 1.8 in the scale of hardness, a weight of 75 to 80 pounds per cubic foot, and a varying fracture.

Kinds of Coal.—All of the coal found in Indiana belongs in the bituminous class. As far as known, there is no anthracite, semi-anthracite, or semi-bituminous coal in the State, nor are the low-grade sub-bituminous and lignite coals found. However, several varieties of bituminous coal occur, namely, so-called "bituminous" coal (used to distinguish from the next), "block" coal, and cannel coal. The first two differ but little chemically, but when typically developed, show rather marked physical differences. The cannel coal is physically a block coal, but differs chemically from either of the other coals.

Description of the Kinds of Coal in Indiana.—The characteristics and differences of the three kinds of coal in Indiana may be described as follows:

The so-called "bituminous" coal of Indiana is pitch black, the color remaining black even when powdered; the luster is bright or vitreous. In structure it is banded or bedded, the jointing and cleavage is cubic, i. e., tending to break up into cubes; the fracture is irregular, and the texture dense to laminated. This coal is brittle, soft and rather light. It burns with a long flame, with a bituminous or sulphurous odor, running together on burning, and leaving much white or red ash. Sulphur is usually present.

The block coal of Indiana differs from the bituminous in being distinctly banded when viewed on the edges of the bedding, by splitting readily along the dull bands, which prove to be bands of charcoal, by breaking with difficulty across the bedding; especially by the very perfect development of the cleavage, the cleavage planes usually extending vertically nearly or quite the full thickness of the coal, dividing the bed into blocks or cubes, often several feet on a side. This character is reflected in the character of the coal as marketed where it is noted the blocks are commonly in rather thin, square-edged slabs, being square or quadrilateral, often 1 to 2 feet on a side, and 6 inches thick, with charcoal faces. In burning, the coal does not run together or cake, but remains in distinct blocks, like blocks of wood, and burns to a small white ash.

The cannel coal, of which Indiana has but a small amount, is a block coal as regards being divided by the cleavage into distinct blocks, usually the full thickness of the bed. It differs physically in not having the dull or charcoal bands, or any bedding, being quite massive in structure, in its dull, resinous luster, and in its conchoidal fracture. Under the microscope still other differences are seen which need not be discussed here.

The properties of Indiana coal may be divided into physical properties, those not involving change in composition, as hardness, structure, weight, etc., and the chemical properties, or those which relate to the changes in composition that take place when the coal is burned.

Physical Properties of Indiana Coal.—From the practical standpoint these affect the mining, the transportation and marketing, and to some extent the use of the coal. The mining of coal is more or less affected by the hardness and the structure of the coal. In hardness the Indiana coals occupy a medium position among "soft" or bituminous coals, as contrasted with the "hard" or anthracite coals. The splint coals of West Virginia are probably the hardest of the "soft" coals, and the tender coals of Arkansas are possibly among the softest, in the sense of breaking up easily. The splint coals are almost as hard as anthracite, and much tougher. This condition is approached by the cannel coal of Indiana, and to a less degree by the block coal. The hardness may best be indicated in a practical way by the statement that on the average Indiana coal, as at present mined, handled, tipped and screened, will yield 66 to 70 per cent lump coal, over diamond bars 1½ inches apart. The block coals will run some higher, possibly 75 per cent, and in parts of the State the coals will not run that high. This percentage is much affected by mining methods. Where shooting on the solid is allowed and heavy shots permitted, the coal will be more broken up and the percentage of lump smaller.

The structure of the coal, particularly the jointing, affect the ease with which the coal is mined and the size and character of the blocks when mined. In the block coal the joints are few in number and well separated, but strongly developed. In the early days this coal was all pick-mined, the joints, or slips, as they are called locally, making favorable points of attack, and allowing ready breaking away of the coal. In the "bituminous" field the joints are not as marked, but more numerous, and vary widely in the extent to which they assist in the operations of mining.

The hardness or strength indicated by the percentage of lump coal, except as this is affected by the methods of mining, will apply to the transportation and marketing of the coal. Indiana coal will stand domestic shipment as well as most of the coals of the eastern United States, and better than many. It will not make a good export coal in this respect.

The "bituminous" coals of Indiana fuse and run together on burning, forming a cake, which must be broken up to secure rapid combustion. This property forms the basis of coke making, and is common to all coals from which coke is made. While it is true that all coking coals are caking coals, it is not equally true that all caking coals will make commercial coke. The block coals of Indiana do not cake in burning and have been used in the raw state in a blast furnace. Between these two extremes are found the semiblock coals, with intermediate caking properties.

Chemical Properties of Indiana Coal.—The burning of coal is a chemical phenomenon, as it involves changes in the composition of the coal; and as this is the only practical use that Indiana, or any other, coal is at present put to, the chemical properties of Indiana coal are of the first moment. This is true whether the ultimate use of the coal be for heat or for power, whether the coal be burned directly in the fire or whether it first be broken up into gases and coke and then burned or exploded. In common language, when coal burns certain parts of the coal unite with the oxygen of the air, forming new compounds and giving off heat in so doing.

If 100 pounds of average Indiana coal, just as taken from the mine, be completely broken up in the chemical laboratory into the elements (except ash) it will show about as follows:

Ultimate Analysis of 100 lbs. of Indiana Coal.

(On basis of 19 recent analyses of carload samples.)

	Lbs.
Carbon	61
Hydrogen	5.5
Oxygen	18
Nitrogen	1.1
Sulphur	3
Ash	11.4
Coal	100.0

In the first place, it is evident that the coal contains in the ash and nitrogen, which it is well known will not burn, 12.5 per cent of plainly non-combustible material.

In the second place, as there is an abundance of oxygen in the air for the burning of the other elements, and as we measure the amount of heat given off in the combination of oxygen with any other elements by the amount either of the oxygen or of the other element that enters into the combination, but not by both, it is evident that the oxygen in the coal reduces the combustible part of the coal by at least that much. This would be exactly true only on the condition that the oxygen were not already united with some of the other elements. However, it appears quite certain that some, and probably all, of the oxygen is already in combination with the other elements of the coal. If the coal be put in a dry place it will be found that it will lose about 8 per cent in weight, the loss being in the form of water vapor or moisture, which is composed of eight parts of oxygen and one part of hydrogen, and if the coal be then reanalyzed it will be found to contain that much less oxygen and hydrogen. If next the coal be put in a drying oven four more pounds of moisture may be driven off. Evidently, these 12 pounds of moisture are not combustible. The loss of this moisture will reduce the oxygen in the coal by 10 2-3 pounds, and the hydrogen by 1 1-3 pounds. There is still left 7 1-3 pounds of oxygen.

Leaving out of account the sulphur, which it is known is combined with iron in the coal in the form of pyrite or iron sulphide, it is now known that the 7 1-3 pounds of oxygen left, the 4.2 pounds of hydrogen left, and at least part of the carbon, exist in the form of one or more compounds. Just the nature of these compounds in the raw coal is not known definitely, for as yet no satisfactory method has been devised for separating this part of the coal into its component parts without the use of heat, which, it is known, produces changes, so that the final compounds obtained may be quite different from those originally existing. However, if this thoroughly dried coal be heated in a retort, as is done in the manufacture of illuminating gas, it is found that a gas is given off known as the volatile matter, and there is left in the retort the remainder of the carbon and the ash, forming coke. Analysis of this gas will show about 18 pounds of carbon, 4.2 pounds of hydrogen, and 7.3 pounds of oxygen, the remaining 43 pounds of carbon being left behind with the ash. If this gas be burned it is found to yield only about the amount of heat it would give if it contained only 18 pounds of carbon, and 3.3 pounds of hydrogen;

in other words, the 7 1-3 pounds of oxygen, and one-eighth of its weight of hydrogen, act under these conditions as though already combined in the proportion of water, and therefore not in a condition to yield further heat. It is evident then that not only is all the oxygen an element of no value, but the portion of hydrogen equal to one-eighth of the weight of the oxygen is also of no value for combustion. The remaining part of the hydrogen is known as the available hydrogen. The combined oxygen and hydrogen in the gas is known as the water of constitution, and it is believed to originally form an actual constituent part of the compound, and is commonly called, with the nitrogen which is driven off then, the inert volatile.

The carbon in the volatile matter is called the volatile carbon. The volatile carbon and available hydrogen together constitute the combustible volatile matter. The carbon left in the coke is known as free carbon, or fixed carbon.

We may now regroup the elements of the coal according to their heat-giving possibilities.

Analysis of 100 lbs. of Indiana Coal on the Basis of Combustion.

Combustible Matter (Pounds).

Fixed carbon		43	
Volatile carbon	18		
Available hydrogen	3.3		
Total combustible volatile matter		21.3	
Sulphur		3	
Total combustible matter			67.3

Non-Combustible Matter (Pounds).

Ash		11.4	
Nitrogen	1.1		
Oxygen of water of constitution in gas	7.3		
Hydrogen of water of constitution in gas	.9		
Total inert volatile matter		9.3	
Oxygen in "moisture"	10.7		
Hydrogen in "moisture"	1.3		
Total "moisture" in coal		12	
Total non-combustible matter			32.7
Total coal			100.0

Heat is measured by calories or British thermal units, commonly called B. T. U.'s. The former is the amount of heat required to raise the temperature of 1 gram of water 1° Centigrade. The latter is the amount of heat required to raise the temperature of 1 pound of water 1° Fahrenheit. Careful experiments have shown that when burned, 1 gram of carbon will yield 8080 calories; 1 pound of carbon will yield 14,544 B. T. U.'s. One gram of hydrogen will yield 34,460 calories, or 1 pound of hydrogen will yield 62,028 B. T. U.'s. One gram of sulphur will yield 2250 calories, or 1 pound of sulphur will yield 4050 B. T. U.'s. The theoretical heat value of the coal just described would therefore be:

Heat Value of Indiana Coal.

		B. T. U.'s
Carbon	61 lbs. × 14,544 =	887,184
Hydrogen	3.3 lbs. × 62,028 =	204,692
Sulphur	3 lbs. × 4,050 =	12,150
Heat value of 100 lbs. of Indiana coal =....		1,104,026

These figures, it should be understood, are only approximately correct, because part of the carbon and hydrogen are united, and those compounds when burned do not yield exactly the same amount of heat as the two elements concerned would if burned separately.

As some of the carload lots that were analyzed as the basis of this determination were lump coal, some run of mine, and some screenings, the figure 11,500 B. T. U.'s per pound of coal may be taken as the fair average of commercial Indiana coal, that is, the coal as delivered to consumer. Actual determinations of the heating value of Indiana coal from samples from carload lots will show a little higher value for lump coal and a little lower for run of mine and screenings, individual determinations running from 9500 to 12,000, with an average of about 11,200. However, the samples included more cars of screenings than of lump coal, so the figure of 11,500 is probably not far from an average, which is the equivalent of 6633 calories. If the former number be divided by 963.9, the latent heat of steam, there is obtained practically 12, which represents the number of pounds of water at the boiling point one pound of coal will convert into steam. This figure is, of course, an ideal or theoretical value, which cannot be realized in practice, because there will always be losses, as follows:

(1) Loss due to the converting of the moisture of the coal into steam;

(2) Loss due to converting into steam the moisture formed by the burning of the hydrogen.

(3) Loss due to heat carried away by dry chimney gases;

(4) Loss due to radiation;

(5) Loss due to incomplete combustion of the carbon (burning only to CO instead of to CO_2);

(6) Loss due to other forms of incomplete combustion.

These losses will vary with the boiler, manner of firing, etc. Probably 60 per cent of the heat in a good boiler is absorbed by the boiler, as a fair average. This will be discussed more at length farther on.

A comparison of the average analyses given with many of the older analyses, or with analyses often secured by coal mine owners, may show a difference in favor of the older analyses. It may not be out of place, therefore, to point out where the difference arises. The analyses made by Mr. Cox in the early days of the Survey, and many of those made for mine owners, were made from small hand specimens picked up, or more often, selected from a pile, wrapped up and taken to the laboratory, where they were placed on a shelf until the analyses could be made. Later the method of cutting a strip the whole thickness of the coal, as described in Appendix A, or of taking selected shovelfuls of coal from a car or cars, was adopted. In addition the samples were at once put into tight glass jars, and so conveyed to the laboratory and kept until used. Samples taken in this way, even though analyzed by many different chemists, showed a great increase in the percentage of moisture and of ash, with necessarily a corresponding decrease in the percentage of other constituents. Then, more recently experiments have shown that some types of fruit jars and metal screw-top cans used for holding the samples are not entirely air-tight, and that unless the sample be analyzed within a day or two of being taken certain special precautions must be used to insure that there is no loss of moisture or of other gases. For this purpose sealing with bicycle tape has been extensively used.

To show how misleading the older type of analyses may be in showing just what is shoveled into the consumer's coal bin, four analyses are given. The first is of a thoroughly representative sample taken from a car of screenings at the St. Louis testing plant. The second is of a mine sample from the same mine. The third is a representative sample taken by Mr. Epperson in 1896 at the same place. The fourth is an analysis by Mr. Cox of the same coal from a closely-adjoining mine. All the samples are of Coal VI, from near Star City, in Sullivan County:

Comparative Analyses of Coal from Near Star City, and Vicinity, Sullivan County, Indiana.

	A.	B.	C.	D.
Moisture	13.99	14.86	9.40	4.00
Fixed carbon	42.29	46.14	48.77	51.50
Volatile matter	29.40	31.65	38.53	43.50
Ash	14.32	7.35	8.74	1.00
Sulphur	2.31	2.26	2.18	....

A.—Car sample (screenings); see U. S. G. S. Bull. 290, p. 97, 1906.

B.—Mine sample, same mine, taken 4,000 feet southeast of shaft, same reference.

C.—Star City mine, Geol. Surv. of Ind., 21st Ann. Rept., p. 105, 1896.

D.—Pioneer shaft, near Star City, Geol. Surv. of Ind., 2d Ann. Rept., p. 7, 1871.

Since the appearance of the 1898 report, attention has been called by Professor Parr, of the Illinois Survey, to the difference in the quality of the volatile matter of different coals. Though it has long been known that the oxygen in the volatile matter of the coal added nothing to its heating power, and that a part of the hydrogen equal in weight to one-eight of the weight of the oxygen, was likewise of no avail in the combustion of the coal, yet it has been customary to speak of the gas or volatile matter as though it were all combustible, and to add this weight to the weight of the fixed carbon in determining the total amount of combustible matter. This was done in the 1898 report. To determine the amount of "water of constitution" of the volatile matter requires an ultimate analysis, and only approximate analyses were being made. Furthermore, it was not appreciated that the different coals differed greatly in the proportion of their volatile matter that was in the form of water constitution. By means of diagrams Professor Parr, in 1904, showed that in Pocahontas coal 22 per cent of the volatile matter is non-combustible; in Illinois coal 40 per cent of the volatile matter will not burn, while in lignites this "inert" volatile matter rises to nearly 50 per cent.

There is another reason why this subject has been neglected. In Pocahontas coal while 22 per cent of the volatile matter is inert, as the volatile matter forms only 18 per cent of the coal, the inert volatile makes only 4 per cent of the coal. In Illinois coal, on the contrary, the total volatile matter is 35 per cent of the whole, so that the inert volatile is 14 per cent of the whole. It could, therefore, very well be neglected in the Eastern coals, but going westward it reaches a value, or rather a lack of value, that very materially affects the efficiency of the coal. The difference is made more striking if it be noted that this overlooked element in a ton of Pocahontas coal amounts to 50 pounds of unconsidered waste, while in a ton of Illinois coal it may amount to 280 pounds of unconsidered waste.

Commercial and Economic Character of Indiana Coal.—In the 1898 report the utilization of Indiana coal was entered into at considerable length, nearly fifty pages being given to that subject. It will, therefore, not be necessary to go over that discussion again beyond repeating one or two general conclusions then reached. Attention will be given mainly to summarizing the results of some recent tests and calling attention to present tendencies in the use of coal.

Not many years ago it was customary for manufacturing plants to buy their coal largely on the basis of quality, other facts being but little considered, if at all. Today many of the large plants are giving the whole subject most careful consideration, and in many cases reach the conclusion that it pays to spend money to adapt their power plants to the use of a cheap coal rather than to use an ordinary furnace and buy high-priced coals. Thus, more and more the use of screenings and low-grade coals is coming to be the practice of large plants. Particularly is this true of the Chicago market. The question becomes not "Which is the best coal?" but "How can I get the power I need for the least money?"

It has long been true that in most coal fields the profits of coal mining come mainly or altogether from the larger sizes of coal, the smaller sizes being sold for what they would bring, and it is still true in Indiana that the demand for screenings is not as great, proportional to the amount made, as for the screened coal. The result is that screenings are often sold at barely the cost of mining, or even less. Large power plants are more and more taking advantage of this fact to adapt their furnaces to the burning of this size of coal, and it is probable that before many years the demand for screenings will place their sale well on the credit side of the ledger. Special attention is therefore called to the results of boiler tests with Indiana screenings.

Experimental Tests by the United States Government.—The detailed report of these tests is contained in the U. S. Geological Survey Bulletins Nos. 261, 290, 316, 323, 325, 333, 334, 336, 339. 341, 343, and Professional Paper No. 48. As the Geological Survey's stock of many of these publications has already been exhausted, some of the results of those tests may be summarized here. The following table gives some of the results of the steaming tests of Indiana coal, and there are also added the results of tests on some of the coals with which it has to compete:

Table Showing Results of Steaming Tests of Indiana and Other Coals, as Obtained in the U. S. Geological Survey Fuel Testing Plant at St. Louis.

NAME OF MINE.	Duration of Test.	Heating Value of Dry Coal.	Water Apparently Evaporated per Pound of Coal as Fired.	Water Evaporated From and at 212°F. per Pound of Coal as Fired.	Efficiency of Boiler.	Pounds of Coal Fired per Indicated Horsepower Hour.	Pounds of Coal Fired per Electrical Horsepower Hour.
Indiana No. 1. Run of mine, Mildred	9.93	13,377	5.87	7.06	61	....	....
Indiana No. 2. Run of mine, Electric	10.13	12,452	6.09	7.29	62.19	....	....
Indiana No. 3. Mixed nut and slack, Wooley No. 3	9.65	11,669	6.14	7.10	67.12	3.98	4.92
Indiana No. 4. Screenings, Cons. Ind. C. Co. No. 29	10.05	11,977	5.74	6.64	62.41	4.26	5.26
Indiana No. 5. Run of mine, Cons. Ind. C. Co. No. 33	10.02	12,564	6.26	7.30	63.25	3.87	4.78
Indiana No. 6. Run of mine, Cons. Ind. C. Co. No. 34	9.97	12,505	6.30	7.30	63.02	3.87	4.78
Indiana No. 7A. Lump, Littles, Pike Co	10.02	13,248	6.80	7.95	63.56	3.56	4.39
Indiana No. 7B. Screenings, Littles, Pike Co	10.03	12,838	6.05	7.06	59.49	4.01	4.95
Indiana No. 8. Lump, Deep Vein mine	9.98	12,838	6.34	7.38	61.31	3.83	4.73
Indiana No. 9A. Lump, Redbird mine	9.92	12,181	6.37	7.44	66.99	3.80	4.69
Indiana No. 9B. Run of mine, Redbird mine	6.7	12,740	6.23	7.24	62.08	3.91	4.82
Indiana No. 10. Lump, Rosedale	10.05	12,866	6.63	7.74	65.00	3.65	4.51
Indiana No. 11. Lump, Dugger, Is. C. C. No. 4	9.65	13,423	6.61	7.88	64.32	3.59	4.43
Indiana No. 12. Run of mine, Hartwell, Pike Co	10.08	12,116	5.85	7.02	64.16	4.03	4.97
Indiana No. 13. Run of mine, C. VII. W. Terre Haute	10.00	12,497	6.45	7.50	66.46	3.77	4.65
Indiana No. 14. Run of mine, Seelyville	9.92	11,986	6.30	7.35	64.70	3.85	4.75
Indiana No. 15. Run of mine, Linton, Coal IV	9.7	13,099	6.34	7.39	62.66	3.83	4.72
Indiana No. 16. Run of mine, Linton, Coal V	10.03	12,350	6.47	7.51	64.59	3.77	4.65
Indiana No. 17. Run of mine, Bicknell, Coal V	9.88	12,929	6.41	7.46	61.70	3.70	4.68
Indiana No. 18. Lump, Ayrshire, Pike Co	10.1	13,545	6.70	7.79	63.10	3.63	4.48
Indiana No. 19. Screenings, Upper block, Diamond	7.57	11,930	5.92	7.15	63.62	3.96	4.88
Illinois No. 6. Coffeen, Montgomery Co., run of mine	10.	12,762	4.69	5.56	49.64	5.09	6.26
Illinois No. 12. Bush, Williamson Co., run of mine	10.03	11,963	6.17	7.15	64.04	3.96	4.88
Illinois No. 18. La Salle, lump	10.	12,951	6.51	7.60	64.20	3.72	4.59
Illinois No. 24. New Baden, Clinton Co., screenings	9.62	12,245	5.90	7.09	63.64	3.99	4.93
Illinois No. 30. Shiloh, St. Clair Co., nut	8.58	13,271	6.41	7.76	62.58	3.64	4.50
Iowa No. 1	10.01	11,443	5.55	6.61	61.10	....	....
Iowa No. 4	10.	11,678	5.19	6.15	58.79	....	....
Kansas No. 5. West Mineral	9.9	13,144	7.04	8.5	65.24	....	....
Kentucky No. 1. Straight Creek, eastern field, slack	8.13	14,414	7.53	8.94	62.58	3.16	3.91
Kentucky No. 5. Black Mt., eastern field, run of mine	9.78	14,571	8.01	9.63	66.94	2.94	3.63

TABLE SHOWING RESULTS OF STEAMING TESTS—Continued.

NAME OF MINE.	Duration of Test.	Heating Value of Dry Coal.	Water Apparently Evaporated per Pound of Coal as Fired.	Water Evaporated From and at 212°F. per Pound of Coal as Fired.	Efficiency of Boiler.	Pounds of Coal Fired per Indicated Horsepower Hour.	Pounds of Coal Fired per Electrical Horsepower Hour.
Kentucky No. 7. Central City, western field, lump	9.60	12,564	6.67	8.01	67.95	3.53	4.36
Maryland No. 1. George's Cr., run of mine	10.	13,680	7.59	8.90	63.96	3.18	3.92
Ohio No. 1. Wellston, run of mine	9.92	11,704	6.36	7.44	66.42	3.80	4.69
Ohio No. 3. Perry Co., run of mine	9.78	13,237	6.95	8.17	65.44	3.46	4.27
Penna. No. 4. Greensburg, Pittsbg. bed, lump	10.	13,979	8.10	9.47	67.01	2.99	3.69
Penna. No. 5. Washington Co., Pittsbg. bed, ¾ in. coal	10.	14,029	8.29	9.92	71.25	2.85	3.52
Penna. No. 8. Cambria Co., run of mine	9.88	14,886	8.51	10.12	67.27	2.97	3.67
West Virginia No. 13. Loup Cr., Kanawha coal, run of mine	10.	14,999	8.71	10.12	67.60	2.79	3.45
West Virginia No. 15. Clarksburg, Pittsburg bed, run of mine	8.78	14,126	7.65	9.00	62.76	3.14	3.88

Result of Actual Experience.—A large amount of correspondence was carried on for the 1898 report with manufacturers and others in regard to their use of Indiana coal. As a result of that the general conclusion was reached that considered from the standpoint of cost per horsepower of power, or for other use, no outside coal can compete with Indiana coal, except in the northeast corner of the State, along the eastern edge and the southeast corner, or in the area bordering the Ohio River. The experience of those in the area mentioned seems to be that the difference in the freight rates between the Indiana field and the Eastern fields is hardly sufficient to compensate for the difference in the quality of the coals. Thus, for example, at South Bend it was found that a number of large plants there had experimented and watched their expense accounts carefully, with somewhat diverse results, showing that the cost, all things considered, was just about even between the Indiana field and the Eastern field, though that did not apply to the poorer coals from Ohio and the western edge of Pennsylvania, in which case the advantage over the Indiana coal hardly made up for the difference in freight, but was true of the higher grade coals of Pennsylvania. In the same way, along the Ohio River the area which can be supplied by coals sent down from the Monongahela locks by boat, that coal is able to compete not alone on account of its somewhat superior quality, but on account of the lower freight rate. With these exceptions, however, the testimony seemed universal that for power production in Indiana, Indiana coal was far cheaper than any other coal.

Smokeless Combustion.—Another fact that is going to have great influence on the use of Indiana coal is, first, the increasing legislation against smoke in the cities, and, second, the great advance that is taking place in securing smokeless combustion in the high-gas coals.

It is well recognized that the higher the percentage of gas or volatile matter in a coal the greater the tendency of the coal to smoke. In this respect the coals of the Illinois-Indiana field suffer by comparison with the coals of much of the Appalachian field. Many of the coals of the eastern part of that field which have 20 per cent or less of gas are often called smokeless. It is generally recognized that they are so only if properly fired. Aside from the objection to smoke as it comes from the chimney, it is well known that it represents just so much loss of heating power of the fuel, its blackness being due to the unconsumed carbon it contains. Efforts have therefore been directed toward securing complete combustion, in which case there is no free carbon left over to produce smoke.

Notwithstanding the belief of many that smokeless combustion of bituminous coal is not possible, many plants in Chicago and elsewhere are demonstrating that it is possible. Mr. A. Bement, the consulting engineer, of Chicago, who is giving the subject much attention, has published a number of pictures of Chicago power plants in full operation in which, to judge by the picture, one might suppose that the plant had suspended operation. Mr. Bement has stated the requirements for smokeless combustion briefly as follows:

"(1) That the evolution of gas from the coal shall proceed uniformly; (2) that the gases distilled uniformly from the coal shall enter a fire-brick chamber, either (a) of sufficient length to allow their complete natural combustion, or (b) provided with such auxiliary mixing and baffling devices as will effect the artificial mixture and complete combustion of the gases before their exit from the chamber."[a]

To secure these conditions it is of the utmost importance that the stoking be regular and uniform. This is almost impossible with hand-fired furnaces. The best results are secured with some form of chain-grate stoker that automatically receives the coal at one end, moves it forward regularly, and discharges the ashes at the other end. Some forms of underfeed stokers can also be successfully used. Where such a stoker is not available complete combustion can be more or less successfully secured by adapting the form and construction of the combustion chamber of the furnace to that end, the object being, by the use of fire-brick walls, arches, etc., to increase the length of the chamber, or to so compel the mixing of the gases in the chamber that the combustion of the gases given off from the fresh coal is insured. Where the firing is intermittent it is often necessary to temporarily supply some additional oxygen immediately after firing, when for a short time a large volume of gas will be given off. A steam jet is often used for this purpose, being put into service only for a short time following the introduction of the fresh coal.

In some cities the smoke laws are so rigid and so rigidly enforced that bituminous coal, as formerly fired, is almost out of the question. For example, in the city of Washington today no more smoke can be seen than could be seen in Indianapolis when the use of natural gas was at its height.

Recent practice has clearly demonstrated that the old idea that smokeless combustion cannot be obtained with bituminous coal with

[a]Bull. Am. Inst. Min. Eng., Nov., 1908, p. 1151.

economy is a fallacy, and that mechanical stokers in small plants give not only smokeless combustion but good economy.

Domestic Use.—The rapid change from the old-time base-burner for household use to the modern furnace for steam or hot water is introducing a new use for Indiana coal. In the past the fact that the soft coals of the Illinois-Indiana field were dirty to handle, dusty through the house, difficult to regulate, and often did not keep fire as well as anthracite coal, gave off smoke, soot, and noxious gases, has greatly hindered their use. One difficulty has been that the attempt has been made to use bituminous coal in stoves and furnaces adapted for anthracite coal. Now, however, many manufacturers are endeavoring to design and supply stoves and furnaces especially for the use of bituminous coal. It cannot be said that as yet the manufacturers and dealers have been able to keep pace with the need and demand. Such items as the delivery of coal in bags by the retailer, and the proportioning of stoves to better utilize the high-gas coals of Indiana and Illinois, is a distinct advance, and will doubtless be followed by many others. The use of Indiana coal in the form of coke is another advance, provided that the by-products of the coke-making be also used.

At the Engineering Experiment Station at the University of Illinois studies are being made in the anthracitization of Illinois coals; that is, in the production by slight changes in the coal which while only slightly reducing its heating value, will tend to render its combustion more or less nearly smokeless. The process consists in heating the coal at a low temperature. Some of the volatile matter and oil products are driven off, as well as the moisture. An interesting thing about the experiments to date is that apparently there is a greater proportionate loss in the water of constitution or the inert volatile matter than in the more valuable hydro-carbons. Chemically the product resembles the so-called smokeless coals of Pennsylvania and West Virginia. To complete the process the coal should be briquetted, as the product of the experiment is quite fragile. In this form it would not only be practically smokeless, but would be as clean as anthracite to handle and to burn.

To pass over the objectionable features connected with the combustion of Indiana coal for household use, there can be no question of its economy. Some of the results obtained in a study of this question by the experiment station of Illinois may be of interest here. First is given a table showing the relative cost of various coals and cokes at Urbana, and their B. T. U. value for comparison. This table is as follows:[a]

[a]Bull. Am. Inst. Min. Eng., Nov., 1908, p. 1145.

Cost of Various Fuels.

Fuel-Tests with House-Heating Boilers.

Kind of Fuel.	Cost Per Ton of 2,000 Lb. at Urbana, Ill.	Cost in Per Cent. Based on Anthracite Coal as 100 Per Cent.	B.t.u. Per Lb. as Fired.	B.t.u. in Per Cent. Based on Anthracite Coal as 100 Per Cent.
		Per Cent.		Per Cent.
Anthracite coal	$8 25	100	12,690	100.00
Pocahontas coal	5 50	67	14,753	116.3
Coke (gas-plant by-product)	5 00	61	12,033	94.8
Coke (Solvay process)	6 00	73	12,488	98.4
Illinois coal (Christian county), nut	2 75	34	10,473	82.5
linois coal (Williamson county), washed nut	3 75	46	12,278	96.7

Then in another table the relative costs are given, taking into account the actual results obtained, using two different designs of house-heating boilers. The experiments follow the standard methods of the A. S. & E. code. Results are given in the following table. The prices given are those at which the coals were purchased from local dealers, in small lots, such as are usually obtained by householders. It is noticed that the actual cost of evaporating 1,000 pounds of water with anthracite coal is just double the cost of doing the same with Illinois coal, and the latter cost from one-third to one-eighth less than coke or Pocahontas coal:

Comparison of Fuel Costs—Data and Results.

Fuel-Tests with House-Heating Boilers.

1	2.	3.	4.	5.		6.		7.		8.		9.		10.	
Kind of Fuel.	Cost of Fuel Per Ton of 2,000 Lb. Dollars.	B.t.u. Per Lb. of Fuel as Fired.	Cost of 14,600 B.t.u. Cents.	Per Cent. of Builders' Rating Developed (Based on 0.3 lb. water from and at 212° F., equivalent to 1 sq. ft. of radiation).		Fuel as Fired Per Sq. Ft. of Grate-Surface Per Hour. Pounds.		Equivalent Evaporation from and at 212° F. Per Hour Per Sq. Ft. of Heating-Surface. Pounds.		Fuel-Cost of Evaporating 1,000 Lb. of water from and at 212° F. Cents.		Cost of Fuel Per 100 Sq. Ft. of Radiating-Surface served per Hour. Cents.		Efficiency of Plant (Boiler, Furnace, and Grate). Per Ct.	
				Boiler.		Boiler.		Boiler.		Boiler.		Boiler.		Boiler.	
				D1.	D2.	D1.	D2.	D1.	D2.	D1.	D2.	D1.	D2.	D1.	D2.
Anthracite coal	8.25	12,690	0.47	65.9	62.3	5.6	4.4	3.6	2.7	62.5	53.7	1.88	1.62	50.3	58.6
Pocahontas coal	5.50	14,753	0.27	63.6	64.0	5.2	4.1	3.5	2 7	40.2	32.6	1.20	0.98	44.9	55.4
Coke (gas-plant by-product)	5.00	12,033	0.30	65.4	62.5	5.3	4.2	3.6	2.7	36.3	31.5	1.09	0.95	55.6	63.6
Coke (Solvay process)	6.00	12,488	0.35	64.4	60.8	4.6	4.0	3.5	2.6	38.1	37.1	1.15	1.11	61.1	62.9
Illinois coal (Christian county) nut	2.75	10,473	0.19	63.5	62.3	7.8	7.0	3.5	2.7	30.1	28.6	0.91	0.86	42.0	44.4
Illinois coal (Williamson county) washed nut	3.75	12,278	0.22	63.9	64.8	6.0	5.5	3.5	2.8	31.2	28.7	0.93	0.86	47.4	51.5

Use of Indiana Coal in the Producer Gas Plant.—The subject of the better utilization of Indiana coal opens up most fascinating possibilities, particularly in connection with its use in the gas engine. Considerable space was given to the subject in the 1898 report, and many figures and tables were given. At that time the writer's interest was more particularly directed toward making from the Indiana coal a transportable fuel gas that should in some measure take the place of the natural gas, the decrease in which at that time was being most keenly felt. At that time he was inclined to predict that the time would come when Indiana coal might be converted into a high-grade fuel gas in the mines and piped to the cities in the coal fields and to the eastward, and used in the same way that natural gas was then.

Since then little progress has been made in the production of high-grade fuel gases or their transportation, and indeed, the dangerous nature of water gas, which is apt to enter into any high-grade fuel gas, has proved so objectionable that its use has rather decreased than increased. This certainly seems to be true in regard to its use in connection with ordinary city illuminating gas, as many cities in this country and Europe now have restrictive legislation on the amount that may be used.

On the other hand, great advance has been made in the production of low-grade gases—such as producer gas—in the gas engine, and in the transportation of energy by electricity. In this connection one of the most important results of the experimental work of the St. Louis fuel testing plant of the U. S. Geological Survey was in pointing out the possibility of the use of lower grades of bituminous coal in the producer gas plant. Up to that time it had been the general impression that only anthracite or the highest grade of soft coals could be used. It was plainly demonstrated there that not only the medium grade coals of the Mississippi Valley could be successfully used, but even the lignites and peats. The point of most interest is the comparison of the actual results of using Indiana coal in the steam engine and of changing it into producer gas and using it in the gas engine.

In the following table are given the equivalent pounds of coal as fired per electrical horsepower per hour developed at the switchboard for both the steam and gas plants, first, for a number of Indiana coals, then for comparison of a number of coals from the competing fields:

Table Showing Equivalent Pounds of Coal as Fired per Electrical Horsepower per Hour for Steam and Producer Gas.

Fuel Used.	Locality.	Steam.	Producer-gas.
Indiana No. 1	Mildred	4.95	2.17
Indiana No. 2	Boonville	4.78	1.68
Indiana No. 3	Boonville	4.92	1.97
Indiana No. 5	Hymera	4.74	1.51
Indiana No. 6	Hymera	4.78	1.94
Indiana No. 7	Littles	4.39	1.65
Indiana No. 8	Terre Haute	4.52	1.61
Indiana No. 9	Macksville	4.63	1.84
Indiana No. 11	Dugger	4.37	1.73
Illinois No. 4	Troy	5.47	2.01
Illinois No. 8	Paisley	6.26	1.98
Illinois No. 11	Carterville	4.35	1.37
Illinois No. 16	Herrin	4.24	1.81
Indian Territory No. 1	Henryetta	4.37	1.92
Iowa No. 2	Marion County	5.82	2.07
Kansas No. 5	West Mineral	4.11	1.57
Kentucky No. 1	Straight Creek, E. Ky	3.72	1.41
Kentucky No. 5	Big Black Mountain, E. Ky	3.54	1.39
Kentucky No. 3	Earlington, W. Ky	4.58	2.05
Kentucky No. 7	Central City, W. Ky	4.36	1.65
Missouri No. 2	Bevier	5.44	1.94
Ohio No. 3	Shawnee	4.27	1.51
Ohio No. 6	Neffs	4.00	1.30
Ohio No. 9	Clarion	3.91	1.43
Pennsylvania No. 4	Greensburg	3.63	1.42
Pennsylvania No. 6	East Millsboro	3.83	1.23
Pennsylvania No. 8	Ehrenfeld	3.43	1.28
Pennsylvania No. 10	Bruce	3.55	1.22
West Virginia No. 1	Kingmont	3.98	1.60
West Virginia No. 8	Ansted	3.83	1.82
West Virginia No. 13	Page	3.45	1.04
West Virginia No. 20	Acme	3.46	1.31

In a general way it may be stated that the results showed that to obtain the same results the steam engine required rom 1.8 to 3.7 times as much coal as the gas engine, with an average of 2.7 times as much. In this connection some figures given by Mr. H. G. Stott, Superintendent of Motive Power of the Interborough Rapid Transit Company of New York City, are of interest. He shows the losses found in a year's operation of their plant, which is probably one of the most efficient in existence today and therefore typical of the present state of the art. The figures are as follows:[a]

[a]Stott, H. G., Power Plant Economics, Trans. Am. Inst. Min. Eng., 1906.

Average Losses in Steam Plant of the Interborough Company in Converting 1 Pound of Coal, Containing 12,500 British Thermal Units, Into Electricity.

	British Thermal Units.	Per Cent.
Loss by friction	138	1.1
Loss in exhaust	7,513	60.1
Loss in pipes and auxiliaries	275	2.2
Loss in boiler	1,000	8.0
Loss in stack	1,987	15.9
Loss in ashes	300	2.4
Total losses	11,213	89.7
Energy utilized	1,287	10.3
	12,500	100.0

Mr. Stott further presents a table showing the thermal efficiency of producer-gas plants, concerning which he says:

"The following heat balance is believed to represent the best results obtained in Europe and the United States up to date in the formation and utilization of producer-gas:"

Average Losses in a Producer-Gas Plant in the Conversion of 1 Pound of Coal, Containing 12,500 British Thermal Units, Into Electricity.

	British Thermal Units.	Per Cent.
Loss in gas producer and auxiliaries	2,500	20.0
Loss in cooling water in jacket	2,375	19.0
Loss in exhaust gases	3,750	30.0
Loss in engine friction	813	6.5
Loss in electric generator	62	0.5
Total losses	9,500	76.0
Converted into electric energy	3,000	24.0
	12,500	100.0

At the St. Louis experimental station the relative economics of steam and gas-power plants were estimated as follows:

Relative Economics of Steam and Gas Power Plants at St. Louis in the Conversion of 1 Pound of Coal, Containing 12,500 British Thermal Units, Into Electricity.

	Steam Power.		Gas Power.	
	British Thermal Units.	Per Cent.	British Thermal Units.	Per Cent.
Losses in exhaust, friction, etc.	11,892	95.14	10,812	86.5
Converted into electric energy	608	4.86	1,688	13.5
	12,500	100.00	12,500	100.00

It had been hoped to have Mr. W. H. Duncan, Secretary of the Commercial Club of Terre Haute, prepare a supplemental paper on the successful use of the producer-gas plant in Indiana using Indiana coal, as he has given the subject much study and is thoroughly familiar with the results obtained. With this in view the writer did not himself investigate the subject. Pressure of other duties, however, has prevented Mr. Duncan from preparing his paper, and the writer has had to content himself with quoting from a paper on this subject by Mr. R. H. Fernald of the United States Geological Survey. In 1906 Mr. Fernald visited several of the producer-gas power plants of the country with the idea of ascertaining from the owners and operators their exact uses, efficiency and defects. The list included producers made by fourteen manufacturers, and the territory visited extended from Maine to central Nebraska. The deductions made from these visits are:

1. The plants as a whole are giving remarkable satisfaction, considering the very brief period of development that has passed since the introduction of this type of power.

2. The most serious difficulty seems to arise from the lack of competent operators to run the plants rather than from defects or troubles inherent in the plants themselves.

3. Inexperienced salesmen are undoubtedly to blame for serious misrepresentations and misunderstandings.

4. The neglect shown by some manufacturers in respect to their plants after they are installed and paid for has not been far-sighted, and the failure of manufacturers to give the purchasers or operators of plants full information regarding their construction and method of operation has certainly been detrimental to the business.

The situation as a whole at the present time seems to be very favorable for the producer-gas plant, not only as to cost of installation, operation and maintenance, but also as to reliability. The successful demonstration at the Government fuel-testing plant that bituminous coals, lignites and peats can be utilized with great economy in these plants should lead to an increase in the use of this form of power within the next few years that may surpass even the most sanguine hopes of the manufacturers.

Finally, it must be remembered, as suggested in Mr. Fernald's paper, that engineers are often not familiar with the gas engine plants, which have improved rapidly, so that sometimes mistakes are made in suggesting where they can be used to advantage. Often the difficulty is in not understanding their running after installation, but the facts all go to show that when properly installed, under the right conditions, they will prove economy of the highest kind.

Weathering of Indiana Coal.—Among the difficulties to be met by Indiana coal is that it does not stand transportation and storage well. Some experiments are now in progress at the Engineering Experiment Station of the University of Illinois on the subject of weathering of Illinois coal. In the preliminary experiments only 25-pound samples were used. Some of the samples were stored out of doors, some indoors, dry and wet, and some under water. In a general way the results of these first experiments show that in nine months the samples stored indoors and out of doors had losses varying from 2 to 10 per cent, with no marked advantage on storage indoors or out of doors, except that where there was a large amount of pyrite the coal was more broken up when wet than when kept dry. The coal, however, that was submerged was found to remain practically unchanged. There are now in progress a series of experiments, using carload lots. For the first six months the analyses show a decrease in the percentage of B. T. U.'s of less than 3 per cent in all cases, and of less than 2.5 per cent in most cases. The smaller loss in these experiments would seem to be due to the fact that the air has less access to the coal. In these experiments, too, the submerged coal does not appear to have as great advantage over the other coal samples. Figures are not yet available in regard to the breaking up of the coal, but it looks now as though the experiments would show that the deterioration is greater in a physical way than in a chemical way.

CHAPTER III.

INDIANA COAL MEASURES.

General Character and Relations.—On the stratigraphic chart, Plate II, is given a comprehensive survey of the coals of the State and the rocks with which they are associated, showing the number of coals, their relation to each other and to other rocks, and to some extent their distribution in the field. To facilitate the correlation the sections have been placed so that the coal mined at Alum Cave, Petersburg, etc., called Coal V in the old reports from Sullivan County southward, shall, where present, always be in the same horizontal line. It is believed, with much confidence, that this coal has been correctly correlated the entire length of the coal field. It has therefore been used as a base from which to measure up and down. It is, without any doubt, the most important bed in the State, having usually a good thickness, and is nearly everywhere characterized by a hard, black, sheety shale roof, commonly containing pyrite bowlders that project downward into the coal, and with a limestone overlying the black shale.

There are only a few points at which some question has arisen as to its identity, and these points do not affect the general correlation, one or two of them being on outliers at some distance to the east of the outcrop, where the character and roof of the coal has changed, and a few of the others well back to the westward of the outcrop, where the coal is met in shafts or drillings, and where some changes have taken place in its character and roof. From the east branch of White River southward to the Ohio River this particular coal is almost the only workable coal in that section of the State, reaching a thickness much in excess of any of the other coals, and in Pike and Warrick counties there are long distances in which it has been exposed by drifting or stripping on almost every 40 acres along its outcrop. Farther to the northward it is distinguished as stated by its large thickness in combination with its peculiar and characteristic roof, composed of black sheety shale, overlain with limestone. Some other coals of the section have this roof, but as a rule they are thin coals, with one exception, which lies several hundred feet stratigraphically lower than Coal V, and therefore is not confused with it today, though it was so confused in the early days of the Survey, and in part of the area in the report of 1898.

One hundred to 150 feet above it is everywhere a somewhat thinner coal, overlain by a light-colored shale or a sandstone, frequently with a rolling roof, and usually underlain, within a few feet, by a limestone. This is Coal VII of the old reports. Between the two, in Sullivan County, appears a thick coal, divided by a remarkable series of thin bands into a number of benches of constant character. This bed has not been recognized in Indiana north of Sullivan County, and it becomes inconstant south of central Knox County.

About 100 feet below No. V coal is usually found a workable bed, which is considered to correlate with the main coal at Linton, old Coal IV. About 70 feet below that coal is generally found a coal that in places reaches a considerable thickness, but which frequently is badly split up by partings, and in some districts runs out entirely. It is correlated as the lower bed at Linton, the main coal at Seelyville, Staunton and Rosedale, the lower coal at Lyford. Below this bed for 200 feet are found a variable number of beds, many of which are locally workable, especially the three at the bottom, which are now correlated as the rider, upper and lower block coals of the Brazil district. Above the uppermost coal just mentioned, Coal VII, come about 1,000 feet of rocks with a number of thin coals, and below the horizon of the Lower Block coal are sandstones and shales, and at least one coal bed.

Naming and Grouping of the Coals and Rocks.—In the 1898 report the principal coals were numbered from I to VII, and the whole column of rocks divided up into "divisions," the base of each division being the bottom of the coal of the same number. In addition coals VIII and IX, lying above Coal VII, afforded the basis of divisions VIII and IX. Not only have these numbers been quite generally used by those in the mining industry of the State, but in many cases these numbers have been used in corporation names, and appear in wage scale agreements and other documents. It appears, therefore, to be very desirable that wherever possible these old numbers be retained. While the errors of the 1898 report have thrown the naming of the beds into confusion in certain districts, it so happens that in the main these districts have not been districts of much recent development, and, as in the Brazil block coal field, the old names antedating the 1898 report have remained current there. This is fortunate, as it allows the continuance of these old names in regions where it would now be difficult to apply a number system. Thus, as old Coal VI of Clay County corresponds to Coal III of most of the State, and as there are four workable coals below it, it is evident the system of applying the numbers would have to be modified. Furthermore, a broader knowledge of the field as a whole tends to render more uncertain the correlation of the lower coals outside of the region of their greatest development in the Brazil district.

It is therefore proposed to retain the numbers for coals VII to III as originally applied in Sullivan County, and around Linton; to use the No. II for the coal exposed above drainage at Minshall, for reasons given beyond, and to use local names for the lowest coals.

Starting again with coal V: Coal V, as used in this report, refers to the bed outcropping at Alum Cave, in the eastern edge of Sullivan County, northwest of Coalmont, and to what is believed to be the same bed elsewhere in the State. As thus correlated, Coal V is the thick coal outcropping at Clinton and Lyford, the second bed down or the "lower vein" at West Terre Haute, a similar bed mined in the small area just south and west of Riley, the lowest bed at present worked around Bicknell, and at Wheatland, the old "main" coal around Washington, the coal at Murray's on White River, southwest of Washington, the main coal around Petersburg, Littles, Winslow, Princeton, Booneville, Evansville, Henderson, the "Knob" coal of Spencer County, and believed to correspond to Coal 9 of Kentucky, and to Coal 5 in southern Illinois, as typically mined at Harrisburg.

Coal VI will refer to Coal VI as used in the old report on Sullivan County, where it occurs 50 to 75 feet above Coal V. It is characterized nearly everywhere in that county by three shale partings, the lowermost about one foot from the floor and overlying a bony bench that is seldom mined, and the upper two coming about 2 feet from the top, and from 4 to 6 inches apart. This coal seems to run out north of Sullivan County, and south of Bicknell is only mined at a few points in Gibson County.

Coal VII is the old Coal VII of Sullivan County, outcropping on Busseron Crek, east of Farmersburg. It is correlated as the coal outcropping on Broulett Creek, in Vermillion County, Coal Creek in northwestern Vigo County, outcropping at water level west of Terre Haute, and along White River, just northeast of Wheatland. It is Coal VII around Hosmer, and outcrops just east of Newburg, Warrick County, where it is known as the Little Newburg.

Coal IV is the old Coal IV at Linton. It is correlated as the old Coal VII of northeastern Vigo County, and around Coxville and Mecca, around Hillsdale, and northward to the Horseshoe of Little Vermillion River. It possibly corresponds to the Grape Creek coal at Danville. It is correlated as the coal mined at Montgomery, Daviess County, and the Survant coal of the Ditney folio, U. S. Geological Survey, in Pike and Warrick counties.

Coal III is the lowest worked bed at Linton and the district north to Coalmont, the thick bed in the hill south of Clay City, the thick bed mined around Seelyville, Staunton, Turner, Fontanet, Coal Bluff, Rosedale, and Coxville, the lower bed at Clinton and Lyford, where it is 170 feet below Coal V. North of that it runs out. South of Sullivan County the horizon of Coal III does not seem to be marked by a regularly workable coal. However, the recurrence of a group of small coals close together, one of which very often is 3 feet thick, suggests that it splits in going southward and becomes unimportant before reaching the Ohio River. Its representative in Pike and Warrick counties is considered to be the Rock Creek coal of the Ditney folio.

From 90 to 150 feet below Coal III in Vermillion, Parke, Clay, and Vigo counties are two coals often coming within 2 or 3 feet of each other, but again separating until 20 to 40 feet apart. Where the space between them allows there is commonly found a limestone having a thickness up to 15 or 18 feet. The two coals have been worked at Minshall, Mecca, Fontanet, Coal Branch of the Big Vermillion River, and at many points in Parke, Fountain and Warren counties. Through a study of the fossils associated with these coals Mr. David White is inclined to correlate the upper of these coals with Coal II of Illinois, as mined in Grundy County, Rock Island County, at Murphysboro, and elsewhere. It is therefore proposed to call the upper coal which outcrops at Minshall, the one over the limestone, Coal II.

For the coals below Coal II, local names will be used. The coal below the limestone at Minshall has been called by the trade the Minshall coal not only at Minshall but at other points in Clay, Vigo, Parke and Vermillion counties. That name will therefore be used for it as a general term, especially for the northern half of the field. From Daviess County southward exact correlation cannot be made at this time, but coals which in that region are thought to come about at the horizon of the Minshall coal have been called the Sugar Creek coal, the Haysville coal, and the Holland coal.

In the Brazil field the Minshall coal overlies two coal beds that have long been known as the Upper and Lower Block coals.

They were called coals IV and III in the 1898 report. As they evidently do not correlate with coals IV and III of most of the field and as it will be easier to drop the numbers here than in the rest of the field, in this report the writer has returned to the old well known names of Upper and Lower Block coal.

The Cannelton coal, Coal II of the old report, is believed to come below the block coals of Brazil. It will be called the Cannelton coal. It is possibly at the same horizon as the lowest coal around Shoals, Martin County, which is there called the Shoals coal.

Another result of great interest from Mr. White's study is that the boundary between the Allegheny and Pottsville formations of the Appalachian coal field is found to come between the two Minshall coals, apparently about the top of the limestone mentioned in the preceding paragraph. The Allegheny formation includes what was formerly known as the "Lower Productive Coal Measures" of Pennsylvania, including the Freeport coals, the Kittanning coals, and the Clarion and Brookville coals. The Pottsville formation in Western Pennsylvania is of small thickness and of little interest from the coal standpoint, but it has a thickness of several thousand feet in the southern anthracite field of eastern Pennsylvania, and carries some of the most valuable coals of Ohio, while in West Virginia it contains the valuable Kanawha series of coals, the New River coals, and the Pocahontas coals. According to this, the main or lower Minshall coal, and the block coals at Brazil, are of Pottsville age. Furthermore, Mr. White's studies have shown that the so-called Mansfield sandstone of Fountain County, which underlies the block coals of the northern part of the State, is much younger, and therefore was deposited much later than the Mansfield sandstone of Martin and Orange counties. So that the exact correlation of these coals along the eastern edge of the field must await the time when good topographic maps are available, and can be supplemented by a detailed paleontologic study of that field.

It is therefore probable that in the future all of the rocks and coals below the limestone between the two Minshall coals, and down to the lower Carboniferous rocks will be grouped into a formation to be called the Pottsville formation, in correlation with the formation of that name in the Appalachian coal field. Such a grouping into a formation will not, however, be attempted until much additional field work has confirmed the evidence now on hand or has allowed the closer delineations of the proposed formation.

Again, Mr. White has found that Coal 7 of Illinois, which is believed to be the same as Coal VII of Indiana, is almost exactly of the same age as the Upper Freeport coal of Pennsylvania, which comes at the top of the Allegheny formation or old "Lower Productive Measures" of that State. The interval in Indiana between and including coals VII and II, as above defined, is believed to therefore correspond in age with the Allegheny formation of Pennsylvania. It is possible that in the future this group of coals and other rocks will be called the Allegheny formation or given some local name.

For the present it will be sufficient to remember that in a general way the coals from the Minshall coal down to the bottom of the coal measures correspond in age with the Pottsville coals of Pen--sylvania; the coals from coal II up to coal VII, to the Allegheny coals; and the coals and rocks above coal VII, to the Conemaugh and higher formations of Pennsylvania; and that where desired it may be allowable in a loose way to group the lower coals as Pottsville coals, and the higher coals as Allegheny coals.

Generalized Section in Sullivan and Greene Conuties.—More coals are developed and known in Sullivan and Greene counties than probably any other similar area in the State. It may therefore be helpful to notice the general section of the coal measures as they are there developed, and then trace those measures from that point northward and from that point southward. Starting with Coal V as typically exposed at Alum Cave on the eastern edge of Sullivan County, there are found two coals of workable thickness above it, the first lying on the average about 70 feet above, and the second about 50 feet higher. The first of these two coals will be designated Coal VI, the uppermost of the two Coal VII. Between Coal V and Coal VI is frequently found a thin coal, which may occasionally have a thickness of 2 or 3 feet. About 70 feet above Coal VII occurs a coal that while generally thin, in a few places in the western part of Sullivan County has a thickness of 3 feet or over. Still above that are other coals that in Indiana are always thin and unimportant. Of the other rocks it will be noted that there is a limestone close above Coal V, another limestone close below Coal VII, and other limestones above Coal VIII. The other rocks of the section are shales and sandstones, with clays immediately below the coals. There is no dominant sandstone, except one above what may be called Coal IX, which is believed to be the sandstone outcropping at the top of the bluff at Merom, and from this exposure has been called the Merom sandstone. Below Coal V is a coal that has been very extensively mined around Linton and to the northward for several years. This has been designated Coal IV. It lies about 100 to 130 feet below Coal V. Between Coal IV and Coal V are usually two thin coals, the lower of which is frequently overlain by black shale and limestone, and is generally known by the miners as the Coal IV rider or Coal IVa. About 70 feet below Coal IV is another thick bed all through the Linton-Jasperville region, known as Coal III. This bed is usually broken up more or less by partings, but in that region has a thickness of over 6 feet. Between coals III and IV is one small coal frequently overlain with a limestone. With the exception of the two limestones mentioned, the one over Coal IVa and the one over IIIa, no limestones are noted in this section between coals III and V except occasionally just below Coal V. Coal IV is frequently overlain by a sandstone, and often underlain by a sandstone, one of the few cases in Indiana where a coal is underlain by some other rock than clay. During recent years considerable drilling has been done east of Jasonville, which has shown that below Coal III exist at least five coal beds, two or three of which may be of workable thickness. One of these has been reached by a shaft at Howesville, where it shows a thickness of 3 or 4 feet. The coals below Coal III are much better known in the Brazil district of Clay County, a little to the northeast of this district. In that district the lowermost of the five coals mentioned is known as the Lower Block coal; the next one above it as the Upper Block coal; the one next above that as the rider Block or Minshall coal. Between the Minshall coal and Coal III are several coals, in this region usually thin. The Minshall coal commonly has a limestone over it, as have also in many places the first two coals below Coal III. This repetition of a limestone closely overlying a coal below Coal III, led to their confusion in the 1898 report, before the amount of drilling now accomplished had been done. Of these coals between the Minshall coal and Coal III, the one next above the Minshall coal has been designated as Coal II. In this region it is not a coal of any importance as far as known. Still below the five coals mentioned outcropping to the eastward from them, below a massive sandstone is found a coal designated Coal I in the old reports. The massive sandstone between this coal and the Lower Block coal is the one that in the old report was designated the Mansfield sandstone, from the exposure at Mansfield, Parke County, where it had long been quarried. The interval from Coal III down to the Minshall coal will run about 100 feet; from the Minshall coal to the Upper Block coal from 20 to 30 feet, and from the Lower Block coal to the Upper Block coal an average of about 30 feet. From the Lower

Block coal to the old "No. 1" coal the interval is little known, but judging from the thickness of sandstone frequently exposed, in most areas is at least 100 feet.

For the purposes of discussion we may take first the coals in the strata above Coal V to the north of Sullivan County, then those above Coal V to the south of Sullivan County, then those below Coal V to the north of Sullivan County, and finally those below Coal V to the south of Sullivan County.

Coal Measures Above Coal VII North from Sullivan County.—In the southwest corner of the State the strata above Coal VII reach a thickness approaching 1,000 feet, the full thickness being attained probably only in Illinois. In Sullivan County there are remaining probably not more than 250 feet of these measures. As before stated, the coals contained in them are usually thin. Several of the drillings in Sullivan County west of the E. & T. H. R. R. report a workable thickness for one of the coals above Coal VII. Furthermore, a coal of workable thickness has been reached by shafting at Merom, and by shallow wells on Turman Creek. This coal has been thought to correspond with Coal VII of the Sullivan-Farmersburg district. Comparison, however, of the exposures on Turman Creek with drillings in that region, and with the position of Coal VI at the Scott City mine, seems to point to the fact that the workable coal on Turman Creek and at Merom is at the horizon of Coal VIII, or about 70 feet above Coal VII. This is the only region in which that coal is known to reach a workable thickness. A short distance below the Merom sandstone is commonly found a limestone, which is thought to correlate with what has been called the Somerville limestone of southern Indiana, and possibly with the Carthage limestone of southern Illinois and southwestern Kentucky, though that correlation is rather conjectural than demonstrated. A number of limestones are usually met in the sections in the upper part of this division of the coal measures, as developed in Sullivan County and in the corresponding part of the section elsewhere in this State, so that the determination of which of these limestones corresponds with the Somerville limestone is often difficult, if not impossible.

Coal V to Coal VII Inclusive North from Sullivan County.—(Divisions V and VI with Coal VII of 1898 report).—Reference has already been made to the fact that the correlation of the coals of Sullivan County northward as now made differs materially from that of the 1898 report. As a basis for the present correlation, Coal V is traced from Alum Cave to Lewis at the northeast corner of Sullivan County, thence northward to Riley by way of the Meyers, Ray, and Pierce banks of Pierson township, and the Fox, Pickens and Christy banks in Riley township; thence from the outcrop west of Riley it can be traced by the Foster, Forest Hill, Fleshner, Hazeltine, and East Hulman Street banks to Terre Haute. While these small mines are in some cases well separated, the fact that the coal in each case resembles closely in thickness, character, and the peculiar roof, the coal at Alum Cave, and the fact that the coal in Alum Cave differs in those respects from any of the other coals above it, or for 300 feet stratigraphically below it, is considered good evidence that the coal in these mines is Coal V. Crossing the Wabash River at Terre Haute Coal V is worked at many mines and can be recognized in a large number of drillings between Terre Haute and Clinton, where the rise has brought it to above the level of the bottoms, it having risen to the river level at Durkee's Ferry. According to this interpretation it is the old Coal VI of the 1898 report at Terre Haute, and the Coal VII of that report at Clinton. It is the "Lower coal" of the operators at West Terre Haute as mined at the Fauvre mine No. 2 and the "Lower Vein" mine, and the upper bed at the "Deep Vein" mine, and the highest worked bed at Clinton.

Assuming the correlation just made to be correct, a comparison of the drillings and sections above Coal V in Sullivan County with those above Coal V in northwestern Vigo County, reveals at once a change in either Coal VI or VII, for whereas all of the sections in Sullivan County show two workable coals above Coal V, in northwestern Vigo County there appears to be only one. It has generally been assumed by the operators of the West Terre Haute district that that one coal is Coal VI. A study of the sections in pl. II, however, leads to the conclusion that that coal is Coal VII.

This condition is one hitherto unsuspected. This conclusion is reached from three general facts: in the first place the interval in the sections given on pl. II is based on hundreds of records in which that particular interval is given; these bring out much more strongly than the few figures presented in that plate, the constancy of that interval from Coal V up to the first coal above, in Vermillion County, with the interval from Coal V to the second coal above in Sullivan County, the interval in Sullivan County tending to run about 10 feet less than near Clinton or northwest of Terre Haute. In the second place, Coal VI in Sullivan County and northern Knox County has a unique and remarkably persistent section, as described beyond. No coal with such a section is known north of

Terre Haute. Furthermore, along the northern edge of Sullivan County Coal VI becomes very irregular, and many attempts to mine it there have had to be abandoned on account of the coal running out; and many drillings in that region fail entirely to find that coal. In the third place, the rocks above and below the first large coal above Coal V in Vigo and Vermillion counties resembles strongly the rocks near Coal VII in Sullivan County. No workable coal is found above it, but about 70 feet above in each case is a thin coal underlain by one or more thin layers of limestone. Below this upper coal in Vigo County is a conspicuous limestone. In Sullivan County Coal VII is everywhere underlaid by a very similar limestone, while no such limestone appears under Coal VI.

Coal VII of northwestern Vigo and Vermillion counties, as just described, differs greatly in its roof and top from Coal VII of Sullivan County. That fact is almost the only argument against the correspondence. As thus correlated Coal VII agrees with the number given it in the old report at Terre Haute. In the old report, however, it was thought to tie with the surface bed at Clinton, and that the surface bed of Coal Creek and Brouiletts Creek was a higher bed (Coal VIII). It is now clear that the surface bed at West Terre Haute (Coal VII) is also the surface bed on Coal Creek and on Brouiletts Creek in the southwestern part of Vermillion County. The rocks between Coal V and Coal VII pass out of the State to the northwest of Clinton and are but little known for more than a few miles to the north of that town.

Coals and Rocks Above Coal VII South from Sullivan County. —Southward from Sullivan County the strike carries any given coal bed farther and farther to the eastward, and as the general dip in Indiana is south as well as west, the coals are found most deeply buried in the southwestern part of the State. So too, in that part of the State is found the best development of the uppermost coal measure rocks. In Sullivan County only about 250 feet of these rocks as a maximum occur above Coal VII. The first workable coal at Mount Vernon, in Posey County, according to the diamond drilling, is at a depth of nearly 600 feet. To the westward, in Illinois, shafts and drillings have shown a possible thickness for the upper "Barren Measures" of about 1,000 feet. Only a small amount of drilling has been done through these upper rocks south of Sullivan County, but that appears to show a section somewhat similar to that found in Sullivan County. There is first a small coal about 70 feet above Coal VII, called Coal VIII in the old report; then about 50 feet higher another, called Coal IX. Limestone occurs occasionally below the lower of these two coals, and usually between the coals, and generally above the upper coal, in which position it is thought to correspond with the limestone outcropping in the hills around Somerville and called by that name in the Ditney folio. A short distance above the upper limestone, and lying unconformably on the rocks below, is a soft, coarse-grained, quartzitic sandstone believed to correspond to the Merom, though not much weight should be given to that supposed correlation. In the Ditney and Patoka folios of the U. S. Geological Survey, Coal VII was called the Millersburg coal, and the rocks from that coal up to the bottom of the Somerville limestone called the Millersburg formation. Above the Somerville limestone to the base of the sandstone just described was called the Ditney formation, from its exposures at Ditney Hills in Warrick County. From the base of that sandstone to a coal about 150 feet higher was called the Inglefield formation, the coal at the top of which was called the Parker coal. Above this to the top of the section was called the Wabash formation. Above the Parker coal occurred two other coals in the Wabash formation, which were designated the Aldrich and Friendsville coals. All of these coals reach a local thickness which has led to their being worked locally by country banks, though only the Friendsville reaches a commercially workable thickness. The formation names just mentioned will not be used in this report.

From Coal V to Coal VII Inclusive South from Sullivan County.—From the northern edge of Sullivan County well into northern Knox County the relation of coals V, VI, and VII is clear and definite. Coal VI through that distance runs about 70 feet above Coal V, and Coal VII about 40 feet above Coal VI. The interval from Coal VI to VII varies from 25 feet or less up to 70 feet, but the great majority of the large number of drillings made in that county give the interval betwen 30 and 45 feet, with an average of not far from 40 feet. Practically the same interval is maintained to Edwardsport and Bicknell, the coals and limestones showing the same characteristics as in Sullivan County. Most of the sections in Sullivan County show no coals between Coal VI and Coal VII, and only one coal between Coal V and Coal VI. In some cases, however, a thin coal occurs less than 10 feet below Coal VI. In northern Knox County this coal just below Coal VI is more persistent. It is usually about 1 foot thick, but in some drillings thickens up to 2 or 2½ feet. The limestone over Coal V is quite persistent. That under Coal VII is not noted in most of the sections in Knox County. As given in drillings, these regular conditions exist for at least three miles south of Bicknell. Between this point and Wheatland or the new road bridge across White River, northeast of Wheatland, apparently Coal VI pinches out much as it does at the north end of Sullivan County, though not so completely. Coal V is being mined at Wheatland at a depth of 250 feet. Forty feet above it, or about in the position of Coal Va of Sullivan County, is a thin coal. One hundred and twenty feet above it is a 5-foot coal; 223 feet above it, or about 100 feet above the 5-foot coal, is another thin coal. These are reported to be the only coals found in the shaft. The 5-foot coal 120 feet above No. V also outcrops along White River, near the new road bridge, and has been mined in the same region by shafting. In the section at this point Mr. John Collett, the former State Geologist, reported 4 feet 5 inches of coal to come 28 feet below the coal being worked. The writer could only find a thin coal (1 foot 8 inches thick) at this horizon, 24 feet below the worked coal, and this thin coal ran out entirely 150 feet up the river, the roof shale coming down on its underclay without a trace of coal. The upper worked coal at Wheatland and in the river bank resembles Coal VI at Bicknell to the extent of each having a bench of bony coal at the bottom. But it will be noted that the interval at Wheatland from this coal down to Coal V is exactly the same (120 feet) as from Coal VII to Coal V in drillings 3 miles to the north, where Coal VI is fully developed. Again, in all of the sections around Bicknell Coal VII is overlain by a heavy sandstone often 60 to 80 feet thick; so, likewise, is the upper worked bed around Wheatland. The writer has therefore assumed that this upper worked bed around Wheatland is Coal VII, and that Coal VI has become irregular or wanting.

At Vincennes Coal V does not show the typical development that it has along the eastern edge of the county. It has been assumed to be the third coal of workable thickness in drillings at that point. Seventy feet above it is a coal that has been considered to be Coal VI, and 13 to 18 feet above that is a 4-foot bed that has been mined, and is said to show many of the characteristics of Coal VII of Sullivan County. Between the two is usually only clay or soft shale. These two coal beds have therefore been correlated as coals VI and VII.

At Washington, in Daviess County, Coal V is typically developed west of town, but south and east of town the coal thins from 6 or 7 feet down to 3 or 4 feet, and the roof changes from a black shale to a light-colored shale or sandstone. This change in the roof of Coal V at Washington is an interesting feature. A similar change is noted in the roof of this coal near High Bank in Pike County, south of Algiers, northeast of Oakland, and a tendency toward such a change is seen at points along the eastern outcrop in the north-central part of Pike County. In some of the mines, as at the Blackburn mine, this light-gray shale comes between the coal and the black shale roof, the gray shale occurring as lenses, and the black shale rising above these. Around Petersburg and northeast of Oakland the occurrence of the light-colored shale roof is not associated with a thinning of the coal—rather the reverse, as the thickest coal measured was under that kind of roof; but farther eastward, as at Washington, High Bank, and south of Algiers, the black shale disappears and the coal bed is much reduced in thickness. It suggests that following the laying down of the coal some stream entering the coal swamp from the east had brought out a quantity of mud, extending out irregularly on the newly deposited coal bed, this condition preceding the laying down of the normal black shale roof. This fact also suggests that the border of the swamp was not far to the east in this region, and that possibly this coal was not laid down as far to the eastward as some of the underlying coals, suggesting that the higher coals were laid down within more restricted outside limits.

Coal V is typically and finally developed all through the western half of Pike and Warrick counties. Coal Va appears above it, ranging from 40 to 50 feet above in northwestern Pike, to 5 to 20 feet above in central Pike County. It is not certain that these coals are at the same horizon. The Va coal of central Pike County is usually represented by less than 1 foot of coal, but in a few places, as south of Ayrshire and at Hartwell, this coal reaches a thickness of 3½ feet or more. The positions of coals VI and VII in this area are in much doubt. Most of the sections show only one workable coal above Coal V. In the hills west of the E. & I. R. R., from Petersburg to Littles, this single workable bed appears to be about 80 feet above Coal V. At Oakland the first coal above Coal V is 125 feet. At Fort Branch, Francisco, and a few other places, there appear to be two workable beds above Coal V coming close together, the lower being from 90 to 135 feet above Coal V, and the other 15 or 20 feet higher. Probably an average interval would be 100 feet and 20 feet more to the upper bed. In some of these drillings the distance between these two upper coal beds is much reduced, in one case near Oakland the two being separated only by 3 feet 7 inches, the two coals being apparently the same as the two coals found at Francisco and Fort Branch. Two possible correlations may be made of these two coals, the first that they are coals VI and VII, the second that they are coal VI and the underlying coal previously mentioned, Coal VII, under that hypothesis, having thinned out. The fact that apparently these two coals can be traced southward to the Ohio River and then into Kentucky, where at different points, or in some cases at the same point, both of them are of good workable thickness, sometimes reaching even 6 or 8 feet, suggests that they belong at the horizons of coal VI and VII, rather than at the horizons of VI and the little underlying coal found below Coal VI in northern Knox County. One feature which renders this correlation uncertain is the fact that at several places under the lower of these two coals is found a limestone, no limestone appearing between the two. If this limestone is the same as the limestone underlying Coal VII from Vermilion County southward into northern Knox County, then it is evident the two coals must be considered as split benches of Coal VII, and Coal VI is entirely lacking. If it is not that limestone, and the lower coal is Coal VI, it is evident that this is a new limestone which appears below Coal VI only in this region. The fact that farther south two coals supposed to correspond with these two coals are found frequently in western Warrick County, and, as stated, in Kentucky, and that between these two coals in a majority of cases a limestone does occur, would suggest that the limestone found below the lower coal in this particular region is a local lens and does not tie in to the limestone under Coal VII farther north, or between the two coal beds farther south. Some difficulty has been experienced in determining the stratigraphic position of a pocket of thick coal lying just northeast of Oakland on the east side of the south fork of Patoka River. It is nearly, if not exactly, in the horizon of Coal V. Within this small area in the west part of Turkey Hill this coal shows a thickness of about 9 feet, usually broken up by one or more partings of clay or bone coal, and overlain by first a few inches of soft shale, and above that a sandstone. At Oakland, at Dongola, and at the old Carbon mine at Sophia P. O., Coal V has a fairly uniform thickness of about 4½ feet or less. These three points make a triangle enclosing the pocket of coal in question. Indeed, points much closer to the pocket in question may be selected at which Coal V shows a thickness of less than 5 feet, overlain with its typical black shale roof and limestone. Thus, at the first mine of the Peacock Coal Company, near the E. & I. R. R., Coal V has a thickness of about 4 feet, overlain with black shale, the coal lying at a depth of about 40 feet. Again at the Eureka mine, east of Oakland and west of the south fork of Patoka River, Coal V is mined at a depth of 40 feet with a typical development and typical black shale roof. Again, in the southwest corner of Sec. 10, T. 2 S., R. 8 W., less than a mile east of Ingleton slope, Coal V has again its typical thickness. Thus at all of these points very close to this area Coal V appears to be developed with its typical thickness and roof.

Again, in the way of elevations, this pocket of thick coal appears to lie higher than the position of Coal V, as indicated by these other openings. At Oakland Coal V is about 340 feet above sea-level, at Sophia 420 feet, at Dongola 360 feet, or 40 feet below water level; at the Massey mine (Peacock Coal Company) the coal is about at river level or 400 feet above tide. The Massey mine is about half-way in a line from Sophia to Dongola. With the dip uniform between the two places, Coal V should have an elevation at Massey's of about 390 feet, or very close to the actual elevation of the coal at that place. At the road crossing near Massey apparently this same thick coal bed is just below water level, but with a rise to the south which should, if continued, carry it well up into the hills a short distance south of the river. Again, at the old Whitman shaft in the southwest corner of section 10, Coal V has an elevation of about 400 feet, with a dip to the southwestward which would rapidly carry it much lower. Apparently in contrast to this dip, the coal at the Ingleton mine, three-quarters of a mile to the northwest, has an elevation of about 420 feet, indicating a rise rather than a dip. On the other hand, however, the writer's notes indicate that from the Ingleton mine northward through section 9 this coal shows a strong rise to the north, giving the appearance of an anticlinal roll between the Ingleton mine and the Massey mine. The new shaft of the Peacock Coal Company, about three-fourths mile southeast of their old one, finds this thick coal in the hills about 15 or 20 feet above the bottoms. The only other possible correlation seems to the writer to be to assume that this thick coal is a thick pocket of Coal Va, which through this region in general is less than a foot thick, though in some places it thickens up to 3 feet or more. In view, however, of the dips suggested by the outcrops, which would seem to account for the discrepancy in the position in the hills of this coal, the writer has been inclined to interpret this coal as Coal V, though not without some question. The fact that Coal V frequently does have a gray shale roof in this region just eastward, reduces the argument against its being Coal

V on account of the roof. While the assumption that this thin coal has thickened up to 9 feet seems much less likely than that Coal V has thickened up, as Coal V is known to have a thickness of 6 to 8 feet at the Littles mine just a short distance north, and to run up to and over 6 feet in mines and drillings within 2 or 3 miles to the east.

Turning again to the coals and tracing them southward to the Ohio River, Coal V can be traced, without any further question, from Winslow to Evansville. As was before stated, it has been opened or stripped on nearly every 40 acres. The limestone above the coal is not as persistent as it is farther north, but it is often replaced by a calcareous clay full of fossils, which in places becomes a true limestone. This clay is known to the miners as ''pennywinkle'' (periwinkle) rock, from the gasterpod shells with which it abounds. It is often spoken of as ''tumble'' rock also, from its tendency to fall if the strata underlying it fall in a mine. The little coal, Coal Va, is seldom noticed through Warrick County or around Evansville. Most of the drilling in southern Warrick County and around Evansville shows only one coal of any thickness above Coal V. That coal comes from 90 to 100 feet above and is usually underlain by a limestone of some prominence, this limestone frequently having a thickness of 9 or 10 feet or more. At a large number of places in western Warrick County there appears to be a coal below this limestone. In some cases the two coals come quite close together, and in Greer Township apparently these two coals come within a few inches of each other and are worked as one thick bed, with a clay parting in the middle. In most of this district the upper coal is the more important and the lower coal is seldom seen, but is frequently reported as having been found within a few feet underneath the limestone.

It is of interest to note that very similar conditions exist in tracing the coals across the river into Kentucky, the coal worked at the People's mine at Henderson being evidently the same as Coal V at Evansville, not Coal VII, as interpreted in the 1898 report. The presence of limestone below the clay under that coal misled the writer at that time. A similar limestone proves to underlie the coal at Evansville, and in some of that district, usually not occuring as a rock ledge, but being found as long lenticular masses, or in some cases as short masses only a few feet in diameter, and a foot or less in thickness. The occurrence at Henderson is quite similar. Coal V as thus mined at Henderson has also been mined at many points to the eastward, as at Baskett, on Greene River, around

Owensboro, and elsewhere. Above this coal at all of these points is commonly found a coal seeming to correspond in position with Coal VII of Indiana, underlain with a limestone. In general, Coal VI underlying the limestone is absent, but at many places, particularly west and south of Henderson, both coals are present. At Corydon the coal over the limestone reaches a thickness of 6 feet or more, as it does also at Smith Mills.

In the Madisonville district the No. V coal of Indiana is known as Coal 9, and coals Nos. VI and VII of Indiana as coals 11 and 12. In that district both 11 and 12 reach a workable thickness. In the Reinecke mine, west of Madisonville, the upper coal has a thickness of 4 feet 2 inches, the coal underneath the limestone a thickness of from 6 to 8 feet. The interval between the two coals is quite variable. At one point in that mine they are found 38 feet apart. At a distance of 4,200 feet to the south the No. 12 is down to within 3 feet of No. 11, suggesting a variability similar to that found in southern Indiana.

Some question has been entertained in Kentucky as to the correlation of the coals around Madisonville with those at Henderson. A comparison of the sections in southern Indiana with those around Henderson and Madisonville with those again found in southern Illinois has convinced the writer that Coal 9 at Madisonville is the same coal as mined at the People's shaft at Henderson, and is in turn the same as Coal V of Indiana; that coals 11 and 12 of the Madisonville district correspond to coals VI and VII, as here interpreted, in southern Indiana.

Coal III to Base of Coal V from Sullivan and Greene Counties Northward.—As indicated by the sections on Plate II, little difficulty is experienced in tracing coals IV and III northward from Sullivan County, notwithstanding that they were incorrectly traced in the 1898 report. With the knowledge now in hand that mistake could not have been made. Coal III as now known in western Greene County and under all of Sullivan County was then practically unknown, as were all of the coals below Coal VII in western Vigo County. Today hundreds of drillings have demonstrated that at nearly every point Coal V is underlain at a distance of about 200 feet by a coal that averages over 6 feet in thickness. This is true all over Sullivan County and the western edge of Greene County. The same drillings show that between Coal V and this 6-foot bed is another bed somewhat more variable in thickness ranging from 4 to 5 feet, and lying about 70 feet above the 6-foot bed. Tracing these drillings eastward, it is clear that the intermediate bed is the bed so extensively mined from Linton to Jasonville and known as the Linton coal, and that the underlying bed is the coal that is mined around Midland and at many other points in the Linton-Jasonville district. This more recent drilling further shows that these two beds do not tie into the upper and lower Block coals of the Brazil district, for drillings at many points today demonstrate the presence of as high as seven or eight coals below the 6-foot coal, or Coal III, as it is now known. And, further, between Jasonville and Howesville a line of close drilling has made clear that the coal in the Howesville shaft is the same as the coal that in the drillings further westward comes about 200 feet below the 6-foot coal or Coal III. Further, the coal in the Howesville shaft, from its position, and on the testimony of a number of competent mining men and engineers who examined it, and who are thoroughly familiar with the Lower Block coal, appears to be certainly the equivalent of that coal.

Coal IV tends to run from 110 to 150 feet below Coal V all through Sullivan and western Greene counties, the average being about 130 feet. Between coals V and IV there is usually one thin coal, and often two. The lower of these, Coal IVa, is known as the rider of the Linton bed, and is always watched for by miners in shafting or drilling. It lies from 25 to 40 feet above Coal IV, and is usually overlain by a limestone, between which and the coal is black shale. Another limestone commonly occurs just below Coal V. The rest of the space is filled about equally with sandstone and shale. Sandstone usually occurs between Coal IV and IVa, often making the roof of Coal IV.

The interval from Coal III to Coal IV in Sullivan and Greene counties runs quite regularly from 60 to 75 feet. There is almost always one thin coal about half way between, which is often overlain by limestone, Coal IIIa, otherwise the rocks are shale and sandstone. It will thus be seen that in their stratigraphic relations there is considerable resemblance between coals IV and III in the fact that they do not differ greatly in thickness, that each tends to be split, that each has a shale or sandstone roof, that each is overlain at about the same distance by a thin coal, which in turn is overlain by black shale and limestone. These similarities have led to confusion at many points, and at many of the mines great uncertainty seems to exist as to whether the coal being worked is Coal III or Coal IV. After a study of hundreds of drill records now in hand, the writer is inclined to doubt if Coal III ever comes within 150 feet of Coal V in this region, and if Coal IV is ever found more than 160 feet below Coal V. Exceptional cases, of course, are likely to be met with. There appear to the writer to be some other differences that may or may not be of value in distinguishing the two coals. Coal III of this district very generally has a thickness of over 6 feet, and while it sometimes runs much under that, on the whole it appears to hold that thickness quite persistently, tending to run up to 7 feet more often than it runs down to 5 feet. On the other hand, Coal IV seldom reaches a thickness of 6 feet, and in a great many cases will run under 5 feet, and not infrequently thins down to 3 feet or less, occasionally running out entirely. Again, while both coals tend to be split, it has appeared to the writer that Coal III has rather regular partings, there often being several of them, while in Coal IV there is usually only one parting, which is irregular, in many areas not showing at all or only as a smooth parting, while elsewhere this parting may thicken up and vary widely within short horizontal distances. While the roofs of the two coals have many points of resemblance, Coal IV probably has a sandstone roof much the more frequently. The floors of the two coals, however, tend to be quite different. The floor of Coal IV is usually sandstone or a hard sandy clay, while the floor of Coal III is usually clay, which is often soft, and in some mines farther north even shows a tendency to creep. Finally, the two coals seem to differ markedly in their chemical character, the analyses of Coal IV in nearly or quite all cases showing a lower percentage of sulphur, often less than 1 per cent, and seldom much more, while Coal III usually shows several percentages of sulphur or analysis, and in many cases shows an abundance of "sulphur" in visible form in the coal. This difference is usually reflected in the ash of the coals, Coal IV having a white or gray ash, while Coal III tends to have a red ash with clinkers.

Traced northward, coals III and IV seem to maintain much the same relation to each other and to Coal V that they have in Sullivan and Green counties, at least as far north as Clinton in Vermillion County, and Coxville in Parke County. Towards Clinton the interval from Coal V to Coal IV seems to decrease slightly, coming to average nearer 100 feet, and Coal IVa has a limestone under it more often than over it. Otherwise, the rocks are much the same as in Sullivan County. The interval from Coal IV to Coal III differs mainly in the fact that to the east Coal IIIa approaches very close to Coal III, while in most of Vigo County Coal IIIa usually keeps 30 or 40 feet above that coal. Around Stanton and Coxville it is often only 4 or 5 feet above, though usually the distance is somewhat greater. In western Vigo the interval from Coal III to Coal IV increases somewhat over that interval farther south, in some cases reaching 80 feet.

From a few miles north of Coxville and Clinton northward the conditions change greatly. The outcrop of Coal V is deeply buried below the glacial drift to the north of Norton's Creek, and it cannot be referred to as a key horizon. The interval from Coal III to Coal IIIa decreases so as to run regularly 6 feet or less, decreasing the interval from Coal III to IV correspondingly, and Coal III becomes irregular and finally runs out, being last seen south of Hillsdale and near the mouth of Rocky Run. On the west side of the Wabash from Clinton to Hillsdale there are so few outcrops that the correlation of the sections between the two points would be very difficult were it not that fairly abundant exposures exist along Raccoon Creek northward from Coxville. Two or three days were spent the past summer reviewing the evidence along Raccoon Creek of the thinning out of Coal III. The new evidence obtained only strengthened the conclusions reached before. Coal III continues sporadically to Mecca and beyond, separated from Coal IIIa only by a few feet of clay. Extensive quarries for clay product factories along Raccoon Creek and northward and across the river at Hillsdale and West Montezuma greatly increase the data to be obtained from the abundant natural outcrops, in many respects giving a better visible display of the strata than anywhere else in the coal field, as some of these quarries show 70 or 80 feet of perpendicular section. In striking contrast with this irregularity and thinning out of Coal III, Coal IIIa is remarkably persistent all the way from central Clay County to where it leaves the State in the Little Vermillion River district. Everywhere it ranges from 10 inches to 18 inches in thickness, seldom over that and seldom under it. Nearly always there is a thin parting above the middle. It is overlain by black, bituminous, sheety shale, and above that one, or often two, layers of ferruginous limestone and calcareous iron ore. While in Clay County one of these limestones often reaches 2 feet or over in thickness, over most of the district they have a persistent thickness of 3 or 4 inches each. One of these two layers often shows cone-in-cone structure, and is a shaly limestone, while the other is more often a calcareous, slightly fossiliferous iron ore, the outcrop being cut by regular joint planes, making it resemble a line of bricks stuck into the bank. Below the position of Coal III is a great body of shales that furnish the material for the brick and tile works. Coal IV is but little exposed in Parke

County, and the horizon of Coal III is not seen north of Montezuma. On the west side of the Wabash River Coal IV is exposed in the top of the bluff from Hillsdale to Little Vermillion River and up that river to the Horseshoe, everywhere running about 4 feet thick. Below it can be traced Coal IIIa, with the horizon of Coal III about 6 feet below, though no coal appears at that horizon. The clay between this horizon and Coal IIIa is a very refractory clay, and so has been mined at many points north of Hillsdale, and this in connection with the openings on Coal IV make the tracing easy. The interval from Coal III to IV varies north of Hillsdale, in some cases becoming less than 20 feet, though generally much more. In most of this district Coal IV, where exposed, is so near the top of the hill that little or none of the strata overlying it can be seen. On Little Vermillion River, however, at the Horseshoe, there appears another workable coal only a short distance above Coal IV. Much question exists as to what coal that is. The best solution seems to be that it is Coal IVa, which has at that point come nearer to Coal IV, and has at the same time thickened up. Another possible solution is that the upper coal is Coal V. Three sections are given on Plate II, taken from Illinois, from the region northwest of the Horseshoe on Vermillion River. In the first of these, two coals, considered to be the Grape Creek and the Danville, of the Danville district, are seen, having the normal distance between them of Coal IV and Coal V in central Indiana. The lower of the two coals at the Horseshoe of Little Vermillion River has been traced by Mr. DeWolf, of the Illinois Survey, with some question, into the Grape Creek coal of Illinois. The section in question is taken near Westville. Going northward, a number of drillings have been made and many mines exist on the two coals which show a steady decrease in the thickness between them, until in the region about Danville these two coals have come to within a few feet of each other, the distance often being less than 20 feet. The possibility, therefore, that the upper coal at the Horseshoe is Coal V has some facts in its favor. The roof of the upper coal there is not exposed, so that it cannot be told whether it has any resemblance to the roof of Coal V in Indiana. The correlation of the Grape Creek and Danville coals of Illinois with Coals IV and V of Indiana is not without some question. It is based primarily on the tracing by Mr. DeWolf, as just stated, and further upon the fact that at about the right distance below the lower of these two coals some other coals in Illinois are met with in drillings in about the position of the Minshall and No. II coals of Indiana, which, as it happens, are the only important coals in Indiana at about that horizon in that part of the State.

The correlation made is only suggestive, and it is hoped will be given further study before the final comprehensive paper on the Eastern Interior Coal Field is issued.

Coals Below Coal III North of Sullivan County.—These coals are best known in the region of northeastern Vigo County and northern Clay County, where several of them have been extensively mined, and where a large amount of drilling has given a clear conception of their relations. In that region three of the coals are being mined. Above the three coals being mined drilling shows the presence of at least five other coals. The three coals mined are the three lowest, the uppermost of which occurs about 100 feet below the bottom of Coal III. It is overlain by a limestone that outcrops on Otter Creek west of Perth. Of the coals overlying this limestone the lowest one sometimes reaches a thickness of 3 or 4 feet, and has in a few cases been mined in connection with the next lower coal. Stratigraphic work by Mr. David White, of the U. S. Geological Survey, has led him to suggest that this coal, the first coal above the limestone, will be found to correlate with Coal II of Illinois, and it has, on that basis, been so designated in this report. Of the other coals between that and Coal III, two of them are frequently overlain by limestone, and sometimes a third. The first two coals underlying Coal III have variable roofs, but in many places each of them has a black shale roof overlain with a thin limestone. Another limestone occurs, sometimes as far as 75 feet below Coal III, and thus may be confused with the heavier limestone lying a little lower. The heavy limestone referred to outcrops at Minshall, and as the coal immediately underlying it has been called by the trade the Minshall coal, from its extensive mining at Minshall, this limestone will be referred to as the limestone at Minshall. The intervals of these coals from each other and to Coal III vary considerably. The Minshall coal may range from 70 feet to well over 100 feet, as it lies in basins in which the thickest coal is in the center of the basin and at the greatest distance below Coal III, while toward the edges of the basin the coal is found much closer to Coal III, and also much thinner. It is therefore easily confused with the overlying coals when only found in outcrop, even though the distance below Coal III may be obtainable at that point. Below the Minshall come the two Block coals of Brazil, known as the Upper and Lower Block coals. The Minshall coal in that region has frequently been referred to as rider Block coal. These three coals in the 1898 report were designated as coals III, IV and V. The Minshall coal, with its overlying limestone, having been confused with the Alum Cave coal with its limestone, correspondingly the Upper Block coal was supposed to correlate with the Linton coal (Coal IV) of this report, while the Lower Block coal was thought to correspond with the coal below the Linton coal, and therefore designated as Coal III. The Minshall coal in all the district northward from this was designated as Coal V in the old report. As that designation has been more widely used for the Alum Cave coal some 300 feet higher, and is so used in this report, it cannot be used for this coal, and therefore the trade term of Minshall has been adopted. In like manner the designations III and IV having been used for coals of that number in Sullivan and Greene counties, cannot be used here and, as it happens, those numbers have been little used in the field in designating the Block coals, the old names of Upper and Lower Block will therefore produce no confusion. The distance from the Minshall coal to the Upper Block coal will average here about 30 feet, and from the Upper Block to the Lower Block coal a similar amount. These intervals vary greatly. In a few cases the Upper Block coal has what is called a "whitetop" roof, which is found to be the under-clay of the Minshall coal, and in such cases the Minshall coal is found to have come within a few feet of the Upper Block coal. In general, however, the intervals tend fairly constantly to hold to the figures given. All of these coals occur in basins of limited extent, in which the coals may be thick in the center, ranging up to 4 or 5 feet and thinning out to a few inches on the edges of the basins. No limestone has been noted in this region below the limestone which outcrops at Minshall. As a rule, no coal appears between the Minshall and the Upper Block or between the Upper Block and the Lower Block, though a coal does appear in those intervals in a very few cases. Coming southward, the Upper and Lower Block coals can be readily traced to the south line of Clay County. The Rider Block coal has not been mined and is not as readily traceable. Apparently, the relations continue much the same as those between Brazil and northeastern Vigo County. They can also be traced clearly into southern Parke County. Beyond that openings become scattered and comparatively little drilling has been done, so that from that point northward correlations are based almost entirely on the assumption that the rather heavy limestone that is found abundantly all through Parke, Fountain, and the southeastern edge of Warren County is at the same horizon, and that it corresponds to the limestone at Minshall. In view of the fact that other limestones are noted in the sections in northern Clay County, the possibility of error in making the limestone the basis for correlation is admittedly large. However, the other limestones referred to wherever seen are usually not more than 1 or 2 feet thick, while the limestone at Minshall, though irregular, frequently is 10 or 15 feet, or even more, in thickness. Going northward from southern Parke County, at a great many points the limestone is found underlain closely by a coal of workable thickness, and this has been correlated as the Minshall coal. It has been worked at Minshall, and it is now believed that the coal worked at Mecca in the shaft is at this horizon. There are found at Mecca two coals, frequently separated by a limestone, the lower of which is being worked, but in some cases the upper coal comes so close to the lower coal that both can be worked together. The Minshall coal is again typically exposed between Minshall and Sand Creek, at which points a few exposures are seen of the underlying Upper Block coal. That coal, however, appears to be very pockety, and no trace is found there of Coal III. Continued northward, very few stratigraphic sections are found except those along Sugar Creek or its branches, which involve mainly the Mansfield sandstone, believed to underlie the Lower Block coal. The exposures are almost entirely of coal openings, and where the coals are not drifted upon or stripped, they are usually reached by very shallow shafts. It has not been possible to correlate the coals at all points in the north part of the field because at many points no limestone is found overlying the coal, and it is not always certain whether the absence of the limestone can be interpreted as meaning that this is not the Minshall coal, or that the limestone has run out at this point, as the limestone is known to run out at many points on the Minshall coal. At many places in southern Fountain County what is taken to be the upper Block coal, lying 20 or 30 feet below the limestone at Minshall, reaches a workable thickness. Apparently, no workable coal underlies that, suggesting that Coal III was not deposited in this district. Coal IV appears to be found as far north as Veedersburgh, and most of the sections in that region do not show any limestone. The limestone, with its underlying coal, is found at Yeddo, and across the river in Warren County, where it appears to be the lowest workable coal. In that region one or two of the coals above the Minshall coal reach a thickness of 2½ feet to over 3 feet in places. This higher workable coal was designated Coal VI in the old report, though it is recognized now that it does not correspond to the coal designated Coal VI in southern Parke County, now called Coal III. It was in this coal that Mr. White found the fossils that led him to correlate it with Coal 2 of Illinois. Northwest of Covington it appears to lie about 30 feet above the Minshall coal. West of Indiana Mineral Springs sections indicate that not only is the Minshall coal workable underlying its limestone, but two of the overlying coals reach a workable thickness, the first one correlated as Coal II, running from 15 to 20 feet above the Minshall coal, and the other as much higher. The Minshall coal in this district appears to be the lowest coal deposited, Coal IV having run out. Below the Minshall coal here is a body of black shale, apparently lying unconformably on a mass of sandstone correlated as the Mansfield sandstone.

Coals Below Coal V from Greene County Southward.—The fact, as demonstrated the past summer, that coals IV and III of western Greene County do not correspond with the Upper and Lower Block coals, as had been assumed in the 1898 report, has resulted in throwing into confusion all of the correlations of the coals southward from Greene County. In the early days of the Survey, under Mr. Cox, it was quite largely assumed that there were in that district but few coals. At many points a coal was found overlain by a limestone and was usually designated as Coal K. In most of Daviess County, for example, it was assumed that there were no coals between Coal K and the lowest coal of the coal measures. Coal K was supposed to correspond with Coal V of Sullivan County. In the 1898 report it was recognized that there was more than one coal overlain by a limestone. However, later work on the Ditney quadrangle in Pike and Warrick counties in 1900 showed that there were more coals overlain by limestone than were recognized in that report, and the writer now has the feeling that future detailed work will demonstrate the existence of at least one more limestone than was found in the Ditney folio work. For example, in Sullivan and Greene counties the thin coal between Coal V and Coal IV is usually overlain with a limestone. Again, the thin coal between Coal IV and Coal III is often or commonly overlain with limestone; still lower, below Coal III, as typically exposed in Vigo County and northern Clay County, there are at least three limestones, of which the lowest or third is most prominent.

During the past summer no attempt was made to go over the area in which the underlying coals outcrop to the east of the crop of Coal V, as it was felt that to do so would occupy many months of time and vastly more money than had been provided for in the plans for the resurvey. Considerable time, however, has been given in the office to the attempt to readjust, out of existing knowledge, the relations of those coals in the light of the better information now held of the general stratigraphic column. Some additional time was given to the subject in Daviess County, sufficient to demonstrate the presence of at least three of the limestones mentioned. The field work for the Ditney folio in Pike and Warrick counties had previously demonstrated the existence of three limestones in that area. The possibility of there being still a lower limestone is pointed toward by certain facts as given beyond.

Coals III and IV and their intermediate thin coals, IIIa and IVa, can usually be recognized in drillings that pass through Coal V, on the assumption that these four coals are present and only these four coals. In many of the sections the second and fourth coals below Coal V are somewhat thicker than the others, and the first and third coals are overlain by limestones, to that extent resembling the typical section and giving some confidence in their identification.

In some of the drillings in Pike County many of the records show that the first coal below Coal V, while resembling Coal IV in its distance from Coal V and its thickness, is found to be overlain by a limestone. One or two drillings, however, show the limestone coming 10 or 15 feet above the coal, with a thin coal just under, so that it is considered that in the other cases the strata between the limestone and the main coal, including the thin rider coal, have pinched out. In going southward, the correlation of Coal III, especially in these drillings, becomes more and more uncertain.

In a general way the interval from Coal V to Coal IV remains about 100 feet, running over rather than under, and the coal is generally overlain by a light-colored shale or sandstone, except in part of Pike County, as described in the last paragraph. The position of Coal III becomes very uncertain, as will be evident from an examination of Plate II. The thick coal of the northern counties has disappeared. Whether it has thinned out, split up, or feathered out cannot be determined until much more drilling has been done. At present it looks as though Coal III had split and finally run out altogether before reaching the Ohio River. The amount of drilling within the outcrop of Coal V that reaches below Coal III is as yet so small that no attempt at correlation can be made.

The eastern outcrop of Coal V can be traced without difficulty because of the great number of openings made upon its edge. Largely because of the presence of this thick and easily-mined coal, the smaller underlying coals which outcrop farther east have been but little opened or developed. Then, too, there has been lacking the incentive to drilling and other exploration, so that our knowledge of the lower coals which outcrop east of the edge of Coal V is obtained almost entirely from the occasional weathered exposures in the roads or the scattered neighborhood banks. Within the drift area extending south into northern Pike County there are few outcrops of rocks in the roads or stream banks, and relatively few neighborhood mines. Toward the edge of the mantle of glacial deposits in southern Daviess County the rocks are more frequently exposed.

Attempts to trace and correlate the coals have been based on resemblances, particularly of the roof of the coals and on their relative elevations. For example, just east of the crop of Coal V the first coal met with is usually a thin coal overlain with a black sheety shale and limestone. Usually near it is a bed of thicker coal overlain by light shale or sandstone. If the easternmost crop of Coal V is in the top of a high ridge, as often occurs in Pike and Warrick counties, these two coals will often be found down the slope of the hill and about 100 feet below Coal V. If their elevation can be determined it may be assumed that in a mile farther east these two coals will probably be found at an elevation 20 to 40 feet higher, and twice as much two miles farther east, and so on proportionally. If, then, two similar coals be found to the eastward of those first found and at such an elevation as to indicate a rise to the east at some such rate as suggested, it is assumed that they are the same coals unless other facts point to the contrary. These coals will be considered the equivalent of coals IV and IVa. In tracing them eastward two similar coals are usually found. In some cases they can be clearly seen to be two lower coals, as the first two coals outcrop above them in the hill. More often a comparison of the elevations shows that to bring the first coals from where they were first found to the position of the newly-found coals will require a much lower dip than the normal, or an actual dip to the east, and on this basis they are therefore correlated as lower coals.

To take a concrete case: Coal V is just caught in the crest of the hill 1½ miles northwest of Selvin and at an elevation of 600 feet above sea-level, according to the U. S. Geological Survey topographic map. One-half mile or less to the east, and 100 feet lower, or at 500 feet above sea-level, is a 3-foot coal, with an 18-inch coal overlain by black shale and limestone, coming only 6 feet above it. A mile farther to the east, down the same branch, is a similar 3-foot coal, overlain at about 6 feet by an 18-inch bed of coal having a similar roof to the rider of the coal first found. At first sight the two 3-foot coals are the same bed. The U. S. Geological Survey topographic map shows, however, that though apparently at the same elevation, the coals at the east are at an elevation of 470 feet above tide, or 30 feet lower than the coals at the foot of the hill to the west. Adding a dip of as low as 20 feet and it is evident that the coals are apparently, stratigraphically at least, 50 feet apart, a relation that is confirmed by the outcrops at Selvin, where both sets of coals are found, the first set in the top of the hill just west of town, and the other in the foot of the hill northeast and south of town. In the same area 3 miles east of the point where the second group of coals was first noted, there is an outcrop of a coal overlain by a black shale and limestone. The topographic map shows that it is at an elevation of 430 feet above tide, or 40 feet lower instead of 60 to 80 feet higher, as it should be were it the same coal as those found northeast of Selvin. This point is 2 miles south of Holland, and the coal there has been called the Holland coal. Three miles farther east and 1½ miles west of Ferdinand station are openings on another coal, also overlain by black shale and limestone, but the topographic map shows these coals to come at an elevation of 520 feet above tide, or 80 feet higher than the coal south of Holland, and if the dip be assumed to be normal, it is evident that they are probably the same coal as the Holland coal, a conclusion that is strengthened in this case by the presence of many intermediate outcrops on that coal. Two or three miles still farther east, around St. Henry, are reported many fragments of limestone which cannot be higher than 520 feet above tide. Are they from the limestone over the Holland coal? If so, there is no dip in this district, or possibly a dip to the east. Two miles still farther east is a coal under a limestone at about 540 feet above tide, and 4 miles beyond that, or 3 miles beyond Ferdinand, is a coal and limestone at about 640 feet above tide. Are all of these outcrops on the Holland coal and limestone? The elevations given are not very reliable, as they are made from Mr. Price's notes for the 1898 report, and adjusted as nearly as possible to the St. Meinrad topographic sheet. On the assumption that the normal dips prevail in this district, the limestone found around Ferdinand and St. Henry is a lower limestone than the one over the Holland coal. It is true, there are known a very few cases of a very low eastward rise, or even a dip to the eastward, extending for several miles, as west of Montgomery, in Daviess County, but in the great majority of cases where the data is sufficient to render the correlation of any coal certain in an east and west line for many miles, it is found that there is a more or less uniform dip to the west, usually ranging from 20 to 40 feet to the mile. Therefore, when data to the contrary is lacking such a dip has been assumed and correlations have been made accordingly. In most of Dubois, all of Daviess, Martin and Greene counties no topographic maps exist, so that in those counties the relative elevations have been roughly estimated from the observed relations to drainage, checked as well as might be with barometric elevations, but the determinations in those counties, due to this fact and to the fact that the data are much more scattering, have not been as satisfactory as farther south where the topographic maps have been available. In the case of eastern Greene and Martin counties, the rugged character of the topography of the high hills gives a better opportunity for correlating the coals, as coals can frequently be found, one above the other, in such a way as to demonstrate their relationships. Even here, however, the great abundance of sandstones of generally similar character, but coming apparently within different intervals, and the abundance of thin coals, has rendered uncertain many of the correlations.

In Greene County the broad drift-filled valleys and accompanying prairies on either side of White River render correlations difficult. The drillings and test shaft near Howesville indicate the relation of the Block coals to coals III and IV, and drillings along the western edge of the county give the relation of coals III and IV to Coal V. The relations of coals V, IV and III have already been described in the typical section. In the 1898 report it was assumed that coals III and IV extended eastward to the bluffs of White River on the assumption that they correlated with the Upper and Lower Block coals of Clay County. With the present understanding of their stratigraphic position it would appear that they outcrop within or close to the eastern border of Range 7 West. Many shallow wells have been sunk in the upland in several directions from Switz City. None of these wells report a coal corresponding in thickness with Coal III, as developed in northwestern Greene County, and from the elevations it is assumed that the coals reported belong below that coal. Coals of workable thickness occur near Switz City and to the westward, and have been worked to some extent. As drillings seem to show two workable coals below the one worked at the Lundy shaft, it is suggested that that surface bed is probably the equivalent of the rider Block coal or Minshall coal. West of its area of outcrop, to the center of Township 6 West, shallow wells should catch the thin coals between Coal III and the Minshall coal. Near the Lundy shaft the distance from the Minshall coal to the Upper Block coal ranges from 11 to 41 feet, and from the Upper to the Lower Block coal from 23 to 42 feet.

The block coals outcrop in the river bluffs west of White River. As a rule only one coal was found at any point, so that the relations of the two coals that were assumed to be present could not be definitely made out. East of White River the Lower Block coal is caught by the hill tops, and in the southwestern corner of the county the general rise of the land away from the river just makes up for the rise of the coal, so that the hilltops are made up of the rocks above the Lower Block coal almost as far east as Owensboro. Below the Lower Block coal is the massive sandstone correlated as the Mansfield, and below that one or two thin, not workable, coals. Still below the latter, and usually not far distant, are found outcrops of the Lower Carboniferous limestones with their characteristic Pentremites.

In Daviess and Martin counties there is a long break between the coals west of White River and the coals in the eastern part of the county, except in the latitude of the B. & O. S-W. R. R. The river bottoms produce broad praries, broken only by sand hills through a wide belt on either side of the river. At Washington hills set in carrying Coal V almost to the east side of Range 7 West. Around Washington the dips are quite diverse. South of town the dip is to the southeast as far as the old Sulphur Spring mine, where Coal V is at an elevation of 467 feet above tide. Going northeastward, the coal rises at a rate of nearly 40 feet per mile, and at the Price drift east of town, near the railroad, it is 71 feet higher than at the Sulphur Spring mine, and at the old Raymond slope 91 feet higher, or at an elevation of 558 feet above tide. Ninety feet below the coal at Washington is a coal overlain with black shale and correlated as Coal IVa. At the Raymond drift this thin bed would have an elevation of about 468 feet. Were the same rise to continue to the east it would have an elevation of about 668 feet at Montgomery. A study of all the facts has led to the conclusion that instead the dip decreases or is reversed going eastward, and that this same thin coal outcrops in the railroad cut just west of the depot at Montgomery at about 510 feet. At the old

No. 1 mine just west of Montgomery it is found at an elevation of 484 feet or lower. Mining on the underlying coal has demonstrated that from the No. 4 mine near Black Oak switch, 2 miles west of the No. 1 mine, there is an eastward dip of 15 feet, and drillings suggest that this condition continues to the westward, so that the first two coals at Montgomery will tie into the first two coals below Coal V at Washington, though the evidence is not conclusive.

Where a large area has a broad monoclinal structure it is generally the rule that a flattening or reversal of this structure is followed in adjoining areas by steep dips that in some measure even up the general dip. So at Montgomery we have visible evidence of a rapid rise to the east, succeeding a long flat bench west of town, which brings up to daylight the rider coal (Coal IVa) near the depot. About 30 feet under this rider coal is the worked coal at Montgomery, which is, in accordance with the facts just given, thought to be the representative of Coal IV. It will be called here the Montgomery coal. It is believed that the rapid rise observable near the depot will bring this coal to the surface a short distance east of Montgomery, and that the surface coal at Cannelburg is a lower coal, possibly corresponding to Coal III. It will be called the Star coal, from having been mined at the Star mine, just east of the Mutual mine, southeast of Cannelburg. Its relation to the Montgomery coal is not clearly established. It was formerly thought to be the same as the Montgomery coal. To make it such, however, would require another bench in the structure or a low dip to the east between Montgomery and Cannelburg, which supposition is opposed by the apparent dips a short distance to the north and south.

About 60 feet below the surface bed at Cannelburg is the Cannelburg Cannel coal. On the basis of the correlation already made this is assumed to be in about the same position as the Minshall coal of the northern counties, and possibly to be the representative of that coal. Drillings have shown two or three beds between the Cannel bed and the surface bed. It is suggested that the Cannel coal is the equivalent of the black shale ordinarily found overlying the Minshall coal, which in this area accumulated as a fairly pure carboniferous deposit, analyses showing as high as 23 per cent of ash. What is supposed to be the same coal is seen in the cut of the Indiana Southern Railroad near Burns City, where the Cannel coal can be seen grading up into a gray shale. East of Cannelton little is known of the coals, but it is believed that the rise to the east would make this coal possibly the equivalent of the surface bed at Loogootee. It is also believed that this coal may be the equivalent of the coal on Sugar Creek, overlain by black shale and limestone. Below this in the shaft at Alfredsville are found three coals that are believed to be about the equivalent of the Block coals of Clay County. This shaft coal at Alfredsville is again correlated with the workable coal in the ridge between Boggs Creek and Indian Creek in northern Martin County, and in Sampson Hill southeast of Shoals. It is called the Sampson Hill coal. In Martin County below that coal is a massive sandstone outcropping, notably around Shoals, and making the "Jug Rock" and the "Pinnacle," where it is over 100 feet thick. Below this sandstone is a coal that reaches a workable thickness near Shoals, and may be called the Shoals coal. Outcrops of the Lower Carboniferous limestone, full of its typical fossils, are found from 6 to 20 feet below this coal at Shoals.

North of the B. & O. S-W. R. R. it is assumed that the coal mined around Epsom is the equivalent of the Montgomery coal; that the coal mined in the branch halfway between Epsom and Raglesville is the equivalent of the Star coal, being the surface coal met with in wells all along the western edge of Range 5 West. The Raglesville coal is thought to correspond to the Cannelburg coal. Two coals at different levels around Bramble P. O., in northwestern Martin County, are correlated with the Block coals, and with the coals in the ridge east of Boggs Creek, in the hills southwest and southeast of Shoals, at Rusk P. O., and the hills southeast of that, extending into Orange County.

In southern Daviess and northern Pike and Dubois counties the exposures in the river hills indicate correlations as follows: It is now assumed that the coal at the Carlisle bank, northwest of High Rock, is Coal V instead of Coal IV, as has previously been thought. Seventy-five feet below it, in the river, is the limestone over Coal IVa. The rise to the east brings this up so that the underlying Coal IV outcrops above drainage east of High Bank and north of Long Branch P. O.; also on the Daviess County side just at drainage on the stream a mile west of Hudsonville. At Hudsonville the rise brings this coal well up into the hills. Stratigraphically below this a few feet, and assumed to make the "Rock Eddy" west of Hudsonville, appears a chert and limestone believed to come over Coal IIIa. This chert and limestone appear in force on the west bank of Mud Creek east of Hudsonville and southeast of Glendale. Some 15 feet below it in the latter locality is a split coal bed. East of

Hudsonville it can be seen to overlie a massive coarse-grained sandstone which appears in the east bank, and which is recognized as of the same character as the sandstone of High Rock. Though not seen in this district, it is believed that the horizon of the thin coal belongs close under the flint, while the split bed referred to belongs a few feet lower, the latter possibly being the equivalent of Coal III, and the former, as stated, of Coal IIIa.

The chert and the two underlying coals are found in the top of the ridge over the High Rock, which at that point is a massive sandstone 65 feet thick. Below the High Rock and in the valley of Sugar Creek, some four coals have been found. The uppermost of these underlies a black shale and limestone and chert. As previously stated, as a long range correlation it seems to occupy the position of the Cannelburg coal, or possibly of the Minshall coal. This coal has not been recognized east of Sugar Creek in Daviess and Martin counties, but in Dubois County it has been mined at many points just south of the river from Beach Creek, where it has an elevation of 430 feet, eastward past Portersville and Haysville, until it is in the crest of the ridge around Kellersville at an elevation of about 650 feet. It may be designated the Haysville coal in that region. The underlying coals come to outcrop and have been opened in a few places around Mount Pleasant, Whitfield P. O. and west of White River.

Coal V outcrops in the top of a high ridge south of Survant in east-central Pike County. One hundred feet lower, beside the railroad at Survant, is the outcrop of Coal IV, or the Survant coal, as it was called in the Ditney folio. Above it at other points in this district is found a thin bed overlain with black shale and limestone that corresponds with Coal IVa. In the Ditney folio it was called the Houchin Creek bed. At Velpen the Survant coal is the surface bed. About 20 feet below it is the 18-inch bed overlain by black sheety shale and limestone, known as the Velpen coal. Just east of Velpen there is a coal at this level overlain with black shale. A few yards to the east another coal can be seen coming down over the first coal, until the interval between the two coals consists only of 6 inches of clay and ½ inch of black shale. These coals are about 20 feet higher than the Velpen coal just west of Velpen, or in about the position the Velpen coal would have with the normal rise. At several points within 3 miles to the south there occurs at practically the same elevation two coals, or a double coal, usually showing 1 foot of clay between the two benches. In the 1898 report it was assumed that the Survant coal had come down to the Velpen coal, and that the double coal found at many points southeast of Velpen represented the two beds, in that report called coals IV and IIIb. This view seemed to be greatly strengthened by the fact that at one of these points near the center of Section 22, in Township 2 South, Range 6 West, the two coals are 4½ feet apart, and between them comes a bed of limestone 7 inches thick; and many other facts could be cited along the same line.

In the Ditney folio a different view was taken. The Velpen coal is typically exposed at Pikeville. In the hills south of the bridge north of Pikeville supposedly this same coal is exposed, underlain by a thick, massive sandstone reaching down to river level. As no coal appeared within a few feet between the Velpen coal and the top of the sandstone, it was assumed that the next coal below the Velpen coal must underlie the sandstone. Southeast of Pikeville the split or double bed already referred to occurs high in the hills overlying a large thickness of sandstone, but high dips to the northwest show at several points, and such a dip was assumed as would carry this coal below the sandstone underneath the Velpen coal at the bridge, since no such coal as this appeared in the clearly exposed section at that point. On this assumption this split coal must underlie the Velpen coal by at least 80 feet. While many points appear to sustain that position, a review of the facts in the office, in the light of what was seen near Hudsonville the past summer, has led the writer to the belief that this split bed, called the Rock Creek coal in the Ditney folio, comes not very far from the horizon of the Velpen bed, and that the thick sandstone under it is the same as the sandstone which outcrops below the Velpen bed at the Jonesboro bridge, and possibly the same as the massive sandstone at High Rock in Daviess County. Just what its relation is to that bed is uncertain. Near Selvin an 18-inch coal, correlated as the Velpen coal, is underlain at a distance of only 6 feet by a 3-foot bed, and the writer is inclined to consider this Rock Creek coal as the equivalent of the 3-foot bed of Pokeberry Creek, northeast of Selvin, and the same as the coal in the bed of Mud Creek beside the road southeast of Glendale in Daviess County, and again, the representative of Coal III, and tentatively he has so treated it. The facts, of which one or two cases have been given, tending to show that this split bed is only the Velpen and Survant coals brought close together, make it desirable to withhold definite decision until the field can be further examined.

Below the massive sandstone in the banks of Rock Creek and the adjacent part of Patoka River is found a limestone and a coal.

This limestone and coal are found to be the same as those outcropping around Holland, from which point it has been called the Holland coal. From its stratigraphic position as determined in the way just stated, and from the fact that this coal is frequently of a workable thickness, they are believed to occupy the position of the coal and limestone around Haysville and on Sugar Creek in Daviess County, and possibly to be the equivalent of the coal and limestone at Minshall.

East of Holland, as described in a previous paragraph, a coal overlain with a limestone is found at a point 3 or more miles east of Ferdinand. While not conclusive, the evidence points to this being a lower limestone and coal than the Holland coal. Two miles southeast of Ferdinand this limestone has an elevation of about 590 feet above tide. Two miles farther southeast, and at an elevation of 420 feet, is an outcrop of a 4-foot coal bed that is thought to be the same as the coal long mined at Cannelton, and therefore called the Cannelton coal. Whether this difference of elevation can be relied upon as giving a measure of the interval between the two coals is doubtful, but as they are about in the strike from each other, and as this point offers a good opportunity for the measurement of this particular interval, this difference of elevation of 170 feet has been assumed to be the correct interval. Unfortunately, the question of whether this limestone east of Ferdinand is the limestone over the Holland coal or a lower limestone, leaves an uncertainty in the relation of the Cannelton coal to the Holland and higher coals. That one or more limestones occur below the limestone over the Holland coal seems certain from a study of the elevations at which limestones occur southeast of Dale, Buffaloville and Newtonville, but the possibility is suggested that these lower limestones may be the equivalents of the limestones found at Troy at 100 feet and at 74 feet above the Cannelton coal. On the whole, the writer is inclined to assume those to be still lower limestones.

Further evidence on the relation of the Cannelton coal to the Holland coal is gotten from the relative positions of the coal and limestone in the south part of Spencer County. In the southeast corner of Spencer County the Cannelton coal is practically at low-water level in the Ohio River. It is reported to outcrop in section 12, northeast of Maxville in the bed of Anderson River, or at an elevation, according to the topographic map, of about 360 feet. The hill northeast, or nearly north of Maxville, by the map has an elevation of 580 feet. A limestone is reported to come about 20 feet below the top of the hill, or at about 560 feet, approximately 200 feet above the Cannelton coal. In a hill west of Maxville, in Section 9, occurs a limestone which may be the same limestone, but here it has an elevation of below 500 feet. Still farther west, in section 19 of the same township, is a limestone at 440 feet. In section 24 of Township 6 South, Range 5 West, presumably the same limestone is at 420 feet. Near Big Sandy Creek in Section 27 of the same township is a shaft going down to a coal of workable thickness, which is overlain by a black sheety shale, no mention being made of a limestone. This coal has an elevation of 380 feet. The presence of the black sheety shale suggests that it may be normally overlain with a limestone, and that this limestone may be the same that has been mentioned outcropping at several points between this place and Anderson River. Forty feet above the coal in the shaft, and not far above Big Sandy Creek, is an outcrop of limestone at about 420 feet. Two and one-half miles to the north the limestone over the Holland coal outcrops at about 460 feet. Notwithstanding this difference of elevation, it has been thought possible that this limestone above the creek level at about 420 feet is the same as the limestone over the Holland coal. In that case the limestone which outcrops in the hilltops around Maxville lies 40 feet below the limestone over the Holland coal, and the Cannelton coal about 170 to 200 feet still lower, say 180 feet. That would make the Cannelton coal about 220 feet below the Holland coal. With the figures now in hand that seems to be the nearest that can be gotten as to the interval between the two. It must be admitted that many difficulties are met with in attempting to apply this to the maps. Thus, for example, northwest of Maxville a coal is worked apparently a short distance below the limestone in the top of the hill that Mr. Price speaks of as the same as the coal in the top of the hill at Troy, but according to the section which he gives, which corroborates Mr. Kindle's section at the same point, the top of the hill is only a little over 100 feet above the Cannelton coal, and therefore not high enough to catch the coal near the top of the hill northeast of Maxville. The section in question was not run with barometer, and the intervals and thickness of the sandstones and other rocks may therefore be much underestimated. In that case the limestone near the top of the section would correspond with the limestone in the top of the hill at Maxville. Assuming Mr. Price's and Mr. Kindle's section at Troy to be correct, the 14-foot sandy limestone near the top of their sections has an elevation of about 455 feet, while, as previously stated, the limestone in the top of the hill near Maxville has an elevation of about 560 feet. The assumption has therefore been made on the stratigraphic plate that the limestone at the top of the section at Troy lies below the limestone in the top of the hill northeast of Maxville. Mr. Cox's section at Troy made the limestone nearly 300 feet above the coal, so that while this interpretation is given to it, it is suspected that an accurate measurement might show the limestone at the top of the section at Troy to correspond to the limestone at the top of the hill near Maxville.

In the attempt to actually trace the several coals from point to point considerable difficulty has been met with. Coal IV or the Survant coal has been traced with some degree of confidence from Survant and Velpen southward, where it is usually found only within 2 or 3 miles to the east of the crop of Coal V, as shown in detail in the Velpen folio. The rocks surrounding Coal V appear to have been of such a nature as to have protected the hills, so that the eastern outcrop of Coal V in Pike and Warrick counties is frequently in the crest of a high hill, near the foot of which outcrops Coal IV. In some cases outcrops of Coal IV are found in the valleys to the west of the easternmost outcrop of Coal V, and the dip appears to carry the former over the hills to the eastward within a short distance, as stated. The difficulties in determining the exact stratigraphic position of the Rock Creek coal have been stated, and these, added to the scarcity of outcrops of that coal, render its tracing very uncertain. The Holland coal fares much better on account of its workability at many points. It can be quite clearly traced from Holland southwestward past Dale, to Lincoln City, to west of Buffaloville, and to west and south of Newtonville. Around Duff, Huntingburg and Jasper the correlation of the limestones, and necessarily of the coals, has been in doubt. At Huntingburg a limestone outcrops in the road about on a level with the town. Chert covers the top of Standpipe Hill to the west, the two limestones being from 60 to 70 feet apart. It is uncertain, however, whether the chert on the hill belongs at the horizon of the Velpen coal or the Holland coal. This region is outside of that covered by the topographic maps of the U. S. Geological Survey, and elevations are dependent on barometric readings from railroad elevations.

CHAPTER IV.

THE COAL BEDS.

Number of Coal Beds.—In Fig. 1 are given the coal beds occurring in Indiana, showing their relation, position, their distance apart, and their average thickness. The sections in Plate II give an idea how constant the coals are in their occurrence, their distance apart, and their thickness From the figure it will be seen that there are at least 25 distinct coal beds in the State. Nearly all of these reach a thickness of 2 feet or more in some places. Nine of them are persistently minable over considerable areas, though only one, Coal V, appears to be persistently minable over nearly the whole area within which it outcrops. The upper five of these nine beds are of the caking or "bituminous" variety, occurring as broad sheets. The lower four coals occur in basins, and while of good minable thickness in the basin, are not workable over much of the field. Of the minor coals, several local beds reach a workable thickness, and in the distant future may add to the State's output. In addition to the coals shown, most of which are fairly regular, coal is occasionally found at still other horizons, so that, all told, coal is found to occur at at least thirty-four horizons.

Thickness of Coal Beds.—From the figures given on Plate III it is evident that the "bituminous" coals being mined average in the mines from 4 to 6 feet thick. Coals III, V and VI reach an average of 6 feet over large areas. Coals IV and VII will run from 3½ to 4 feet, though the former maintains a thickness around 5 feet over a large area in the Linton district. The block coals of the Brazil groups average about 3 feet in the mines, frequently reaching four feet, and occasionally 5 feet in the middle of the basins, and thinning to a few inches on the edges. Taking these beds as a whole, they will probably average well under 2 feet. As already stated, coals III and VI, while very thick over large areas, are entirely lacking over other large areas.

Extent of Coal Beds in Indiana.—The coal measure rocks of the Carboniferous period have always been recognized as possibly the extreme expression of variations in physical surface conditions both horizontally and vertically. Thus, as contrasted with most rock formations, where a single rock ledge may have a thickness of hundreds of thousands of feet and cover thousands of square miles,

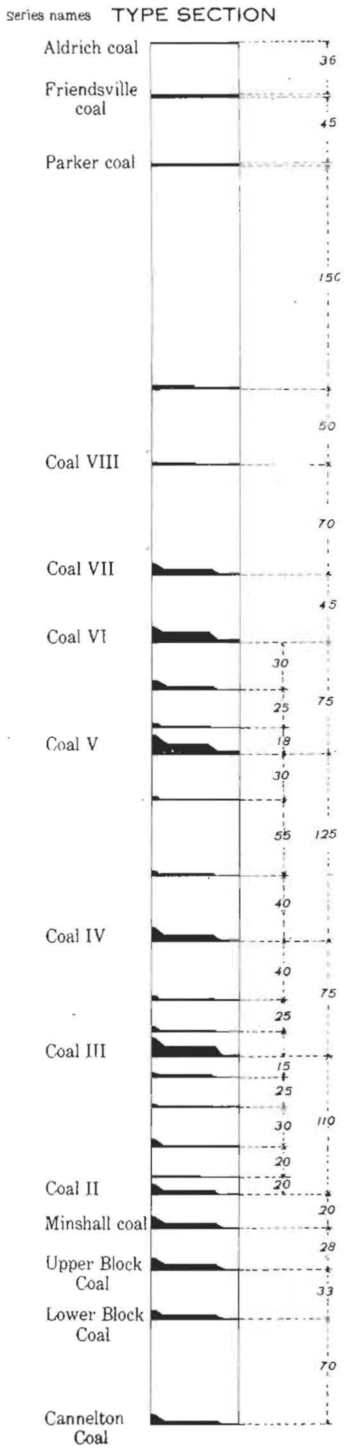

series names
TYPE SECTION
Aldrich coal
Friendsville coal
Parker coal
Coal VIII
Coal VII
Coal VI
Coal V
Coal IV
Coal III
Coal II
Minshall coal
Upper Block Coal
Lower Block Coal
Cannelton Coal
36
45
150
50
70
45
30
75
25
18
30
55
125
40
40
75
25
15
25
110
30
20
20
20
28
33
70

FIG. 1.

with great uniformity, it is not uncommon to find in a vertical space of 100 feet in the coal measures five or six coal beds, as many clay beds underlying each of them, possibly several thin beds of limestone, and a score or more of distinct beds of shale and sandstone. So, too, the tendency of massive sandstone to grade over into shales, and vice versa, in a horizontal space of a few yards, is well known to every one at all acquainted with the coal fields. And yet through all of this, seeming and real, variation there runs a remarkable horizontal persistency. The writer's assumption in the 1898 report that certain coal beds of the Indiana field could be traced the entire length of that field has been strongly questioned by many outside geologists. An examination of the abundant drill records copied last summer not only confirms the writer's previous ideas in that line, but shows a greater regularity than he had suspected. While in certain cases the thinning away of coals is confirmed, in other cases it appears that the assumption that certain coals changed in going from one region to another was the result of incorrect correlations, and that when correctly tied together the coal beds in question maintain the same character from one area to the other. Recent work in Illinois and Kentucky, taken in conjunction with the work in Indiana, suggests, for example, that Coal V may be found to have been deposited as a fairly uniform sheet of coal over most or all of the area within its outcrop, or over an area of 25,000 square miles or more. What this means is better realized when it is remembered that the great Pittsburg coal bed, about the persistency of which so much has been said, probably covers less than 6,000 square miles. More than that, many of the accompanying rock members are but little, if any, less persistent. Thus, through Indiana Coal V has nearly everywhere above it a limestone. In the Ohio River district this limestone is usually wanting, but in its place occurs a calcareous clay, full of the same fossils as occur in the limestone to the north, and which is there known by the miners as the "pennywinkle" (periwinkle) rock, referring to the gasteropods found in it. So, too, of the black shale that occurs between the coal and the limestone, with its iron sulphide concretions (hard heads) that commonly project down into the coal. Even more remarkable is the persistence of thin bands of clay or shale in the coal bed itself; often such a band, with a thickness of ¼ inch, can be traced over hundreds of square miles. Even in the block coal field of Clay County, where the coals occur in hundreds of small basins, the coal thinning out between the basins to a mere film of a few inches, there is still a constant repetition of the same characters in the benches and partings from basin to basin. On a small scale it is as where an old cornfield in the spring has been dotted over with pools of water. The water of any one pool is of variable depth and irregular extent, yet all exist at the same time, under the same atmospheric conditions at least. The coal measures developed, therefore, under two sets of conditions, the one tending to produce widespread horizontal uniformity, while the other tended to produce horizontal irregularity. What these conditions were, it is not necessary to discuss here.

The study of the stratigraphy shows a slight, though not uniform gain in ascending through the series for the forces making toward uniformity. It is not entirely certain that the seeming lack of uniformity in the lower coals and associated rocks is not due to our lack of data. The lower coals are certainly more irregular in thickness than the upper coals, due to their occurrence in basins, but when we have considerable knowledge of the coals in the basins, the persistency is found to exist, as previously noted. Naturally the section of the coal where fully developed in the center of the basin differs greatly from the section of the same coal on the edge of the same basin, or even part way up the side of the same basin. Obviously, then, under the conditions that existed throughout the eastern edge of the field south of Clay County, where data are confined to scattered outcrops or small country banks a few square yards in extent, cutting the coal at various points in the basin between its center and its edge, the same coal presents a great variety of aspects at its different exposures, and as the exposures are usually widely scattered, often several miles apart, and as the rocks accompanying the coals often differ between the center and edge of the basin, and as the interval to other coals varies much in the same way, the correlation and tracing of coals in that region becomes a matter of much uncertainty.

In general it seems to be true that the coals are much more persistent than any of the other rocks, unless it be the clays which underlie the upper coals. With the lower coals the clay, which may exist in the center of the basin under the coal, may run out over the "hill" or divide from one basin to another; but with the upper coals it is often true the clay will persist when it is known that the coal has run out. That this clay under a given coal represents a definite deposit or accumulation, is often evident from its chemical or physical characters or from the contained fossils. Thus, David White has thought that in the clay under the Minshall coal at the Chicago Clay Company's plant at Brazil, he had found the same clay that is extensively worked along the Mississippi River, on the west side of the Illinois field all the way from Rock Island to St. Louis.

While it is true that some of the coals, as Coal V, are remarkably persistent within the field of our knowledge, the evidence is equally clear that other coals of large local thickness, as coals VI and III, certainly die out and are absent over large areas. In some cases this disappearance seems to be complete over a large area, as in the case of Coal VI around Terre Haute and to the north; in other cases, as with Coal III north of Coxville, the coal though generally absent over large areas, may frequently be found in local pockets of very limited extent, reaching about or quite the old thickness. While in some cases these coals, where lacking in this way, may have been eroded before the deposition of the succeeding rocks, in most cases they appear not to have been deposited. The breaking down from the area of large thickness to that in which it is absent is apt to be gradual, and the coal shows much irregularity over the broad belt between the two areas. While it appears to be generally true that the thick coal beds are the more persistent, this is not always true. Thus, Coal IIIa can be traced continuously northward through Clay and Vigo counties, overlying by but a short distance Coal III, which there has a thickness of from 5 to 8 feet. North of Coxville Coal VI becomes irregular and dies out, but close above it continues Coal IIIa, the coal being seen in every case where its horizon is exposed. In the shales above it occur two limestone layers, often so ferruginous as to be more nearly an iron ore layer. These layers, though only 3 or 4 inches thick, can be traced all through southern Parke County and eastern Vermillion County. Next to the coals and the under-coals the limestones are the most persistent rocks of the coal measures. As previously stated, the shales and sandstones replace each other within very short horizontal distances. In some cases this is due to a grading of one into the other; in other cases there is evidently an old surface between the two. In such cases the shale, usually underlying and having been eroded, has been superimposed by sandstone.

The Coal Chart.—On Pl. III is given a comprehensive view of the workable coal beds of the State. It should be noted that the measurements as they are given can not in all cases be taken as average measurements. This is more nearly true of the upper coals than of the lower coals. Most of the measurements given have been made in mines by members of the survey. It should be remembered, however, that in a large number of cases the mines have been located as the result of drilling, which has often been very extensive, and have been located usually in the center of basins where the coal is the thickest. This becomes very apparent to any one reading the old report in comparing the sections given in Clay County, for example, with those given in Dubois and Spencer counties. In the latter two counties there are very few commercial mines, and the relatively small number of country banks, measurements made along road sections, and elsewhere, show a great number of coals with a thickness of anywhere from 2 inches to 8 or 10 inches. The first impression gained might be that the coals of that region were very much thinner than the coals of Clay County. Granting that there may be some advantage on the side of Clay County coals, the probability is that the advantage is nothing like as great as would be indicated by those sections, for the major part of the sections in Clay County are taken from mine and shaft sections in the center of the basins, which have been pretty accurately located by preliminary drillings. Again, in the case, for example, of the Lower Block coal, the figures drawn on Pl. III have usually taken the coal near the center of the basin in order to include the underlying bone coal and its accompanying bed of good coal, for the sake of their stratigraphic value. Had there been no mining in Clay County and had the amount of drilling been only a small fraction of what it actually is, we might have gotten somewhat the same idea of the thicknesses of the coals as we now have of the coals of Dubois and Spencer counties, for the examination of a large number of those drillings shows many cases where the coals known to be of good workable thickness a short distance away have a thickness of only a few inches, evidently the drilling having gone through that coal on the broad divides between the separate basins. It may be that in Dubois and Spencer counties the basins are more restricted and the divides between them where the coal is very thin may be broader. In the plate mentioned the number of sections given is so few that naturally selection has been made from the measurements made in coal openings where the coal showed the highest thickness, on the assumption that future development will probably show scattered basins in the center of which the coals will have the thickness given, the measurements given in all cases being actually made by members of the Survey. In the case of the upper coals, which do not lie in restricted basins, with a marked difference in thickness in each mine, the measurements given as a rule are an average of the mine in which they are taken. There are many places at which the smaller coals coming between these principal coals that are figured, reach a thickness of 3 feet, or occasionally even a greater thickness, but these unusual thicknesses are probably in very limited basins, and for the general purposes of this report have not been figured. In the description of the different coals the section of Sullivan County, western Greene, and southern Clay County, will be taken as the type locality of the coals described from that location northward and then southward.

Coal VII.—Coal VII in Sullivan County is usually of a workable thickness, varying from 3 feet up to 6 feet. It has been little mined as it tends to have a ''rolly'' roof, which cuts the coal down quite seriously, so that a mine which may show 6 feet of coal in many places, may not average over 3 feet. As the rolls are often of sandstone the driving of entries is rendered difficult, and this fact probably more than any other, in view of the easier working of the lower coals, has led to its being passed by in commercial operations. The coal is usually described as a somewhat soft coal for shipping, but a coal very free from sulphur. In this county it is almost always a solid coal. Stratigraphically it is usually characterized by the presence of a limestone which may run from 2 or 3 up to 10 feet or more in thickness lying but a few feet below it, sometimes coming immediately below the fire clay, and in other cases separated from the fire clay by only a few feet of clay or sandstone. The roof of the coal is either shale or sandstone. One characteristic of the roof where sandstone is the occurrence of stringers of coal which rise from the top of the coal bed over a lens of the sandstone roof and form a line of separation which tends to allow the dropping of that sandstone lens, to that extent making it a dangerous roof. The coal shows probably a little thickening from the south end of the county toward the north, some of the thickest sections being measured along the north edge of the county near Busseron Creek and around Farmersburg. The coal has been mined commercially around Farmersburg partly because of its good quality and thickness and partly because Coal VI at this point has proven to be very irregular and tending to run out. From the north line of Sullivan County to Terre Haute there are only a few openings upon what is considered to be this coal. It was probably this coal that was mined at Pimento and that outcrops on Honey Creek near the northeast corner of Linton township and the southeast corner of Honey Creek township. It has been extensively mined west of Terre Haute, where it occurs about at river level, having been mined by shafts in the bluffs from a point southwest of Terre Haute to St. Marys mine, about 3 miles northwest of West Terre Haute. Near the north edge of Sugar Creek township it rises to the level of the bottoms, where it has been stripped west of the river road. It outcrops frequently along Coal Creek and again on Brouiletts Creek in southwestern Vermillion County. The coal shows quite a change from the outcrops in northern Sullivan County or on Honey Creek in going to West Terre Haute. From West Terre Haute northward to where the coal leaves the State in southwestern Vermillion County, it tends to show a solid bed from 4 to 5 feet in thickness, overlain by from 1 to 2 feet of bone coal, which consists of thin layers of coal in black shale. The coal still has under it a limestone similar to that occurring in Sullivan County, though in this region it nearly always underlies the fire clay. In most of the openings the bone coal makes the roof. Over the bone coal is usually a considerable body of shale very suitable for the manufacture of clay products. Similar shale appears over the coal on Honey Creek. This coal around West Terre Haute has been called by the mine operators Coal VI, on account of its being the first coal of any consequence above Coal V. Under the head of "Stratigraphy" the evidence has been given which leads the writer to consider that Coal VI has run out in this region, and that this coal is the equivalent of Coal VII of Sullivan County. Returning to Sullivan County and tracing the coal to the southward, it can be clearly traced into Knox County and for several miles south of Bicknell. In this region it shows a thickness of from 1 foot to 5 feet. Many sections show it overlain by a large thickness of sandstone, often as high as 80 feet or more, the sandstone in some cases coming down onto the coal, in others being separated by a small thickness of shale. The limestone underlying the coal in this region is less persistent, but appears sporadically in many of the drillings and shaft sections. The coal is a solid coal, as in Sullivan County, and there can be little question of its identity in this region. Passing southward from Bicknell to Wheatland a condition is found somewhat similar to that met with in going northward from the north edge of Sullivan County to West Terre Haute. At Wheatland Coal V is found, with its characteristic roof, while above it there is no coal of importance for a distance of 130 feet, or the interval at which the No. VII coal occurs in Sullivan County and to the northward, and also in the drillings southward from Bicknell. Around Wheatland, however, the coal instead of being solid, as it is to the northward, shows a strip of bony coal near the bottom, a point of resemblance to the No. VI coal at Bicknell and to the north. This fact and the fact that there is no coal below it of importance corresponding to the No. VI, has led to some question as to whether the coal formerly worked at Wheatland and still being worked from outcrop from the river bluff to the northeast is not the Coal VI rather than Coal VII. Above this coal there is usually a sandstone, and some of the drillings and mines around Wheatland give a thickness of up to 80 feet, a point of resemblance to the conditions existing around Bicknell. At the exposure on the river bank northeast of Wheatland, at a distance of 24 feet below the coal being worked at one point is a coal which is thought might occupy the position of Coal VI. At one point it shows a thickness of about 2 feet, but thins out to 0 at a distance of 100 feet to the north. From Wheatland to the east fork of White River at the south line of the county apparently only one coal has been met with above the position of Coal V. This shows a thickness of 5 feet at Monroe City, and of 4 feet along Pond Creek. It apparently corresponds with the upper coal at Sand Hill, across the river in Pike County. From that point southward coal ranging from 4 to 5 feet in thickness is met with west of the old canal, the coal usually being solid, but southwest of Rumble showing a section similar to that at Wheatland in that there is a bottom bench a few inches thick of good coal, then a bench of bony. This coal shows a limestone below it at several places, such limestone seeming to correlate with the limestone below Coal VII in Sullivan County. In the central part of Gibson County drillings and mining show the existence of two coals above Coal V, of which the lower is more frequently the thicker coal. These coals will run from 15 to 20 feet apart. A somewhat similar condition seems to exist at Vincennes, where there are two coals in about the position of VI and VII, ranging from 13 to 18 feet apart. The upper coal there has been mined and shows characteristics of roof and of coal similar to the Coal VII in Sullivan County. The lower coal does not markedly resemble Coal VI in Sullivan County, but has been assumed to belong at that horizon. The lower coal in central Gibson County in like manner has no special resemblance to the coal called Coal VI in Sullivan County, but appears to come at that stratigraphic position. The upper coal is variable in thickness, ranging from 4 feet downward. In a mine west of Oakland it can be seen to thin out entirely in a mine. At Dongola it shows as two benches, separated by 12 inches of clay. Passing southward into Warrick County, Coal VII appears to continue as a bed, with an average of about 3 feet, becoming thinner south of Chandler, and at Newburg having a thickness of only 18 inches. Through this district there lies but a short distance below it another coal bed ranging from 1 foot to 3 feet in thickness. In some cases this lower bed is 6 or 8 feet or more below the 3-foot bed assumed to be Coal VII. In other cases the lower bed comes close up to the upper bed, the two being separated by only a few inches of shale or clay. This condition is first met with in southern Gibson County in some drillings near Somerville, in which the two coals are less than 4 feet apart. A comparison with drillings in the neighborhood would seem to indicate that the lower coal was the coal being worked at Fort Branch and Francisco, where it is assumed to be Coal VI. At Lynnville the two coals range from 6 feet to as many inches apart. At Buckskin the two coals are reported in the Buckskin mine to be about 3 feet apart, the interval being largely bony coal, the upper bench having a thickness of 41 inches, and the lower bench having a thickness of from 2 feet to 3 feet. In Greer Township the two coals come together, making what appears to be a single bed, including 6 feet of coal in two benches, separated by 4 or 5 inches of shale. Around Millersburg and southward nearly to Chandler the upper coal has a thickness of about 3 feet, usually divided into three benches, and usually underlain by a limestone. In some cases the limestone lies immediately below the coal, and in others it is separated by a little shale or clay, or both. In several sections below the limestone is noted, or was reported, a coal bed from 2 to 3 feet in thickness. Apparently this is the same coal that is being mined at Fort Branch, or Coal VI. In the south part of the county and around Evansville the lower coal bed appears to have run out. The upper bed, Coal VII, ranges from a foot to 3 feet in thickness. In southern Warrick County and around Evansville the limestone which underlies this bed, coming usually close below the fire clay, is quite prominent, frequently having a thickness of 9 or 10 feet, as shown in outcrop just east of Newburg.

In 1907 the writer, with Mr. Frank W. DeWolf, of the Illinois Survey, visited a number of mines in western Kentucky in the hope of obtaining data which would help to tie the coal measures of southern Indiana across to those of southern Illinois. The evidence that the coal long worked at the People's mine at Henderson was the same as Coal V seemed to be conclusive. At many points about 100 feet or more above Coal V was found a limestone that appeared to correspond with the limestone underlying Coal VII in Indiana. Above and below this limestone at a number of points were found coals, sometimes thin and sometimes of a good workable thickness. This limestone and accompanying coals was noted at a large number of mines in the Henderson district from Henderson eastward as far as Owensboro. In that district, however, the coals around the limestone appeared to be thin. Going westward from Henderson, however, at Corydon the coal above the limestone has a thickness of over 6 feet, the coal below the limestone being in two benches and thin. At Waverly the coal below the limestone is the thicker, the coal above the limestone being in two benches and thin. At Morganfield, again, it is the coal below the limestone that is thick, the coal above being thin. In the Madisonville field it appeared in some cases to be the coal above the limestone that was thick, in others the coal below the limestone. In the Reinecke mine, west of Madisonville, the two coals are reported to be from 3 feet to 38 feet apart. The upper coal has a thickness of 4 feet 2 inches; the lower coal has a thickness of 6 feet at the eastward, where it occurs under the limestone, and of from 6½ to 8 feet on the west side of the mine, where the roof is shale. Similar conditions are given in the reports of the Geological Survey of Kentucky for Ohio and other counties. In that State the lower of these two coals has been designated Coal 11, and the upper Coal 12. If our correlation is correct, it would therefore appear that Coal 12 of Kentucky is the equivalent of Coal VII of Indiana, and that Coal 11 of Kentucky is the equivalent of Coal VI of Indiana.

Coal VI.—In Sullivan County Coal VI has a thickness of from 6 to 8 feet, and holds this thickness with great uniformity. Of this amount there is commonly a bottom bench of from 10 to 14 inches that is bony and usually left for a floor in the commercial mines, reducing by that much the thickness of commercial coal. This coal in this county gives a most remarkable example of the persistence of thin partings and of the coal benches in character and thickness. In nearly every mine in the county two thin light-gray partings appear on the middle of the entries from 4 to 6 inches apart, so that any one taken into a mine on this coal blindfolded could recognize the bed the moment the blindfold was taken from his eyes. These partings are of shale and usually range about one-half inch in thickness. They make it necessary to do a good deal of hand picking in order to make the coal as shipped to market clean. Most of this shale can be gotten out in mining the coal, as it separates readily from the coal benches. Frequently, however, it is necessary that the coal be picked over as it is screened in order to fully eliminate this shale. The roof is usually a shale, overlain at a small interval by a sandstone. The sandstone appears to come nearer the coal at the north than in the central part of the county, where the shale may have a thickness of 15 to 20 feet. This shale makes a poor roof, especially in warm weather, and this fact has tended to discourage mining on this bed probably more than any other. It is hoped that some day experiments may be carried on which may suggest a manner of treatment which will render this roof more stable and will greatly facilitate mining on this bed.

Though involving greater intitial cost, it is probable that the following plan might result in a large economy in the total cost of operating a mine on this coal bed: this is, to drive entries to the boundaries of the property, leaving the top bench of coal for a roof, and taking up enough bottom to give headway, and then to mine the coal back toward the shaft, taking the coal clean as mining retreated, either by a modification of the common room and pillar method, or a regular long wall system, or some combination of the two, such as is being used so successfully in many fields.

At the north edge of Sullivan County, around Farmersburg, this bed becomes very irregular, some of the drillings there failing to find it at all, while several attempts to mine it have had to be abandoned, as the coal would run out or would run down to a few inches in many of the entries. Apparently this coal has not been found at all northward from this point, though it is probable that some workable coal at this horizon will be found to exist in southern Vigo County, as it is unusual for a bed maintaining such a uniform and good thickness as this bed does in Sullivan County to pinch out along such a narrow band. Going southward from Sullivan County the coal maintains its character as far as Bicknell, showing the typical partings and bottom bony bench at Edwardsport and also at Bicknell. Drilling at Bruceville indicates a tendency to split up into a number of benches. Again, at Vincennes the lower of the two coals, as previously described, is variable in its thickness and condition, sometimes appearing as a nearly solid coal, in other cases being split into two or more benches, separated by several feet of clay and shale or other rock.

At stated in a preceding paragraph, in the southeastern part of Knox County this coal appears to be of very variable thickness or to be wanting, and apparently this condition holds southward to the Patoka River. It is suspected, however, that future extensive drilling may develop large basins or pockets of this coal of considerable thickness, and it may prove to gain in regularity and workability westward from the outcrop in western Knox County. In central Gibson County it becomes of workable thickness, and is commercially mined at Francisco and Fort Branch, showing a thickness of 4 feet at both of these points, and probably much workable coal at this horizon will be developed by drilling in this county. Continuing southward into Warrick County, this coal is believed to become thin, and the interval from it to Coal VII to decrease, until, as described under Coal VII, it is represented only by a thin bench from a foot to 3 feet in thickness lying close under Coal VII, in some cases so close that the two coals can be mined as a single bed. This coal appears to be absent in southern Warrick County and southern Vanderburg County, also in the Henderson district of Kentucky. The existence of thick coals at many points in Kentucky at this horizon suggests that the future will prove up much workable coal in territory where present information does not show its presence at all.

Coal V.—As stated several times previously, Coal V is beyond doubt the most important coal bed in Indiana, and if correctly correlated with the coals of Kentucky and Illinois, it is probably the most important bed in those fields. If this correlation is correct it becomes one of the most important beds in the United States. In a general way, it is usually a solid bed, overlain in almost all cases by a black shale that splits readily into great sheets and is characterized by marine open sea fossils, such as nautilus, orthocera and similar forms, and by the presence in this shale of concretions of pyrite or ''sulphur'' which very commonly tend, at the point of meeting of the coal and roof, to project downward into the top of the coal. In some mines these are extremely abundant, occasionally so much so that the whole roof has the appearance of a boiling surface of water inverted and vastly enlarged, while in other cases there is just one here and there, separated sometimes by scores of feet. In some cases they are small, a foot or so in diameter; in other cases they have a diameter of 8 or 10 feet, and in some cases project down into the coal 3 or 4 feet or more. There are a few places, notably in Pike County, and on the eastern outcrop, at Washington, in Daviess County, where the black shale roof is replaced by a gray shale, or sometimes by a sandstone. In some of the mines of Pike County this gray shale roof appears as a lens between the coal and the black shale the latter rising over the lens of gray shale, which evidently preceded it in deposition. In other cases the black shale disappears, as around Washington, and in some cases the coal is immediately overlain by sandstone. This occurs over very limited areas in the region mentioned, and usually only toward the eastern outcrop. Over this black shale is almost universally a limestone, frequently in two benches, this limestone often having a thickness of 4 to 6 feet or more. Toward the Ohio

River this limestone is only found occasionally, but in its place is a clay layer, filled with the same fossils, and apparently the equivalent of the limestone, the quantity of lime being decreased, and the quantity of clay being increased. Coal V has almost everywhere in the State a rider, usually occurring above the limestone, and sometimes a second bed appears. In many parts of the State this rider is 20 or 30 feet above the coal, but in other places it comes close to it, notably in Vermillion County and in Pike County. In Pike County the rider sometimes thickens up to 2½ to 3 feet, or even more, and in one or two cases an attempt has been made to mine it in connection with the underlying coal. Coal V itself is apt to be characterized by partings of "sulphur" (pyrite). These usually do not occur at any particular horizon, a measurement at one part of the mine showing "sulphur" partings at different horizons from those taken at any other part of the mine. The coal, however, appears to make a strong steam coal and to give general satisfaction for that purpose. There is naturally quite a difference in the quality of the coal in different places, particularly as regards the sulphur content. The floor of the coal is usually fire clay, though there is a bone under it in a few places. In Sullivan County this coal will probably average 6 feet or more in thickness. It is exposed in the creek bed at Alum Cave, with a thickness of 8 feet, and is reported to show a thickness of up to about 11 feet in places in the mines at that point. In the northwest corner of Greene County, around Jasonville, appears one of the few points at which this coal is reported to run out. Here wells strike the limestone, but fail to find any coal underlying it. Again near Lewis the coal appears to be variable in thickness, several openings showing a thickness of only 2 or 3 feet, and drilling in that region brings out the same fact. Drillings east of Farmersburg also fail to find it. Going northward through Vigo County, a number of openings have been made in Pierson and Riley townships, and between Riley and Terre Haute. Most of these openings show coal having a thickness of from 5 to 6 feet, with all the characteristic features of coal and roof. Crossing the Wabash, it is well developed and extensively mined around West Terre Haute and to the northward as far as Clinton, where it is the surface bed, both at Clinton and Lyford. In most of that region it shows a thickness of 5 feet or more. It can be traced with certainty, with the data in hand, only as far as the Torrey mine north of Clinton. The writer, however, has been inclined to assign the coal at Dana to this horizon, with, however, some doubt. At that point it is less than 4 feet in thickness. Going southward from Sullivan County, the coal maintains its excellent thickness in eastern Knox County, and is now extensively mined, particularly around Bicknell, and drilling has shown that it maintains this excellent development southward from Bicknell at least as far as Wheatland, where it is just beginning to be developed. It maintains this thickness also east of the river and west of Washington in Daviess County, but to the eastward and on the south of Washington the roof changes from a black shale to a gray shale or to a sandstone, and the coal decreases from a thickness of 6 or 7 feet to a thickness of 3½ feet or less. At the old Murray mine on White River southwest from Washington, the coal had its characteristic thickness and roof. Around Petersburg this coal is developed with a magnificent thickness, showing 8 to 10 feet in the mines of this district. On Mud Creek it is exposed in the creek bank with a thickness of 9 feet. While in most of the mines it has its characteristic roof of black shale and limestone, in some cases it is overlain by gray shale. In view of the fact that at Washington the appearance of a gray shale roof is accompanied by a great decrease in the thickness of the coal, it is of interest to note that in the Smith mine northeast of Petersburg the coal has a gray shale roof, but shows a thickness of over 10 feet, showing that the gray shale roof is not necessarily accompanied with a decreased thickness of the coal. Eastward from Petersburg, on White River, near High Bank, and occurring about 75 feet above the river, are some openings on the 3½-foot coal overlain by a gray shale that have always been considered to be of a coal at a lower horizon. The writer is now inclined to think that this is the eastern edge of the No. V coal, corresponding in thickness and in roof with the same coal as developed at the No. 4 mine at Washington, or as developed in the outlier south of Flat Creek, in Jefferson Township of Pike County. At the Wooley mine in Petersburg this coal shows a parting of up to 6 inches, and some of the drillings around Petersburg indicate a separation of the two benches, amounting in some cases to several feet. Southward from Petersburg to Patoka River the coal maintains its thickness as far as Little's Station. Going eastward from that towards Winslow and White Oak it tends to decrease somewhat in thickness, the average in that district being between 4 and 5 feet, and in some cases the roof changes from a black shale and limestone to a gray shale overlain with sandstone.

South of Patoka River, and just east of the south fork, is a coal believed to be at the horizon of Coal V that differs so in its characteristics and in its local position that it has been the subject of much dispute, many thinking it to be the representative of Coal VI. The coal has a thickness of 6 or 8 feet, and is divided by one or more partings. A careful study of the conditions, in connection with the excellent topographic map of that region, has led the writer to believe that his first correlation as Coal V is correct. All around this region, except at Little's Station, both at Oakland, Dongola, Ayrshire, Arthur and to the southward of Oakland, Coal V has a thickness usually of only about 4 feet. Again in a shaft in the southwest corner of Section 10 it also has a thickness of 4 feet. At Princeton this coal shows a thickness of 6½ feet. In the central part of Pike County the coal tends to run somewhat thinner, averaging probably between 4 and 5 feet. In that section the little rider coal, which is usually less than 1 foot in thickness, tends to come within 6 or 8 feet of the top of Coal V. Southward in Warrick County the coal continues to have its characteristic roof, though often wanting the limestone, and varies in thickness from 4 to 8 or 9 feet, the former figure being the more common. Over a small area near Folsomville the coal splits into two benches, and this splitting can be readily traced from one opening to another until it reaches a maximum separation of 3 feet 6 inches, beyond which the two benches come together. East of Booneville and in some of the territory to the northeast of that the coal shows a thickness of 7 feet or more. South of west of Booneville, however, the coal becomes very regularly about 4 feet thick, continuing in this condition to the Ohio River, and across the Ohio in the Henderson-Owensboro district, where it is known as Coal 9.

Coal IV.—Coal IV finds its typical development in the district around Linton, where it averages about 5 feet, running up occasionally to 6 feet or over. Where solid it usually shows a smooth parting in the middle. It tends to split into two benches which may become several feet apart. The figures in the plate are almost entirely measurements made in the mines. A study of the drillings, however, seems to show that over the coal field as a whole this bed is quite often split and unworkable. At Linton such a splitting takes place just south and west of town, the split following a northwest and southeast line running through the centers of sections 21 and 27. In some of the mines the coal has been followed westward until the split becomes as much as 2 feet in thickness, and drillings still farther west are reported to show the separation to become as much as 13 to 17 feet. In like manner in other cases in Vigo, Sullivan, Vermillion and Parke counties, drillings show this coal "to go to pieces" locally. Through western Greene County and eastern Sullivan County this bed runs from 3 feet 6 inches to 5 feet in average thickness. The roof is either a shale or sandstone. The floor is usually sandstone or very hard, sandy clay.

Going northward from Linton, this coal maintains its thickness in places, though on the whole probably it will average somewhat thinner. At many points it is split into two benches. In southwestern Parke County it is workable at nearly every point seen, though thin, usually running 3 feet or under. From Hillsdale northward the coal runs from 4 to 5 feet to the region of the Little Vermillion River. In much of this territory it is so close to the surface as to have a very poor roof at the outcrop. The westward dip, however, should carry it low enough to obviate that difficulty a short distance farther west.

South of Linton this coal seems to have a workable thickness over large areas in Daviess County, usually running 3 feet or more. It usually has one small parting. Around Washington it appears to be thin, while one drilling in Knox County reported a thickness of nearly 7 feet. At Vincennes it is thin. In western Pike County many drillings report this coal to have a thickness of 4 feet or over. On the outcrop in eastern Pike County it usually is about 3 feet thick. In Warrick County the coal is more variable, and probably will not average over 2½ feet thick, though sometimes running over 3 feet. It will probably more often run down to 2 feet or less as the Ohio River is approached. At Evansville it is too badly broken up to be workable.

Coal III.—Coal III has its typical development in northeastern Vigo County at Coal Bluff and Seelyville. It has a large development from Coxville on the north to Linton on the south, apparently maintaining this thickness from the extreme eastern edge of its outcrop at Turner and south of Clay City as far westward as drilling has been carried. Considering the way it runs out to the north and possibly to the south, it is suggested that it may have been laid down in an east and west basin, and may maintain this large thickness farther in an east and west direction than it does in a north and south direction. In practically all cases where the coal was actually examined it shows one or more partings or binders. In some cases these are regular for some distance; in others they vary from one mine to the next. Thus, over a large area in northeastern Vigo County and southwestern Parke County there is a thin bed of sulphur or pyrite running regularly through the coal from 12 to 18 inches from the top. In some cases there is a sulphur bed near the bottom. This sulphur or pyrite band is so regular and clean at Rosedale that it has been freed from the coal in a rattler and sold for the manufacture of sulphuric acid. In most places in Vigo, Clay and Parke counties this coal has at least three partings, which will range from 1 inch to 2 feet thick, the latter, however, being very exceptional. Usually the partings do not exceed 6 inches. There is often one or more thin streaks of bony coal in the bed. The roof of this coal is usually shale, though often sandstone comes down, in which case it is apt to cut out the top of the coal. Crossing Raccoon Creek from Coxville, an overlying sandstone comes down on top of the coal. Evidently the coal had been planed off until at one point a channel has been cut to an unknown depth below the coal and filled with the same sandstone.

North of Coxville the coal rapidly thins out. This thinning out is evidently not due to the coal having been eroded away, but to its not having been deposited. At Coxville the coal has a thickness of about 6½ feet, with a clay parting near the middle. Going northward, the lower bench thins out, so that a few miles to the north it is represented only by a few inches of coal and then is gone altogether. Then the upper bench thins down. This thinning is apt to be irregular, however, the coal at one point showing a thickness of 3 feet, and in 100 yards being entirely gone. Coal in this horizon was last seen in going northward at the mouth of Rocky Run and a little to the southwest of Hillsdale. That the cutting out of Coal III is not due to erosion of later date is shown further by the presence of Coal IIIa, only a few feet above it, not only where Coal III is thick, but also where Coal III is thin or lacking. As before stated, this little 18-inch rider can be clearly traced from central Clay County to the mouth of Jonathan Creek on Little Vermillion River.

South of Vigo County this coal appears to hold its thickness as far south as a line from Sullivan to Linton, and possibly farther. A number of commercial mines have been opened on it in northeastern Sullivan and northwestern Greene counties. When visited in 1908, nearly all of these were closed. The fact that most of the mines on Coal IV were open when visited, while nearly every mine on Coal III in the district was not running, does not argue well for the workability of Coal III. The sections given of Coal III in this district are mainly from drillings, and the fact that no partings are shown in several of them is not conclsive evidence that no partings exist.

While it is reasonably certain that Coal III, as described from Coxville to central Sullivan County, is a more or less nearly continuous bed, no such claim can be made for the coals described as Coal III south of Sullivan County. Very few drillings within the outcrop of Coal V go farther down than to Coal IV, and those that do fail to find any thick bed corresponding with Coal III of the northern counties. As described under "Stratigraphy" there is not infrequently found a short distance below Coal IV a coal that by reason of its thickness and character and the character of its roof, resembles Coal IIIa of the more northern counties, and below this, often only a few feet, is found a bed that may represent Coal III.

In much of Daviess County the exact correlation of most of the beds is more or less conjectural. The bed we have chosen to call Coal III has a thickness of about 2 feet just west of Raglesville. Farther south, at the Gootee bank, it is 2½ feet thick. At Cannelton, where it is the surface bed, it has a thickness of from 2 to 4 feet in some of the mines and in others is split up into three benches. South of Cannelton the Star coal, as it has been called in this region, shows a thickness of from 2½ to 3½ feet at a number of points until it comes out on the top of the ridge above the High Rock. Usually it has at least one parting, which may vary from 1 to 3 inches in thickness.

From the neighborhood of Velpen southward the Rock Creek coal, which has been taken as the representative of Coal III, is a split coal, often showing as two benches, with a thickness of about 1 foot each, separated by from 6 inches to 18 inches of clay. In other cases it appears to be a solid bed 2 to 3 feet thick or more. In some of these cases it is closely overlain by an 18-inch rider, the Velpen coal. That, as previously stated, resembles Coal IIIa of the northern counties. This condition is shown in the Day and Byers sections. From Gentryville southward nothing of workable thickness was found at this horizon. A few of the drillings to the west show coals of workable thickness, in some cases showing up to 3½ feet. Most of such sections, however, fail to find workable coal at this horizon.

Minshall Coal and Coal II.—In the north end of the coal field it is found that the workable coal at almost all points is overlain by a black shale and limestone. It has been thought possible that these thick coals with that roof were all at the same horizon. In the

1898 report this coal was thought to be at the same horizon as the thick coal with a similar roof from Sullivan County to the Ohio River, so it was called Coal V. It is quite clear now that it comes stratigraphically about 300 feet below Coal V of Sullivan County. As this coal occurs in basins in the same way that the block coals do, the thicknesses given are from measurements taken in the basins and indicate in most cases more nearly the maximum than the minimum of thickness. From the sections given, which might have been multiplied many times, it is evident that this coal is of a good workable thickness at many points in Warren, Fountain and Parke counties. Four feet is a common thickness in the basins, and 6 feet is reached occasionally, as at Mecca. Where it has been explored by drilling, its basins appear to lie in west of north and east of south directions, having a good length and maintaining a good thickness in that direction, and thinning rapidly toward the edges of the basins in an east and west direction. The roof frequently is a black shale, but not necessarily a sheety shale, and often is a gray shale. The history of these beds from the laying down of the coal to the laying down of the limestone apparently has been quite different from that of those following the laying down of Coal V. In some cases the limestone comes down and makes the roof. There is frequently bone coal associated with this coal, and in many cases in Daviess County and farther south the presence of bone coal or of Cannel coal has been made much of, as an evidence of the correlation of those coals with the Minshall coal of Parke County. In a number of cases the first coal above the Minshall coal, which usually is 10 to 20 feet or more above, comes down close to the lower coal, the limestone and other intermediate strata having pinched out, and the underclay of the upper coal makes the roof of the lower bed. In several such cases the "white top" roof of the lower bed has fallen in, and it has been found that the overlying bed was thick enough at that point to work, and some work has been done upon it. This upper bed, which has been designated Coal II, is often of workable thickness in its own right. In Warren County this coal has a thickness of from 2½ to 3½ feet. It is usually cut into benches by partings. This coal was called Coal VI in a former report and thought to correlate with what is now called Coal III. It would appear to reach a workable thickness locally at many points in the northern counties, though the fact that it is so close above the Minshall coal, which is usually thicker, and will usually be worked first, may render much of it unminable.

The limestone which overlies the Minshall coal is quite variable, often changing from a thickness of 10 or 20 feet to nothing in comparatively few rods. In places the roof of this coal changes from a black shale to limestone or even sandstone, as on Sand Creek.

Minshall coal is commercially worked at Mecca, Sand Creek, Minshall, Fontanet and north of Williamstown, and has been worked at other places. South of the Vandalia Railroad it is less conspicuous, the limestone is more frequently absent, and the coal as a rule appears to be thinner. It is thought that it may have been this coal that was worked at the old Markland shaft near Clay City. Neither of these coals are conspicuous across Greene County. It is correlated as the surface coal mined west of Switz City, where it runs from 2½ to 3 feet in thickness. The coal is characterized by having a black shale roof. About Newbury is a coal from 2 to 3 feet thick that has been correlated as the Minshall coal. It also has a black shale roof and shale floor. The Raglesville coal has been assumed to be at this horizon, as has also the cannel coal at Cannelton. At Raglesville the coal is almost always associated with bone coal, coming at the top, the middle, the bottom, as the case may be. The good coal will usually yield a total thickness of about 3 feet, though in some cases the bone coal encroaches upon the good coal until the bed is not workable. Near Burns City what is thought to be the same bed has only 1 foot or so of good cannel coal at the bottom, and from that grades imperceptibly up into a bone coal, and on up into gray shale. At Cannelton this bed consists of from 1 to 2 feet of bituminous coal overlain by from 2 to 4 feet of cannel coal. The fact that the cannel coal has been successully and continuously mined here for a great many years is sufficient evidence that the coal is of high enough grade to meet the demands of the market.

In the southeastern part of Daviess County, on Sugar Creek, is found a coal closely overlain by limestone, which is placed at this horizon. The coal runs from 2 to 3 feet in thickness without partings. The roof varies from shale to clay, limestone and sandstone within short distances. South of White River apparently the same coal that is found on Sugar Creek has been opened at a large number of places in northern Dubois County. At most of these places it has a thickness of from 3 feet to 3½ feet. At Jasper is a coal of workable thickness, overlain by limestone that may come at this horizon, though it is not quite certain that it does not come at a somewhat lower horizon. From this point southward this coal has been called the Holland coal, and reaches a workable thickness at a number of points around Holland, Lincoln City, Buffaloville and Newtonville. At most of these points the coal is without partings, but in a few of them shows a single parting, ranging in some cases up to 2 feet, though in most cases only an inch or two. At Jasper there is a workable coal which comes a short distance above the coal overlain by limestone. If the limestone coal is the Holland coal, corresponding approximately to the Minshall coal in position, then the overlying workable coal belongs at the horizon of Coal II. In that region it has a thickness of from 2½ feet to 4½ feet. It is usually a solid coal with either a shale or sandstone roof. If the limestone coal comes at the lower horizon, then the coal just described probably corresponds more nearly with the stratigraphic position of the Upper Block coal.

Upper Block Coal.—The Upper Block coal appears to be absent in the north end of the State. If the coal on Coal Creek in western Fountain County is correctly correlated, then it appears there in considerable force, having a thickness in places of 6 feet, usually with a small parting. It appears to also be workable near Veedersburg, and near the south edge of Fountain County. It is seen on Sand Creek, where it locally reaches a workable thickness. Its type development, however, is in Clay and southern Parke counties, extending from only a few miles north of the Clay County line practically all the way through Clay County. It is this coal that has largely been responsible for the reputation of the Indiana Block coal, though the Lower Block coal is reputed to often show a little higher quality, but as the Lower Block coal is somewhat thinner, most of the mining in the past has been upon the upper bed. The coal will have in that district an average thickness of but little over 3 feet, though it often reaches a thickness of 5 feet in the center of a basin. Coal occurs strictly in basins, which may range in area from a few acres up to many square miles. Between the basins it thins down to a few inches. It is all through this district characterized by a bench mining, a little below the middle usually, which consists of about 2 inches of hard, brittle coal that before the use of powder was generally used to mine in. The roof is either shale or sandstone. The Upper Block coal is distinguished from the Lower Block among other things by the fact that the jointing, from which it takes its "block" name, is more open at the top than at the bottom. In many of the mines the jointing or slips, as they are called by the miners, are not pronounced below the bench mining. The Upper Block coal maintains a thickness of 4 feet in the basins over most of the southern part of Clay County, especially east of Clay City and that portion of Owen County immediately east of that.

It is supposed to be the Upper Block coal that outcrops in the bluffs west of White River, where it runs from 2 to 3½ feet thick, usually solid, though sometimes split up. The roof is shale or sandstone and the floor fire-clay. Through Daviess and Martin counties the coal assigned arbitrarily to this horizon is a thin coal only 2 to 2½ feet in thickness, with a sandstone roof, outcropping along the western edge of Martin County. In southeastern Daviess County three coals occur below the Sugar Creek coal, which lies under the limestone. It is quite likely that none of these coals correlate exactly with the coals of the Brazil district, or that if they do, the lowest coal here may be the representative of the Lower Block coal of Brazil, the next coal above, the Upper Block coal of Brazil and the coal under the limestone, the Minshall coal, as previously assumed, or, again, it may be that the coal at the bottom of the shaft at Alfordsville is the same as the Sampson Hill coal in eastern Martin County. As there is some possibility that the Sampson Hill coal is at a lower horizon than the Alfordsville coal, the latter will be discussed under the head of Upper Block coal, and the Sampson Hill coal under Lower Block coal. The Alfordsville shaft coal is found at several points in southeastern Daviess County. It runs from 3 to 4 feet in thickness, usually solid, but sometimes with a little bony coal below the good coal.

In Dubois County a coal running from 3 to 4 feet thick, with a shale or sandstone roof, is found at several points southwest of Jasper and in the northwestern part of T. 2 S., R. 5 W.

Farther south, in Spencer County, the first coal below the limestone coal at many points shows a thickness of from 2 to 3 feet, or even more. This is always a solid coal, with a shale or sandstone roof. At most points it is hardly thick enough to be workable under present conditions. Purely on the basis of the interval, the 5-foot coal being mined at the Keystone mine at Henderson, Ky., is supposed to come about at this horizon.

Lower Block Coal.—This coal does not seem to be present in the northern part of the coal field. A coal found at several points in Fountain County may belong at this horizon, as at Veedersburg, and at a few other points even farther north. If at this point the coal has been correctly correlated, the Lower Block coal has a thickness of 4 feet or over. In the Sugar Creek region of Parke County many coals are found which it has not been possible to correlate, and it is more than probable that some of the easternmost of these belong at the horizon of the Lower Block coal.

As typically developed, however, the Lower Block coal can first be definitely recognized only in southern Parke County. From there it can be traced without difficulty to the south edge of Clay County, or possibly over into Greene County. It presents certain peculiarities that distinguish it at once from the Upper Block or other coals. The coal has an average thickness of 3 feet in the basins, as far as mined, running up to 5 feet as a maximum. Of this thickness the uppermost 6 inches to 10 inches is a bituminous coal; the rest is a block coal. The block slips of the Lower Block coal are more open at the bottom than at the top, seldom, if ever, entering the little bituminous bench at the top, in contrast to the Upper Block coal, where the slips are more open at the top. Below this coal in the center of the basins is commonly found a bench of bone coal, which may run from 0 up to 2½ feet in thickness, and below that still is a bench of soft coal running from 0 up to 2 feet in thickness. In some cases the bone coal comes immediately below the main bench of good coal. In most cases, however, the benches of bone and the thin good coal are separated from the coal being mined by from 6 inches to 2 feet of clay. In some cases the little bottom bench of good coal is absent. These two underlying benches are found only in the basins and tend to run out as soon as the coal goes to the rise in going from one basin to another.

This coal tends to hold its thickness into southern Clay County. but in going eastward into Owen County increases in thickness, until at many points around Lancaster it is 6 feet thick. Whether this greater thickness is due to the bone coal having turned into good coal to the eastward or not, is not known. South of Clay County the Lower Block coal is known to have a good thickness at Howesville, where it is up to 4 feet or more over quite a district. East of White River its thickness is from 2½ to 5 feet, though it probably will not average above 3 feet. The writer does not know whether any of the characteristic features which it shows in Clay County persist into this Greene County area.

In Martin County, under this head, will be described the coal east of Boggs Creek, as far south of White River, and east of White River south of the B. & O. S-W. R. R. The coal occupies only a small area in the long ridge between Boggs Creek and Indian Creek. It very frequently has one or more benches of bone coal, sometimes at the bottom, but nearly as often at the top. It shows a thickness of 3 feet at many points, but it is doubtful if it will average that thick through the ridge. South of Shoals there is an area of it in Sampson Hill, where it is known as the Sampson Hill coal. It shows a thickness of 3 feet or over at many of these openings. At many points there is associated with it a bench of bony coal, which in some cases may so encroach on the good coal as to render the whole bed unworkable. South from Sampson Hill it is found in a few hills, where it shows a thickness ranging from 2 feet to nearly 5 feet. In these cases it is a solid coal, with a shale or sandstone roof.

In Dubois County the coal mined in the shaft at Huntingburg has been correlated as at this horizon. The correlation is purely suggestional and mainly made for the purposes of discussion. At Huntingburg this coal has a thickness of 4½ feet, with a shale roof and a shale floor. A coal supposed to be at the same horizon has been opened at several points north of Huntingburg, also up the rise to the east. The coal at most of these places has a thickness of from 3 to 4 feet. In Spencer and Perry counties this coal was correlated as the first coal above the Cannelton coal. In that district as a rule it is quite thin, having a thickness of usually not more than from 6 inches to 2 feet. Its correlation with the Huntingburg shaft coal is far from certain.

Cannelton-Shoals Coal.—All along the eastern edge of the coal field below the massive sandstone that has been called the Mansfield sandstone, is commonly found a thin coal bed. In going southward it seems quite possible that this sandstone increases in thickness, or what is more likely, that older underlying sandstones set in, so that by the time Martin County is reached the first sandstone above the lower Carboniferous limestones is a somewhat older sandstone than the sandstones north of Brazil. It has therefore been questioned whether the Shoals coal will not ultimately be found to belong to an older and lower horizon. The lowest coal at Shoals, coming there usually but a few feet above the lower Carboniferous limestone, with its characteristic fossils, reaches a workable thickness at several points. Its maximum is probably less than 4 feet, though it has a thickness of 3 feet at several places. It was at one time mined commercially near Shoals. This coal usually has associated with it quite a little bone coal, coming sometimes at the bottom, sometimes at the top and occasionally in the middle. The roof is shale often, though sometimes it is composed of a mass of conglomerate sandstone, which here has a thickness of from 50 to 70 feet or more.

This coal has arbitrarily been assumed to belong about at the horizon of the Cannelton coal, though its exact correlations have yet to be demonstrated.

The Cannelton coal is typically developed at Cannelton on the Ohio River. Here it has a thickness of from 3½ feet or possibly 4 feet down to 0. The basin character of the coal is very clearly seen at Cannelton, as the coal has been mined here for three-quarters of a century and can be seen running out to 0 in the entries. This coal usually has under it a bench of bone coal or in places it may have one or more benches of cannel coal. In places all of these can be seen to run out. Going toward Troy, over a small area the coal is split into two benches by a parting of clay, which may become as much as a foot thick. At Troy it has again a good thickness, though broken up with two partings. It is found at several points along Anderson River as far north as St. Meinrad, and at these points shows a thickness of from 2 to 4 feet. Sometimes it is solid; more often it has one or two partings. The roof is usually shale.

CHAPTER V.

DISTRIBUTION OF COAL IN INDIANA BY COUNTIES.

Warren County.—It must be remembered that nearly all of the counties lying in the Indiana coal field have been more or less deeply covered in drift. This is more particularly true of the area north of the Vandalia Railroad, running from Indianapolis to Terre Haute. Apparently the deposits also increase in thickness in going northward, so that Warren County is more deeply overlain than Fountain County, and Fountain County more so than Parke. South of the Vandalia Railroad the deposits are thinner and more nearly of a uniform thickness down to the line marking the edge of the ice lobe. It therefore follows, as a matter of fact, that the underlying coal measure deposits are less and less exposed going northward, until in Warren County they are hardly exposed at all, except along the valley of the Wabash River and the lower courses of some of the streams.

As nearly as can be worked out, under these conditions, Warren County is underlain by Division II and the Minshall coal and the Mansfield sandstone. This last part of the Coal Measures outcrops east of Pine Creek and along Wabash River from Williamsport nearly down to Covington. As shown on the map, it occupies about half of the portion of the county east of Pine Creek. As nearly as can be worked out, it lies between two nonconformities, lying unconformably on the lower Carboniferous below and being overlain unconformably by the block coals of Brazil. The rocks underlying this division consist of the lower part of the lower Carboniferous, or Knobstone formation of the Indiana reports, probably equivalent to the Waverly of Ohio. As the limestones of the upper part of the lower Carboniferous are not found in this section, somewhat greater difficulty is experienced in differentiating the sandstone of Division 1 from the underlying sandstones. Underlying the Mansfield sandstone at a few points there is found from a few inches to a foot of coal, nowhere workable, however, and probably never to be found of workable thickness. The block coals of Brazil are represented in this county apparently only by the Minshall coal. This was designated Coal V in the old report. This is found at a number of places west of Wabash River from Williamsport southwestward to opposite Covington. It is characteristically developed, with its overlying black shale and limestone, and at many points shows a workable thickness of from 3 to 4 feet—sometimes a little more. It will doubtless prove to be in limited basins, much as it is known to occur southward, so that while it theoretically should underlie all of the county west of its outcrop, except where it may have been removed by pre-glacial erosion, still its basin character will probably mean that not more than one-fourth of that area ever contained coal of workable thickness, as now interpreted. Overlying this coal by usually only a few feet is Coal II. It was designated in the old report Coal VI, but is now known not to correlate with what was called Coal VI of Parke County, and to lie, of course, much lower below the Coal VI of Sullivan County. This coal has a thickness of 3 or 3½ feet in many parts of the area, and will occupy about the same territory as the Minshall coal. It is, however, somewhat thinner, and in many sections is more or less broken up by partings, so that it probably will not have the future value that the Minshall coal will show in this county. From the character of the outcrops too little is known of the dip in this county to warrant the assertion that any of the higher workable coals may be found under the mantle of glacial deposits in the western edge of the county. Should future development show that there is a dip corresponding somewhat nearly with the normal dip farther south, Coal II and possibly Coal IV may be found underlying the portion of the county near the State line. It is quite probable that the thin coals overlying Coal II in Division II are present in places in the western part of the county, and in some cases may be of workable thickness. With the present lack of development it is little more than guesswork to judge of the coal resources of the area away from the outcrop.

Fountain County.—Fountain County, lying southeastward from Warren County, across Wabash River, presents much the same conditions as are found in the preceding county, except that the drift is probably not as thick, and somewhat better exposures have been made of the coals. Practically the same divisions and coals exist in Fountain County as in Warren, except that it seems that at least one of the block coals is known to set in before the south edge of the county is reached, and it may underlie nearly or quite all of the county. The basal sandstone of Division I outcrops over a belt from 2 to 10 miles wide in the eastern half of the county, while the coals of the Brazil division and Division II, cover nearly all of the western half of the county. There are a few outcrops of the coal underlying the sandstone of Division I in this county, though none of them appear to show coal of workable thickness.

Some openings have been made upon these coals to test their thickness and character, and in a few cases a little digging has been done, but as far as known nothing of workable thickness has yet been developed. In the Brazil division the Minshall coal and probably the upper Block coal reached, in many places, an excellent thickness, and have been mined commercially, and on a small scale, and in a number of places. A selected series of sections of the Minshall coal are well shown on Plate III, also of the Upper Block coal. The latter coal appears to be of workable thickness around Veedersburg and to the northward on Sugar Mill Creek, southwest of Wallace, near the county line, around Snoddy's Mills and Coal Creek P. O., and around Silverwood. The Minshall coal shows a good thickness around Yeddo, at Silverwood, and on Silver Island to the westward, and locally around Snoddy's Mills, as well as at other places scattered over the county. The correlation of the coals in this county is not above question, but is based on the assumption that the lowermost coal overlain with the limestone and black shale belongs in all cases in the horizon of the Minshall coal. Such a limestone underlain by a coal is met with at many points in the county, and its correlation is based simply on the assumption that there is only one limestone at about this position. Other thin limestones are known to occur over some of the higher coals of Division 2 in this county, as elsewhere, but the coals underlying them are usually quite thin and the limestones are usually a foot or less in thickness. The coals in this county doubtless all lie in limited basins, as the same coals do elsewhere, those basins probably having longer axes in a north and south direction. It will therefore require a large amount of close drilling to determine the areas of workable coal, not only on account of the basin character of the coals as originally deposited, but also because of their removal by the pre-glacial erosion, or because of their lack of roof where not removed. With the interpretation of the structure as made, the dip across this county is very slight. Not enough accurate determinations are at hand to show the amount of dip, but simply judging from the appearance of supposedly the same coals at nearly the same position with reference to drainage, the dip must be but a few feet to the mile. Probably detailed paleontologic studies will be required to determine accurately whether these coals have been correctly tied together. It would seem that the county ought in the future to be found to possess a large amount of workable coal, as the coals where known often present thicknesses of 5 or 6 feet.

Parke County.—Entering Parke County, which lies south of Fountain, much more is known of the coals, which are exposed at a much larger number of points, and have been commercially developed in many basins. The northern half of the county continues the conditions found in Fountain County, with a narrow border of sandstone along the eastern edge of the county, extending over into Montgomery County, which sandstone is underlain at a few points by thin coal, seldom over a foot thick. West of that belt, along Sugar Creek and Sugar Mill Creek, are many outcroppings of coal, which have been correlated with great difficulty or not at all. In a few cases coal overlain with limestone has been assumed to be the Minshall coal, or the Coal V of the old report. Along Sugar Mill Creek, west of Grange Corners, a coal correlated as the Upper Block coal has a good minable thickness. South of this, along Sugar Creek, are a large number of openings on coals, ranging from 1 to 3 and occasionally 4 feet in thickness, but these coals appear to be pockety and to show little resemblance from one point to another. In a general way they would appear to be at the horizon of the Upper Block coal. Possibly some of them are at the horizon of the Lower Block coal, and toward the west coal overlain with limestone is assumed to be at the horizon of the Minshall coal. Coal II doubtless outcrops in this northwestern part of the county, but its definite recognition has been doubtful. South of the Indianapolis, Decatur & Western Railroad conditions are such that the coals are better known, and in the southwestern part of the county for the first time it becomes possible to trace the coals with a high degree of accuracy. In this part of the county the lower sandstone of Division I appears to have a low dip and to outcrop across a broad belt ten or more miles wide.

In Washington Township is found the Sand Creek mining district, where the Minshall coal, overlain by its limestone, has long been worked. This coal lies a short distance above drainage on Sand Creek, but will underlie the level of most of the township. The Upper Block coal is noted at a few points in this district, lying in marked basins, the interval from that coal up to the Minshall coal varying rapidly within a few feet. The Minshall coal in this district has a thickness of from 3 to 4½ feet, the limestone in some cases making the roof, in other cases the roof being of shale, overlain with sandstone. Coal IV has a thickness of about 1 foot as a maximum, thinning out to 0 within short distances. It is overlain by shale. The two coals are here about 18 feet apart. Somewhat similar conditions exist in Adams Township, the Minshall coal being workable on Sand Creek in sections 3 and 4, and along Williams Creek, east and southeast from Rockville, where this coal has a thickness of from 2½ to over 4½ feet. One of the block coals outcrops in the eastern part of the township, especially on Strongers Branch in sections 35 and 36. Raccoon Township is the type locality for the Minshall coal. The upper Minshall coal is above drainage near the old Minshall mines, while the lower Minshall is only a short distance below drainage. The limestone between the two coals outcrops in the stream bottom. In the S. E. ¼ of this township and in the S. W. ¼ of Jackson Township are extensively mined the Minshall and the two block coals, the coals at this point being only an extension of the Brazil Block coal field. Mining here is principally upon the Upper and Lower Block coals. In the southwest corner of Jackson Township the two coals occur in small basins, each having a thickness of 5 feet or more in the center of the basins, and thinning rapidly toward the edge. They are above the level of Otter Creek in sections 31 and 32, but descend below drainage in going westward into Raccoon Township. They are extensively mined by shafts in the region of Caseyville, the shafts frequently finding all three coals.

In the southwest part of the county, in Florida and Wabash townships, Coal III has been extensively worked, occurring above drainage level on either side of Raccoon Creek. It has its regular large development around Rosedale and Coxville, but northward from that point decreases in thickness, so that on the line between Florida and Wabash it usually is not more than 3 feet thick and becomes variable in its development, sometimes being 3 or 4 feet thick at one point and disappearing entirely 100 feet away. It appears locally at points from this northward to Rocky Run, near the mouth of which it was seen to vary from 4½ feet to 0 in the space of 50 feet. At most points in this interval no coal appeared at this horizon. The position of the coal can be readily traced because of the relation to the little rider coal and a number of persistent strata that overlie the rider. The southwestward dip carries it below drainage rapidly, so that it probably passes below the Wabash River in the southwest corner of Wabash Township, and is some distance below in western Florida Township, where it has been extensively worked at Lyford. Coal IV has been opened at a few points in Florida Township and in the south edge of Wabash Township. At most points, however, it is a rather thin coal and has not been mined on extensively. It is below drainage on the western side of Florida Township. Coal V occupies a small area in the western half of Florida Township, outcropping well above drainage at Lyford.

Vermillion County.—Little is known of the coals of the northern end of Vermillion County. Some coals outcrop around Perrysville, and a few coals have been met with in drillings at points west of that. Coming southward, the first coal of any importance appears to be on Coal Branch of Big Vermillion, near Cromerville. Here what is now considered to be the Minshall coal has a considerable development, being, however, badly split up with partings, but as the individual benches in several cases are 3 feet or more in thickness it may be considered a workable coal. Limestone appears a short distance above it, and largely on that basis it has been referred to the horizon of the Minshall coal. It is just above drainage on Coal Creek, and appears again at the Hanging Rock of Vermillion River, and again a short distance above Eugene, where it has been worked on both sides of the river, but shows a much smaller thickness. In most of this district it has a main parting, ranging from 10 inches to 4 feet, while the upper bench also usually shows a thin parting of an inch or less. What is taken to be the same coal is mined southwest of Cayuga at the clay plant at a depth of about 80 feet. It is then carried below drainage and does not appear again in the county except as it is met with in drillings around Hillsdale and a few other points. On the Little Vermillion River, at the Horseshoe, there appear two coals, the lower of which has been assumed to be Coal IV and the upper IVa, both being of workable thickness. Coming down Little Vermillion River to the mouth of Jonathan Creek a coal rises above drainage that is believed to be the rider of Coal III. These three coals are found at many points along the bluff on the Wabash River south of Newport, Coal IV being of a workable thickness through most of that district, and having been opened upon at many points. Coal IVa was not noted in this section. The fire clay below the rider of Coal III coming between it and the horizon of Coal III, near West Montezuma becomes very refractory and has been extensively quarried and mined in that region. South of Hillsdale traces of Coal III begin to appear, in some places several feet of coal showing. West of Hillsdale Coal V is believed to have entered the State, and to have been reached by a shaft at Dana and Illiana. The coals are practically all hidden from Hillsdale to Norton Creek. Here Coal V outcrops a short distance above creek level and has been drifted upon. Coal III has also been found about 175 feet lower. Around Clinton Coal V outcrops above the level of the bottoms and has been extensively mined. Coals III and IV are below drainage, but both have been mined by shafting. Coal VII outcrops on either side of Brouiletts Creek, following the south side of that creek to where it enters Vigo County.

Putnam and Owen Counties.—Coal measures outcrop only in the western part of these counties, the outcrop in the main consisting of the Mansfield sandstone. Under this sandstone thin coals are found at many places, usually, however, less than a foot in thickness. The Lower Block coal is caught by some of the higher ridges and points in Putnam County south of Putnamville, and northeast of the mouth of Mill Creek, also around West Union and west of Eel River in the southwest part of the county.

In Owen County a large area of the block coals occur in Lafayette, Marion and Jefferson townships. The block coals in these townships, however, are usually quite close to the surface and will not be workable in many places for lack of roof. They are usually found only in the uplands, though approaching drainage along the western edge of the county. These coals show a good development around Lancaster or Patricksburg, around Woodside, where they have been extensively mined, and to a less extent around Coal City. While underlying considerable areas around the western edge of the county, in going eastward they occur nearer and nearer the tops of the hills until finally they occupy only the narrow crests of the ridges or divides, in most cases occupying too small areas to pay for commercial working.

Clay County.—The block coals are at or below drainage through all the eastern part of Clay County, while along the western edge of the county Coal III will be found, and in a few places Coal IV, while in the southwest corner Coal V outcrops. The block coals are extensively developed in Van Buren, Jackson, Sugar Ridge and Harrison townships. As a rule, in this district they occur in very small basins and at depths of usually less than 100 feet. The coal in this area has now been very nearly worked out. In some cases the Upper Block coal was worked out many years ago. The Lower Block coal being somewhat thinner and harder, was left and has been worked out at a more recent date. It had at one time been supposed that in going westward to below the outcrop of Coal III the block coals would not be found of workable thickness. Later evidence leads to the conclusion that the block coals will be found in basins under much of the outcrop of Coal III. How far to the westward into Vigo County they will be found in workable basins cannot be stated at this time, though the evidence exists that such basins may be found in places under all of Vigo County. In most of the townships first mentioned the Minshall coal is of relatively little importance and has been mined at only a few points. Going westward, the Minshall coal gains in importance, and is now being mined north of Williamstown, and in a small way at several other places. Coal III just reaches to the western edge of the county at the northwest, in Dick Johnson Township. South of that it covers the major portion of Posey, Perry, Harrison and Lewis townships, in the last two townships occurring only west of Eel River, except for an outlier in the hills south of Clay City. Over most of this region it is quite close to the surface, generally being found at less than 100 feet in depth. It is, however, finely developed, showing a fairly regular thickness of 6 feet or more, though almost always somewhat broken up by partings. In some cases these partings will detract seriously from its workability. The roof is usually a clay shale overlain by an interval of from a few feet to 15 or 20 feet of sandstone. This sandstone frequently comes down, making the roof, and cutting more or less into the coal. Coal IV probably occupies a narrow area in the western part of Posey and Perry counties, in the southwest corner of Harrison, and most of Lewis Township west of Eel River. To the northward it appears to have only a nominal thickness, more often under 3 feet than over, but in the southwest corner of the region it begins to attain the fine thickness which it has all through the Linton district to the southward.

Vigo County.—Vigo County is believed to be entirely underlain by the block coals, at a moderate depth on the eastern edge, at a considerable depth on the western edge. They have all been demonstrated to be of workable thickness and character near Fontanet, where both the Minshall and Lower Block coals are being worked, and it is presumed that future prospecting will develop much workable coal at these horizons. Coal III underlies practically the whole of the county, except a small area near Foleyville. It is just about at drainage level in the northeast corner of the county, but will be below drainage everywhere else. Coal IV is not found in the northeast corner of the county, but occurs at drainage level around Grant and Seelyville, and probably is not far from drainage level in the southeast corner of the county. It is being mined commercially southwest from Seelyville and northwest of Terre Haute. Drillings seem to have demonstrated that while this bed is quite persistent, it is apt to be split with partings, so that the areas within which it is workable will be more or less limited. It will probably appear, however, that it will be found to present a workable thickness under a large share of the county. Coal V is above the hilltops all through the northeastern part of the county, but comes down to drainage level at Durkee's Ferry, in the region east of Terre Haute, around Riley and the headwaters of Splunge Creek, and around Lewis P. O. From this line it is below drainage to the westward. It should underlie all of the county west of the Wabash River and west of a line drawn from Terre Haute to Lewis. What its condition may be in the southwestern part of the county has not yet been determined. From a general knowledge of its persistence it may be predicted, however, to maintain a good workable thickness over nearly all of that territory. It is thin around Lewis and probably will not be workable in some of that district.

Coal VII outcrops above drainage west of the Wabash River as far as Terre Haute. It outcrops at numerous points on Coal Creek, reaching the level of the bottoms near the north edge of Sugar Creek Township, and reaches about the level of the river at Terre Haute. It will, however, underlie all of the region west of a line from Terre Haute to Farmersburg, and extend an irregular distance to the eastward of that line, outcropping in the headwaters of Honey Creek and Busseron Creek. All of the coals in the county will be at a considerable depth in the southwest part.

Greene County.—All of the coals outcrop in Greene County, Coal VII, however, barely overlapping the western edge of the county near Dugger, and possibly at one or two points south of that. East of the west fork of White River the block coals and the coals below the Mansfield sandstone are nearly everywhere above drainage. The Mansfield sandstone outcrops through nearly all of the ridges in the eastern half of the county, the rise of the ridges to the eastward from the river just about keeping pace with the rise of the rocks, so that the Mansfield sandstone forms the crest of most of the divides all through the eastern townships. The coals above the Mansfield sandstone outcrop in the tops of the ridges in Richland, Taylor, and western Jackson townships. They occupy, however, very narrow belts, except in parts of Taylor township. In Cass Township the dip has carried them below drainage. A broad belt runs through these townships, following White River, in which are broad prairies, deeply filled with alluvial matter dating from the Glacial period. This belt is pierced by a ridge running out from Swiss City toward Bloomfield and Plummer. The block coals are believed to outcrop around the base of the bluffs on the west side of White River, from which point the dip carries them rapidly below drainage to the westward. The limestone over the Minshall coal does not seem to be typically developed in this county, and that coal has not been very definitely recognized. The western townships, Wright, Stockton and Stafford, are almost entirely underlain by coals III and IV, Coal V underlying the major part of the west half of those townships, and Coal VI is found over a small area within the western margin of the county. The depth to coals III, IV and V in this county is usually small, generally not over 200 feet.

Sullivan County.—The block coals probably underlie Sullivan County at considerable depth, not outcropping at any point in the county, and it is possible that in the future they may yield a considerable volume of workable coal. The lowest coal outcropping in the county is probably Coal V, which is just at drainage level along the eastern edge of the county, from the northeast corner almost all over the district to the southeast corner. Coal VI outcrops a short distance to the west of that, in many cases the two coals outcropping within distances of half a mile or less. Coal VII is found west of Busseron Creek in Jackson Township, but to the south of that extends nearly to the eastern border of the county. Going westward, all of these coals dip rapidly, and along the E. & T. H. R. R. Coal VI is usually more than 200 feet deep, Coal VII being at a somewhat slighter depth, and the lower coals at still greater depths. It is believed that all of these coals are below drainage along the Wabash River on the west side of the county. A coal correlated as Coal VIII appears to have a workable thickness in some parts of the western half of the county, showing such a thickness at Merom, along Turmans Creek, and in a few of the drillings.

Martin County.—Only the lowest part of the coal measures occur in this county. The lowest coal, here called the Shoals coal, is above drainage through most of the eastern half of the county. A series of faults at and west of Shoals brings it above drainage at several points in the western part of the county. It is also above drainage through much of the upper valley of Boggs Creek, west of Huff Station and to the southward. In the old report it was thought to keep above drainage or at least not to go but little, if any, below drainage along the whole length of White River down to where it meets the Orange County line. The writer is now inclined, however, to consider the coal at Trippy's, at Mount Pleasant, a somewhat higher coal. In like manner the coal at drainage level north of Bramble P. O. he is considering a higher coal. Above this coal several coals outcrop in the ridge between Boggs Creek and

Indian Creek. One of these coals outcrops at a number of points just at the top of the ridge. The coal that was described under the heading of the Lower Block coal occurs somewhat lower in the ridge. It underlies a small area southeast of Shoals in what is known as the Sampson Hill district; also a small area in the top of the ridge south of Lost River at Rusk P. O., and in the high ridge just south of that. West of Boggs Creek it is assumed that the dip will bring this coal down to drainage level along the western edge of the county. South of Loogootee it is assumed to be this coal that is found near Mount Pleasant and in the streams a little west of White River, in the southern half of T. 2 N., R. 4 W., and the northern half of T. 1 N., R. 4 W. It is thought that the Upper Block coal is the coal that is mined at many points along the southwestern edge of the county.

Daviess County.—As already described, it has been assumed that the coal along the eastern edge of Daviess County is, in a general way, about at the horizon of the Upper Block coal. This coal is found in the shaft at Alfordsville, and, it is assumed, passes below drainage of Prairie Creek east of Raglesville. It is assumed to be this coal that has been found at several points along Furse Creek in the northern part of Madison Township. At Raglesville the Raglesville coal, which has been assumed to come about at the position of the Minshall coal, is about 30 feet above Prairie Creek, east of town, but the dip to the southwest carries it down to drainage level a short distance southwest of town. It is assumed that it passes below drainage level, so that the coals that have been opened in Section 7 west of Raglesville belong at a higher horizon. They have been assumed to be the equivalent of Coal III. Were the dip to continue those coals in turn would be carried below the eastern outcrop of the coal mined around Epsom. That coal is high in the hills east of Epsom, but dips rapidly to the westward, and must pass below Prairie Creek a little west of south from Epsom. Through the center of the county it is thought that the coal in the shaft at Cannelburg may be the same as that outcropping on the upland around Loogootee. The surface bed at Cannelburg, it is assumed, passes below drainage in a short distance to the west, and that the Montgomery coal outcrops east of Montgomery. The Montgomery coal dips rapidly westward from its outcrop to just west of Montgomery and then rises slowly to the westward, probably to beyond Black Oak. Approaching Washington, there are some high hills that catch Coal V, and the dip east of town is sharp to the westward so that the coal rapidly passes below drainage, Coal

VII being just above White River at the west edge of the county. In the south part of the county the Sugar Creek coal outcrops at many points just above the level of Sugar Creek. This coal passes below the level of White River, probably not far from High Rock. On top of the High Rock is abundantly scattered the white flint that is supposed to belong just above the equivalent of Coal IIIa. This dips rapidly to the westward and is only a few feet above Mud Creek, east of Hudsonville and Glendale. It probably makes the "Rock Eddy" west of Hudsonville on White River. The Montgomery coal is in the upland around Hudsonville and Glendale, but passes down to drainage level in a mile or two to the westward. Coal V is just at river level at the Murry mine on the west fork of White River southwest of Washington.

Knox County.—All of the coals underlie nearly all of Knox County. Coal V is just at river level at Edwardsport and Murry Station. It is above river level at the mouth of the west fork of White River, and on White River above Edwardsport. At Appraw Ford, Coal VII is down to the level of low water of White River, indicating a broad syncline from east to west in the center of the county on the eastern edge. The northeast corner of the county has the coals below Coal V outcropping, so that Coal V is wanting in that part of the county. Coal VI outcrops, with an irregular line, through the eastern half of R. 8 W. Coal VII outcrops a short distance west of Coal VI. By the time the middle of R. 8 W. is reached all of the workable coals are under cover. From there westward the dip carries the coals down until at Vincennes Coal VI is only 35 feet above tide, or at a depth of about 400 feet, and the other coals will occupy correspondingly greater depths except Coal VII, which is there 18 feet above Coal VI.

Orange and Crawford Counties.—The coal measures outcrop in the western half or more of these counties, but are confined to the ridge tops, except toward the western edge, when they get down nearly to drainage level. Over most of the area covered by the coal measures only the basal sandstone and its underlying coal is found. Along the high ridge followed by the Southern Railroad from Birdseye to east of Tazewell, and also on the crest of the high ridge in the southwest corner of Crawford County, it is thought that the Cannelton coal occurs.

Dubois County.—The bottom of the coal measures is above drainage in the northeastern part of Dubois County, and above Anderson River in the southeast corner. The Cannelton coal occurs in the tops of the ridges in the eastern part of the county, but is supposed to pass down to drainage level in the neighborhood of St. Anthony, on Flat Creek, and to the southwest of Kellersville on White River. The Huntingburg shaft coal comes into the hills around Bretzville and under the high ridge around Ferdinand, and reaches drainage level on Patoka River a little west of north of Huntingburg. It is 40 feet deep at Huntingburg, and outcrops at many points between there and Jasper. The coal just southeast of Jasper is placed at this horizon. In the high ridge around Ferdinand the coal overlain by a limestone is thought to be the coal below the Holland coal. It is supposed to be the same limestone that outcrops in a road cut just east of Huntingburg, and in the fields southeast of Jasper at a somewhat higher elevation than the coal there previously mentioned. The Holland coal is in the top of the ridge at Kellersburg, probably more than 200 feet above White River. Going westward to Haysville and Portersville, it gradually descends until it reaches drainage level on Beech Creek, west of Portersville. What is considered to be this coal outcrops high in the ridge north of Jasper, with the Upper Minshall coal outcropping above it. The exact position of this coal in the ridge north of Duff is still in question. There is a coal there overlain by a limestone and chert, but there is some doubt as to whether this is at the horizon of the Holland coal or at the horizon of the Velpen coal. The Holland coal is at drainage level west of Patoka River in Section 10 east of Velpen and along Rock Creek, southeast of Pikeville. It is above the level of Sugar Tree Fork, just west and southwest of Holland. From there it rises to the east until it has an elevation of 520 feet above tide west of Ferdinand Station. The Rock Creek coal is found in the tops of the ridges along the west edge of the county, south of Patoka River.

Pike County.—The Holland coal is just about at river level on White River in the northeast corner of the county, on Patoka at the east-central edge of the county, and on Pokeberry Creek in the southeast corner of the county. The Rock Creek coal is in the hills and uplands along the eastern edge of the county. Going westward, this coal is carried rapidly downward, and a few miles from the eastern edge of the county the Survant coal is found in the hills, notably just north of Long Branch, in the upland around Velpen, southeast of Pikeville, and just west of Selvin. Coal V occurs in the tops of the ridges near the eastern edge of R. 7 W. It extends out into a long tongue of upland in the big bend of Flat Creek northwest of White Oak P. O. It is in the top of the ridge just south of Survant, around Stendal, and extending southward

[9]

almost to Selvin. It also outcrops near the top of the ridge northwest of High Bank. From these points the dip carries it downward to the west until it passes below river level north of Petersburg on White River, south of Littles, on Patoka River, east of Oakland on the south fork of Patoka. Coal VII is found in the hills near the top of the high ridge from Augusta southward and extending westward past Arthur P. O., also in the ridges in the southwest corner of the county. This coal occupies all of the upland in the northwest part of the county. It is above drainage at Dongola and west of Oakland.

Gibson County.—As just described, Coal V passes below drainage just at the eastern edge of Gibson County at the latitude of Oakland, and Coal VII is in the upland there. These coals dip rapidly downward until at Princeton Coal V has an elevation of about 20 feet above sea-level, and the dip carries it still lower to the west. At Fort Branch Coal VI has an elevation of 175 feet above sea-level, while at Francisco the same coal has an elevation of 270 feet above sea-level. In the western part of the county the dip allows the measures to descend until the highest coals of the State, the Parker, Friendsville and Aldrich, are found in the hills.

Perry County.—All but the eastern third of Perry County is underlain by coal measures except the stream valleys. The bottom of the coal measures usually reach drainage level by the middle of R. 3 W. East of that the hilltops catch the lower coal measures, and to a large extent the Cannelton coal. Going westward the dip carries the Cannelton coal down to river level along the Anderson River.

Spencer County.—As just stated, Coal II is at river level along Anderson River on the eastern border of the county. The Holland coal reaches drainage along the western edge of the northern part of the county, near Lincoln City and Holland. Coal II should therefore occupy all of the county. The Holland coal underlies probably the western part of the county from the middle of R. 5 W. westward. From the middle of that range eastward the hills contain the coals lying between the Holland coal and the Cannelton coal. Coal V is just caught in the top of the knobs west of Centerville and north of Rockport. It is above all of the other land in the southwestern part of the county. Coal IV is not far below drainage level in the southwest corner of the county, but is probably cut out over a large area in what is known as Pigeon Plain on the east side of Little Pigeon Creek. It should, however, be found in all of the hill land or land that rises above the level of Pigeon Plain and the river bottoms. The Rock Creek coal will come between Coal IV and the Holland coal in this territory.

Warrick County.—The Holland coal is just above drainage in the northeastern part of the county, but passes below drainage west of Pokeberry Branch. The Rock Creek coal is caught in the hills east of Pokeberry Branch, and outcrops above drainage in the hills west of Pokeberry Branch. Coal IV is caught in the ridges between Pokeberry Branch and Coles Creek, north of Tennyson. Coal V outcrops in the tops of the ridges southwest of Folsomville and from Folsomville to Scalesville. From there it passes quickly below drainage, so that apparently it does not outcrop on Big Creek, though a few outcrops on Cypress Creek occur south of Boonville. The outcrops of this coal in Warrick and Pike counties is shown in great detail in the Ditney folio of the U. S. Geological Survey. In Anderson Township it outcrops only a short distance below Little Pigeon Creek, and passes below drainage a short distance from Yankeetown. This coal underlies all of the western part of the county. Coal VII outcrops in the ridge tops west of Scalesville and through the ridge west of Cypress Creek around Chandler; also in the crest of the ridge between Boonville and Yankeetown. It is above high water at Newburg, but passes below drainage a short distance down the river. It is just about at drainage at Millersburg on Pigeon Creek, and above drainage on the eastern forks of that creek north and southwest of Chandler. It underlies the western edge of the county.

Vanderburgh and Posey Counties.—All of the coals are below drainage under these counties. Coal V is worked at many points around Evansville at a depth of about 260 feet, the coal being about 125 feet above sea level. All of the coals should be present under these counties, but drilling seems to indicate that many of the coals are thin, as compared with their development farther north. Thus. up to the present coals VII, V and a coal at about the position of the Upper Block coal appear to be all that can be counted upon. Of these Coal V seems to be the only one that is persistently workable. The lowermost coal mentioned has been opened by a shaft at Henderson. The diamond drilling at Mount Vernon reveals the presence of several workable coals, the highest being at a depth of 600 feet. The uppermost coals of the measures outcrop to a small extent in the uplands of northwestern Posey County. They do not, however, appear to be workable there. They will be cut out over the broad band of river bottoms that encircle that county.

CHAPTER VI.

STRUCTURE OF THE INDIANA COAL FIELD.

The general statement has been made that the coal measures of Indiana dip to the south of west. On the large chart prepared by Mr. Lines the attempt has been made to give the amount and character of that dip by contour lines. There will be noticed a series of red lines running irregularly, but more or less nearly parallel, the length of the field in a south of east direction. These lines are numbered from 0 in the southwest corner of the field to 900 feet near the eastern edge of the field. The numbers refer to elevation above sea-level, and are applied to the position of the No. V coal or the position it would have had it not been carried away by erosion. The lines have been drawn by first placing onto a tracing of the map the elevation of Coal V at every point at which its elevation is known. In many other places the elevation of some other coal is known, and knowing very closely the distance of that other coal above or below Coal V, it was possible to compute the approximate elevation of Coal V.

These elevations have been obtained in a number of ways. In a large number of cases through the kindness of the various railways the elevation of the switch rail at the mine has been learned, and by subtracting from this the depth of the shaft the elevation of the coal has been obtained. These elevations are given on the chart in the list of mines. In the same way many of the mining companies have leveled to the top of their drillings, so that the elevation of the coal at a large number of points in undeveloped parts of the field could be obtained in this way. In the area of the Ditney folio the contour lines had already been drawn on Coal V, based on elevations obtained at every outcrop or stripping in that area. As the geology of that folio was studied after the preparation of the topographic map, it was possible to determine quite accurately the elevation of Coal V and of the other coals at practically every point where they are known in that area.

The U. S. Geological Survey has also prepared topographic maps of the Clay City quadrangle in Clay County, and of the St. Meinrad and Tell City quadrangles in Spencer, Dubois and Perry counties. The first of these sheets was only surveyed in 1908 and has not yet been published. Within the area of these sheets, which give the elevation of the ground at all points, it has been possible to obtain the elevation of many of the coal outcrops quite accurately. In the case of the coals on these sheets in Spencer County, the elevations have often been only an approximation, as the writer is not personally familiar with the position of the coals in that county. Mr. Price, who did the work in that county, frequently described the position of the coals he saw, either referring to their distance from some section corner, or to their approximate elevation above an adjoining stream, so that, with the topographic map in hand, it has often been possible to estimate the actual elevation closely. In many other cases, by knowing the position of the coal relative to some neighboring large stream or river, it has been possible to estimate the elevation of the coal. The elevations of low-water on the rivers has been determined at many points, and assuming a regular gradient between any two such points, it is possible to obtain the elevation of the river at any intermediate point. In this way the elevation at the mouth of the larger streams can be obtained, and if the elevation can be obtained higher up that stream, where crossed by a railroad or a State road, the elevation of any point along the creek can be closely approximated. In these ways hundreds of elevations on Coal V were obtained or computed; then lines were run connecting all elevations of each even hundred feet, or so spaced on either side of other elevations given as to place such elevations their proper relative distance between the contour lines on the two sides of them.

Theoretically, from these lines the position of Coal V can be closely approximated at any point in the field. Thus, if the point in question is found to immediately underlie one of the red lines, Coal V is as many feet above sea-level as the figure on that red line. Should it be halfway between these two lines, its elevation will be theoretically 50 feet higher than the elevation indicated by the red line west of it. In the same way, if it is only a third of the distance from the western line its elevation will be theoretically 33 feet higher, and so on. Actually the elevations to be obtained are not as accurate as that. Within the area of the Ditney folio in Pike and Warrick counties it should be possible to obtain the elevation of Coal V from the contour lines to within 25 feet, and the same is probably true of eastern Sullivan County, western Greene County, northeastern Vigo County, and northwestern Clay County. Over the coal field as a whole, however, it is not expected that these contours will give the accurate elevation of the coal within a limit of error of 50 or 75 feet. They are intended primarily to show the general structure of the field in a broad way, and in doing that they also show approximate elevations of different coal beds within the limit of error mentioned. To obtain the elevation of any other coal bed than Coal V, turn to the stratigraphic chart and measure the distance from that particular coal down to or up to Coal V, and add or subtract from the elevation of Coal V accordingly as the coal in question lies above or below Coal V. No attempt will be given in the text to describe in detail the structure. Its character is shown on the map, as stated, and in addition a large number of elevations have been given on the map, and the accurate elevations of the coal at most of the working mines have been given on the chart. A note of caution should be given in regard to these elevations of the coal in that they are based on the assumption that the depth of the coal in the shaft is correct as given on the chart. In many cases the depth of the shaft has been reported differently by different people, or at different times. If the figures giving the depth of the shaft at any point prove to be incorrect, the elevation of the coal at that point should be corrected a corresponding amount.

CHAPTER VII.

THE AMOUNT OF COAL IN INDIANA.

In view of the interest taken at present in the conservation of our natural resources, and the subsequent census of the country's stock of mineral and other wealth, the question of how much coal there is in Indiana is of more than local interest. The present knowledge of the stratigraphy renders the figures given in the 1898 report inaccurate, greatly increasing them, and it is expected that future development may still further increase the amount of estimated coal reserves in the State beyond the figures given in this table, as these figures are thought to be more or less conservative.

It is at once recognized that the value of any figures must depend on how they have been obtained. In this case the attempt has been made to determine in each county the area underlain by each coal bed. That area in square miles has then been multiplied by the average thickness in feet of each coal bed, and again by the number of tons of coal in a bed 1 foot thick and one square mile in area. On the face of it that ought to be simple enough and to give quite definite results. However, the personal element in the interpretation of facts enters very largely. If a given bed is entirely above drainage in any county it may be possible not only to map it accurately, and so determine its area, but to find outcrops so placed as to show whether it runs out or thins in any direction. Under these circumstances it may be possible to estimate the tonnage within a very few per cent. Unfortunately, the conditions are seldom so simple. If it is above drainage it has slight cover, and under the conditions existing in most of the Indiana field, that means that it may have been cut out over indefinite areas by the preglacial drainage, and the evidences of such early erosion have been later covered up by the glacial deposits.

Again, the usual dip to the west is such that the coals do not remain above drainage many miles in an east and west direction, and as each bed passes below drainage mining and exploitation is upon the next higher bed, and little is known of the first bed farther to the west, where it underlies the next succeeding higher bed. This lack of information is much less today than it was ten years ago, due to the large amount of drilling that has been done. Continuing westward, however, a point is usually reached beyond which drilling seldom reaches down more than to one of the overlying beds, and the continuance of the bed and its workability become conjectural. It is here that the question of probabilities enters. For example, in Sullivan County we have fairly definite knowledge of the coals down to Coal III over the eastern half of the county, and no small measure of the northwestern part of the county, but in the southwestern and western part of the county, covering nearly half of its area, the writer has no exact information. Shall we consider that because the coals have maintained their thickness and regularity over the known part of the county, therefore they probably do over the rest? Between the extremes of assuming that the coals in that case do run regularly over the rest of the county, and that it is not safe to assume anything beyond the area definitely and thoroughly known, is a medium course that assumes that the evidence is sufficient to warrant carrying the coals over at least part of the unknown territory, and making some allowance for the possibility that they do not go over all of it.

Thus, to take a concrete case, in Sullivan County, since that has been mentioned: Coal VI is known to be regular and generally workable over the eastern part of the county and part of its northwest area. It appears, however, to run out at the north edge of the county, and to become irregular not far from the south edge of the county. Under these circumstances it may be questioned how far to the westward it is safe to assume its extension with a workable thickness. In the same way, Coal V, that at most points in the eastern part of the county shows an even thickness, is known to be absent east of Farmersburg, around Jasonville, and at other points. To assume its presence over all of the unexplored part of the county would therefore hardly be justified. Under these conditions the writer has probably erred on the side of conservatism.

Next in the case of thickness there is also much room for diversity of opinion. For example, any one going into a succession of mines on the block coals is apt to forget that practically each of those mines has been started only after drilling has developed the position and lay of the basin in which it occurs, and that probably what he sees in the mine is in the very heart of the basin, and not even an average of that part of the basin that has been or will be mined out. Again, in the upper coals, examination of a large number of drillings reveals many points at which one or more of these usually regular beds are absent or thin. So, too, regarding the sections seen in the mines—the mines that are open are the mines that have found the bed workable and continuing regularly. It is only when inquiry is made into the history of the closed or abandoned mines that it is realized that even the most regular of the beds have their weak places where, for some reason or other, they are not workable. It has, therefore, been the writer's plan to assume that the observed thicknesses are more likely to be above than under the average thickness, then to assume that that average thickness persisted only over part of the area—the portion taken depending on the apparent regularity of the bed in question, and the data on hand ranging from a small portion of the area to all of it—and then to assume usually that the bed will underlie the rest of the area with a greatly reduced thickness.

The table giving a "Summary of Coals by Counties" follows:

SUMMARY OF COAL BY COUNTIES.

COUNTY.	Number of Coals Contained.	Greatest Thickness Recorded. Ft.	In.	Maximum Total Thickness. Feet.	Total Thickness Workable Coal (Max.) Feet.	Square Miles Underlain by Coal.	Square Miles Underlain by Workable Coal.	Estimated Total Tonnage of Coal.	Estimated Total Tonnage Removed or Rendered Unworkable.	Estimated Total Tonnage of Workable Coal Left.
Warren	4	4	2	9	7	300	30	500,000,000	60,000	50,000,000
Fountain	7	8		15	9	325	75	500,000,000	3,000,000	150,000,000
Putnam	2	3		5	5	C. M. 100	1	50,000,000	40,000	2,000,000
Parke	11	7	6	35	24	C. M. 470	100	1,000,000,000	30,000,000	425,000,000
Vermillion	12+	7+		35+	22+	250	200	1,500,000,000	30,000,000	600,000,000
Owen	4	6	1	10	8	125	30	67,000,000	700,000	15,000,000
Clay	16	9		27	19	250	100	1,200,000,000	70,000,000	300,000,000
Vigo	18+	7	6	43	33	400	300	4,000,000,000	50,000,000	1,500,000,000
Greene	14	7		50	35	300	200	1,000,000,000	40,000,000	400,000,000
Sullivan	18+	9+		40+	28+	440	365	10,000,000,000	50,000,000	4,000,000,000
Martin	7	4		12	7	175	14	500,000,000	500,000	20,000,000
Daviess	15	7	3	27	19	400	200	2,500,000,000	7,000,000	400,000,000
Knox	15+	9	10	36+	23+	540	300	8,000,000,000	3,000,000	2,000,000,000
Orange	2	2	8	4	2½	1	⅛	1,000,000	....	200,000
Crawford	3	4		4	2½	12	½	10,000,000	150,000	400,000
Dubois	9	5		17	12	300	40	1,000,000,000	100,000	50,000,000
Pike	13	10	2	20+	13+	330	200	2,000,000,000	20,000,000	650,000,000
Gibson	15+	7	7	20+	13+	450	400	6,000,000,000	2,000,000	1,000,000,000
Perry	7	5	8	8	3	30	6	36,000,000	3,500,000	9,000,000
Spencer	11	5	10	20	13	300	25	1,000,000,000	300,000	50,000,000
Warrick	12+	9		25+	19+	356	175	2,000,000,000	10,000,000	500,000,000
Vanderburgh	10+	4	6	18+	12+	240	200	2,000,000,000	25,000,000	1,000,000,000
Posey	11+	6		25+	17+	420	200	2,000,000,000	....	500,000,000
Totals	34	10	2	Max.	Ave. Max.	6,508	3,051	46,864,000,000	345,350,000	13,621,600,000
Approximately	34	10		100	*40	6,500	3,000	50,000,000,000	350,000,000	14,000,000,000

*Obtained by adding together the maximum of all the beds.

In the table there is given in the first column the total number of beds found in each county. The plus (+) signs refer to the incompleteness of our knowledge of usually the lower part of the column. To get the total number of beds in the State it is necessary to count the higher beds, as found in the western counties, and add the lower beds, from their outcrops in the eastern counties. As before stated, the total appears to be in the neighborhood of thirty-four horizons at which coal has been laid down. Of these probably not more than twenty-five have any regularity or can be recognized over any large area. In the second column is given the greatest thickness of a single bed measured in each county. The greatest thickness in the State measured by the Survey is 10 feet 2 inches, though still larger thicknesses are reported. The next column gives the maximum thickness of coal found in each county, obtained by adding together the greatest extensive thickness observed of each bed, not necessarily the sum of the greatest individual measurements, but the sum of the best average thicknesses. Thus, with the workable beds the figure used is usually the average of at least one or more mines. In the table Greene County appears to have the greatest thickness. Our actual knowledge of Sullivan County reaches down only to Coal III, below which are still doubtless six or eight additional coals. The basis of the figures in Greene County may be given as an illustration of how the figures have been obtained. From the table the reader who is acquainted with the thicknesses of the coals in that county can then judge for himself as to the reliability of the thickness for the other counties.

Thicknesses of Coal Beds in Greene County.

	Feet.
Coal VII, as in the Smith mine, sec. 31, T8-R7	4
Coal VIa	1
Coal VI, as east of Dugger	6
Coal Va, as in a number of drillings	2
Coal V, as in the Twin No. 4 mine, Vulcan mine, etc	7
Coal IVa, as in many drillings	1
Coal IV, as in Vandalia mines Nos. 2 to 9	5
Coals IIIa and IIIb, as in drillings	2
Coal III, as at the Letsinger and Tower Hill mines	7
Coal II, IIa, etc	2+
Minshall coal, as at Switz City	2½
Upper Block coal, as at the Aydelotte slope	3½
Lower Block coal, as at Howesville and east of White River	4
Sub-Mansfield coal, in eastern part of county	3
Total	50

In Sullivan County several drillings showed coals to a total of 35 feet, in depths of less than 500 feet, including coals III to VIII. In one such drilling, excluding all coals below 3 feet 10 inches as unworkable, 26 feet 3 inches of workable coal is shown. In this case particular mines have been cited where the larger coals have the average thickness given.

At the bottom of the column the total maximum thickness of the coal for the State is given as 100 feet. This was obtained by taking the thickest measured section at each of the beds in the type region of Sullivan and Greene counties, and adding to it still greater thickness from other regions and the thickness of the coals not found there. The following table shows how the thickness runs in Sullivan and Greene counties, and is used as a basis for this total figure:

Maximum Thickness of Coals Measured in Sullivan and Greene Counties.

	Feet.	Inches.
Coals above coal VIII, total	3	..
Coal VIII	4	..
Coal VII	6	..
Coal VI	8	..
Coal Vb	1	..
Coal Va	3	..
Coal V	9	2
Coal IVb	2	..
Coal IVa	3	..
Coal IV	6	..
Coal IIIb	0	8
Coal IIIa	3	..
Coal III	9	..
Coal II to bottom of III	8	..
Minshall coal	4	7
Upper Block coal	3	6
Lower Block coal	4	..
Sub-Mansfield coal	3	..
Total, about	80	..

It will be at once recognized that the thicknesses given are not the maximum for those beds in the State. Thus, the block coals frequently reach 5 feet in the Brazil district; the Minshall coal reaches 6 feet in Parke County; Coal V reaches over 10 feet in Pike County. Further, in Gibson County are at least three coals giving a total measurement as a maximum of 7 feet that are not found in Sullivan County; and, again, in the southeast part of the coal field, as in Perry County, occur coals below any found in Greene County, so that it is believed that the total estimate of 100 feet is not far from correct, and were the figures accurately known this would probably be increased rather than diminished.

The next two columns give the areas underlain by coal or coal measures (C. M.) and by workable coal. These figures are probably conservative. They are simply copied from the estimates of the previous report. The estimated total tonnage is based on the computation for each county of the area and average thickness of each coal bed. Another way of getting at that figure would be to average the thickness of the coal in a large number of drillings and other obtainable sections, and to multiply that by the area of the county and tonnage per square mile per foot of thickness. The study of Sullivan County in this respect showed that drillings from Coal VIII to Coal III contained from 20 to 34 feet of coal, 30 feet being not far from the average. Assuming that the coals below Coal III will more than make up for any amount under that that a larger number of sections might show, if that average holds over the whole county of 440 square miles, and if it be assumed that every square mile of coal 1 foot thick contains 1,000,000 tons of coal, the county, on that basis, would contain 13,200,000,000 tons. It will therefore be seen that the figure of 10,000,000,000 tons obtained by the other method, while conservative, is probably not unnecessarily so.

The next to the last column is intended to show the amount of coal worked out or rendered unworkable. The total amount is estimated at double the amount of coal actually removed, the difference consisting not only of the loss in pillars, etc., but the crop coal and other portions passed by or lost through conditions of adverse possession and the damage to overlying coals. After completing this computation the writer found that Mr. Parker, of the Division of Mineral Resources, has computed the total output of Indiana at 159,440,390 tons, which agrees closely with the figures used in this table.

The last column gives the estimated actual tonnage recoverable *under present mining conditions*, assuming as workable coal all over 2½ feet thick, and that only 60 per cent is recoverable. Allowance is thus made for not only the actual loss in mining, but for the losses in the overlying beds, etc.

As a matter of fact, the total coal that will probably be recovered will lie somewhere between the figures of the last column and those of the third column from the last, for better methods of mining are bound not only to increase the percentage of any bed that is recoverable, but to make possible the mining of beds now considered unminable. Recent advances have already pointed the way to some of the means that will be adopted. Some of these are as follows:

Better means of utilizing low-grade coals, making it possible to mine with profit bony or poor benches now left in the mines, as, for example, the bottom bench of Coal VI in Sullivan County. The Pittsburg fuel testing plant of the U. S. Geological Survey is at this writing successfully using the roof coal on the Pittsburg bed, commonly called bone coal, and considered to be too high in ash to mine profitably. In the same way, at the St. Louis testing plant, bone coals running up to 30 or 40 per cent ash were successfully used in the producer gas plant, and yielded as good results as high-grade coals in the steam engine.

Better Methods of Mining.—There are mines operating in Illinois and in other states where as high as 98 per cent of the coal owned is recovered. It is only a question of time when that will be true of all mines.

Better Machinery and Appliances Which Will Make it Profitable to Mine Thin Coals.—Where the price warrants coals well under 2 feet are successfully mined at many points today. Undoubtedly in the future new machinery will make it possible to mine these thin coals at a profit in Indiana. There are also many factors which are tending to raise the price of coal in the future, among which may be mentioned the fact that in the past mining has been upon the coal that could be obtained most easily, and therefore that future mining is almost bound to be more expensive, and the product more costly to the purchaser. Again, the agitation for greater safety for the miners is going to render mining more expensive, and again will in turn mean greater selling price. These factors will enable the mining men to turn to the thinner coals than are now considered workable.

Summing up the figures that have been given, the following approximate conditions appear to exist:

Proportion of total amount of coal removed, 1-140.
Proportion of workable coal removed, 1-80.
Average rate of removal for last sixty years, 3,333,333 tons a year.
Life of field if past average rate be maintained, 4,000 years.
Rate of removal in 1907, about 13¼ million tons.

Life of field if present rate were maintained, 1,000 years.

Rate of increase during last few years, about 1,000,000 tons a year.

Life of field if present rate of increase were maintained, 150 years.

Production the 150th year, about 169 million tons.

Considering the factors already discussed, it is probable that the life of the Indiana coal field will be not less than double the figure given, or, say, 300 years, and probably it will be more.

The principal reasons for believing that the life of the field will be longer than the 150 years on the basis of present conditions being maintained may be briefly summarized as follows:

(1) Thinner beds will be worked than are now considered workable, so that much coal that is now included in the figures on total coal, but not in the column of workable coal, will be transferred to that column.

(2) Better mining methods will insure a larger percentage of recovery, and smaller losses to overlying beds and outside districts, so that instead of estimating the recovery at 50 or 60 per cent, it may rise to 80 or even to 90 or 95 per cent.

(3) Better methods of utilization will secure the same power or heat by the use of less coal.

(4) Other sources of power may meet part of the demand, such as water power, the sun's heat, wind and wave action, alcohol from vegetable matter, and other sources not yet recognized.

APPENDIX A.

RECENT ANALYSES OF INDIANA COAL.

In order not to burden the body of the report, and at the same time to make available the large amount of analytical work recently done on Indiana coals, this has been gathered together as an appendix where it can be readily referred to. The table includes many analyses made by the fuel-testing plant of the U. S. Geological Survey at St. Louis. These were made from mine samples and car samples. The former were made by cutting a strip the full thickness of the bed, and after throwing out such portions as are commonly rejected in mining, quartering the rest until a quart sample was obtained, when it was hermetically sealed and sent to the laboratory. The car samples were taken at the plant. The coal, after crushing, was elevated in a conveyor, and the sample was obtained by taking small shovelfuls at regular intervals from the conveyor buckets, mixing and quartering down to make a laboratory sample. They should therefore represent very closely the exact character of the coal and its delivery to the customer. There are also included a number of analyses made under the direction of the State Geological Survey. In most cases these were from properly sampled lots and are perfectly reliable. In a few cases they are from drillings or from samples sent in from interested parties. The methods of analyzing samples by the Technological Branch of the U. S. Geological Survey are fully described in the various bulletins issued by that branch.

Life of field if present rate were maintained, 1,000 years.

Rate of increase during last few years, about 1,000,000 tons a year.

Life of field if present rate of increase were maintained, 150 years.

Production the 150th year, about 169 million tons.

Considering the factors already discussed, it is probable that the life of the Indiana coal field will be not less than double the figure given, or, say, 300 years, and probably it will be more.

The principal reasons for believing that the life of the field will be longer than the 150 years on the basis of present conditions being maintained may be briefly summarized as follows:

(1) Thinner beds will be worked than are now considered workable, so that much coal that is now included in the figures on total coal, but not in the column of workable coal, will be transferred to that column.

(2) Better mining methods will insure a larger percentage of recovery, and smaller losses to overlying beds and outside districts, so that instead of estimating the recovery at 50 or 60 per cent, it may rise to 80 or even to 90 or 95 per cent.

(3) Better methods of utilization will secure the same power or heat by the use of less coal.

(4) Other sources of power may meet part of the demand, such as water power, the sun's heat, wind and wave action, alcohol from vegetable matter, and other sources not yet recognized.

Appendix B.

DESCRIPTIVE NOTES ON THE STRATIGRAPHIC CHART.

In Plate II the attempt is made to present, in a condensed form, a comprehensive view of the stratigraphy of the Indiana coal measures. By placing the sections close together somewhat the effect of a very broad generalized section is produced, while at the same time the local composition and variation is clearly indicated by the individual sections. In this way it is possible to get a comprehensive grasp of the relation of the coals to each other and to other rocks which it is hoped will enable the reader to himself apply to new local conditions in the field. The writer believes that such information is of much more value than a simple statement of supposed correlation, no matter how widely applied. The sections consist in some cases of single shaft, drill, or outcrop sections; more often they are combinations of two or all of these. In some cases a single section is the result of piecing together short sections obtained at different places; in others they are the result of averaging a number of sections covering the same interval. In some of these instances the result is the average of several scores of individual sections. To give the plate more local value additional notes are here added to the brief titles on the plate. The sections have been arranged from left to right in order from north to south, including a few sections from the Danville district of Illinois on the north at the left, and a few sections in the western Kentucky coal field on the south at the right. The scale of the sections is 80 feet to the mile, which is used as a convenient one in that an ordinary rule can readily determine the distance between any given members, as an eighth of an inch is equivalent to 10 feet.

Descriptions of Sections.—The numbers to follow apply to the several columns, beginning at the left. The letters, where used, apply to the individual sections in the several columns.

1. Danville, Ill. From a drilling near.
2. From a drilling at Pawnee, Ill.
3. From a drilling south of Westville, Ill.
4. A combination of exposures along Pine Creek and of sections at the mines on Fall Creek, west of Indiana Mineral Springs.

5. A combination of sections at several of the banks in Sections 3, 8 and 10 of 20 N., 9 W., lying a few miles northwest of Covington.
6. Section of outcrops in Section 38, 18 N., 9 W., on Coal Creek.
7. From outcrops on Silver Island, Section 34, 18 N., 9 W., a short distance west of Silverwood.
8. From outcrops and a drilling in the region of Hanging Rock and Coal Branch, northeast of Cayuga.
9. (A) From outcrops and drilling at the Horseshoe and below. (B) Section at Blacks, Section 22, 14 N., 5 W.
10. (A) From outcrops and drillings north and west of Hillsdale. (B) Section showing general relations on Sugar Creek.
11. (A) From mine shaft and drillings at Dana. (B) Section at the Parrot Mine, southwest of Hillsdale. (C) Outcrop on Sand Creek, northeast of Rockville. (D) Section at Reelsville, Section 21, 13 N., 4 W.
12. (A) Outcrop at Indiana Furnace, on Bruilett Creek, Section 33, 14 N., 10 W. (B) Drilling by the Brazil Block Coal Company south of Clinton, south edge of county. (C) Connected sections at Mecca, from exposures in the several ravines and shaft section. (D) Outcrop on Raccoon Creek.
13. (A) Combined section from outcrops, shaft and drilling records, on Bruilett Creek. (B) Combined section of outcrops, shaft sections, and drilling at Coxville, for the upper part of the section, while the lower part is made up from outcrops and drillings at Minshall. The sections are tied together on the supposition that the drilling at Coxville reaches the Upper Minshall coal.
14. (A) Generalized section from a large number of drillings and shaft sections in the Clinton district. (B) Section of Superior No. 2 shaft at Caseyville, Section 35, 14 N., 7 W. (C) Outcrops at Cataract, Owen County, Section 2, 11 N., 4 W.
15. (A) An average section from a large number of drillings and shaft sections in Fayette Township of Vigo County. (B) An outcrop section from Buzzard Gulch, Owen County, Sec. 6, 10 N., 4 W.
16. (A) Section of the old Hartford shaft at Pimento. (B) Section of the Fleshner shaft, Section 7, 11 N., 8 W. (C)

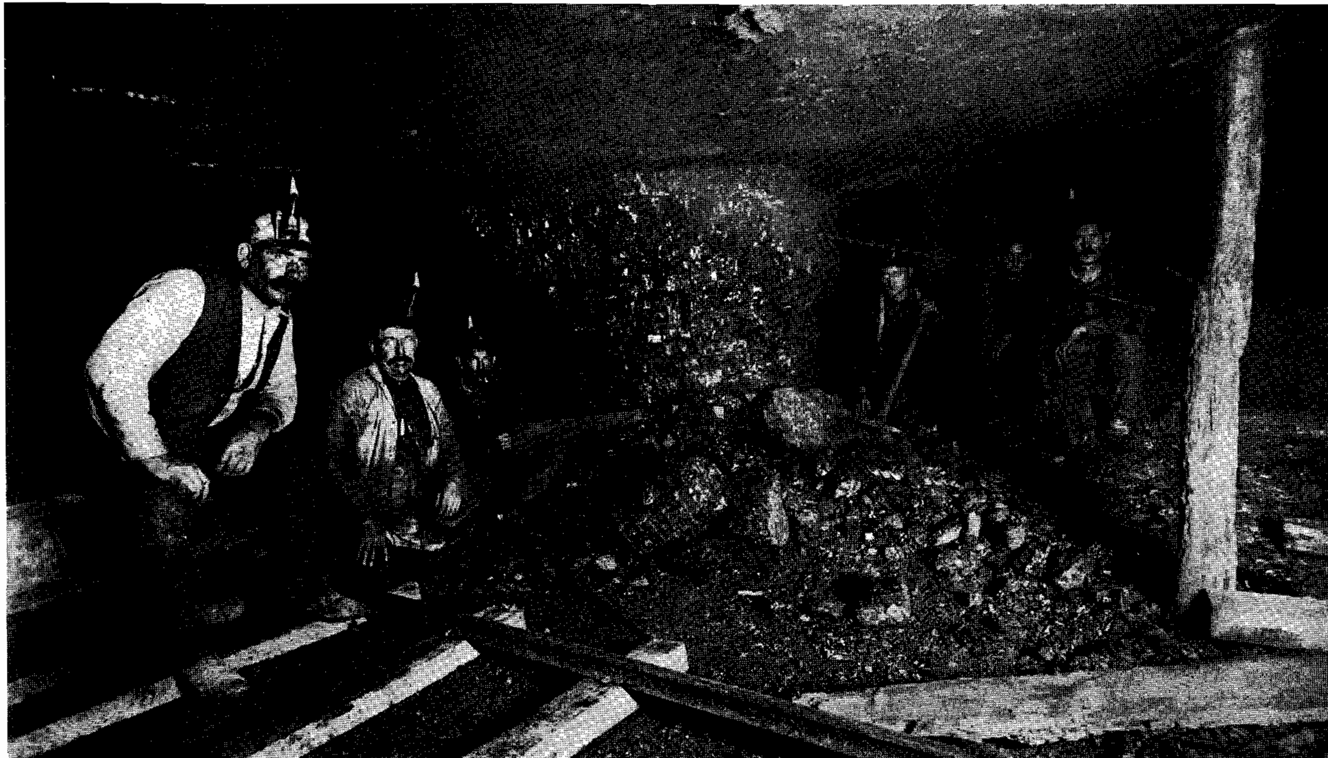
An average section of a large number of shaft sections combined with outcrops and drillings in Nevins Township of Vigo County, and Dick Johnson Township of Clay County. (D) Section from Ritters Hill and Freedom in Spencer County, Section 20, 9 N., 4 W.

17. (A) An outcrop section from Sugar Creek in western Vigo County. (B) Outcrop and shaft sections at Riley, southeastern Vigo County. (C) Bore on the John Harris place, in southern Clay County, Section 20, 10 N., 7 W. (D) A combined section from the Brazil district, made up from shaft and drill records in the Stanton-Turner region, combined with shaft and drill records around Brazil, and outcrops on Croys Creek, east of Brazil.
18. (A) An average section from outcrops, shaft sections, and drillings in Sugar Creek Township in the West Terre Haute district. (B) Section of the old Center Point shaft at Center Point, Clay County. (C) An outcrop from Cemetery Hill, at Greencastle, Section 28, 14 N., 4 W.
19. (A) Section at the Dix Bank on Turman Creek, Section 26, 9 N., 10 W. (B) Outcrop and shaft section at Sanford Hill, Section 1, 10 N., 9 W. (C) Section of the shaft at Hymera. (D) A section of the shafts at Seelyville, and a drilling from the bottom of the old Seelyville shaft. (E) Outcrop on the Lansford place in Owen County, Section 24, 9 N., 5 W.
20. (A) Section of the Pioneer shaft at Curriesville. (B) Combined section of outcrops and drillings around Lewis and Clay City. At Clay City the section at Middlebury is not tied into the section at the Harrison mines to the east, an interval of unknown extent coming between the two sections. (C) Section on the H. T. Weathers place, Section 12, 12 N., 5 W.
21. (A) Generalized section of the Farmersville district and the north-central edge of Sullivan County. (B) Section at Needy Bank, Section 17, 9 N., 5 W.
22. (A) A section of the cliff at Merom, Sullivan County, combined with a shallow shaft at that point. (B) Part of a section of the Farnsworth shaft. (C) A generalized section of drillings around Jasonville and eastward to Howesville, including the Howesville shaft. (D) A section on Beech Creek, eastern Greene County, Section 14, 7 N., 5 W.

23. (A) Generalized section of a large amount of drilling in Fairbanks, Turman and Hamilton townships, Sullivan County. (B) Section of the old Coal City shaft, Section 11, 9 N., 6 W.
24. (A) Generalized section from drillings and shaft sections in the region about Sullivan. (B) A drilling on the edge of Switz City, Greene County. (C) An outcrop section at the Sexton place, Section 15, 6 N., 3 W.
25. (A) Section at the Barnes place on Turman Creek, Section 9, 8 N., 10 W. (B) Section made up from a large number of shaft sections and drillings in Cass Township, Sullivan County. (C) Drilling record from near the Lundy mine, southwest of Switz City, Greene County. (D) An outcrop section near the Monon tunnel, southeast corner of Greene County, Section 28, 6 N., 3 W.
26. (A) A section of the shaft at Carlisle. (B) A section combined from drillings at Lines, Section 4, 6 N., 6 W.
27. (A) Outcrop near the Narrows of Wabash River, Section 25, 9 N., 11 W. (B) Combined section of shafts and drillings at Edwardsport, Knox County. (C) Combined section at Raglesville, northeastern Daviess County.
28. (A) Combined from drillings about Bruceville and Bicknell. The upper part of the section is taken from the neighborhood of Bruceville, and the lower part from a large number of drillings about Bicknell. (B) Section of Sampson Hill, Martin County, southeast of Shoals.
29 (A) Section of a core drilling at Vincennes. (B) Generalized section of Orange County.
30. (A) Section at Mantel place, Donation 10, east of Vincennes. (B) Section of a drilling 3 miles south of Bicknell. (C) Section of a drilling at Chelsea, near the B. & O. S-W. R. R., between Washington and Montgomery.
31. (A) Section from the shaft at Wheatland and outcrops along the river northeast of that town. (B) Section of the shaft at Montgomery. (C) Section of the Mutual mine shaft at Cannelburg. (D) Section of the cliff north of Shoals.
32. (A) Section of Cox Hill, Section 8, 4 N., 8 W. (B) A drilling on the Williams place, Section 35, 2 N., 8 W. (C) Section of the shafts at Washington, combined with a deep core drilling near the C. & K. No. 4 mine.

33. (A) Section combined from exposures in the hill of shaft and boring at Bunker Hill, Knox County, Section 28, 3 N., 10 W. (B) A generalized section from outcrops about Petersburg and Sand Hill combined with an oil drilling at the Wooley mine. The coals in this drilling are not represented the full width of the section, to imply that the data in regard to them is not overreliable.
34. (A) Section at the Hoffman Bank, 1 mile south of Bruceville, on Donation 183. (B) Section from outcrops and drillings near Hosmer, Pike County. (C) Section on Mud Creek, one-half mile southeast of Glendale. (D) Section of the shaft at Alfordsville.
35. (A) A section at Patoka, in Gibson County. (B) A partial section at the Bird mine at Francisco. (C) A combined section from Dongola and the hill east of the south fork of Patoka River, east of Oakland. (D) Section at the Cross place, on Aikman Creek, Daviess County, Section 17, 2 S., 6 W. (E) Section at High Rock, in southeastern Daviess County, on White River, Section 18, 1 N., 5 W.
36. (A) Section from outcrops and boring at Hazelton, Gibson County, Donation 101. (B) Section derived from a number of borings in the Arcadia district. (C) Combined section from those obtained at several of the whetstone quarries in Orange County.
37. Generalized section of Gibson County, as given in the Patoka Folio of the U. S. Geological Survey, combined with the drillings for oil at Princeton. As at Petersburg, the coals in the lower part of this section are not carried across the section on account of the general unreliable character of coals reported from oil drillings.
38. (A) Section of the shaft at Fort Branch. (B) A section at Pikeville, extending north to Patoka River. (C) A section at Huntingburg, Dubois County, extending from the top of Standpipe Hill to the coal in the shaft. This section is not overreliable.
39. (A) Section at Somerville from outcrops in the hills at that point, combined with a drilling there. (B) Outcrop section on Rock Creek, southeast of Pikeville, combined with a section on the road west of the bridge across Patoka River, northeast of Duff.

40. (A) Section at Lynnville, made from sections of the hills to the north, combined with drilling at that point. (B) An outcrop section at St. Meinrad, Spencer County.
41. (A) Section at Millersburg, Warrick County. (B) Generalized section of eastern Pike County, as given in the Ditney folio of the U. S. Geological Survey. (C) ——. (D) Section of Little Deer Creek, Sections 12 and 13, 6 S., 3 W.
42. (A) Section at Babytown, northwest of Evansville. (B) Section from outcrops and a drilling at Scalesville. This section is of interest in showing the unreliability of reported thicknesses of coal as given in the record of drillings for oil and gas. A drilling near Scalesville had reported 6 feet of coal at a depth of 25 feet; 11 feet of coal, with a sandstone roof, at 100 feet; 7 feet of Cannel coal, with a black shale roof, at 130 feet; 4 feet of coal, with a limestone roof, at 250 feet, the record stating that they had "dry-holed through all veins except first." The section shown was obtained from a diamond core drilling put down close to this oil well drilling to test the accuracy of the report made for that. (C) Section of a well in Holland, Dubois County. (D) Section at the Reed Bank, Perry County, Section 26, 6 S., 3 W.
43. (A) Section from outcroppings and a shaft at Priests Bluff, Section 19, 7 S., 11 W. (B) Section from drillings and outcrops at Boonville. (C) Section from the shaft and outcrops at the Lloyd mine on Big Sandy Creek, in southern Spencer County. (D) Section of the hill east of Troy, Perry County.
44. (A) Section of the shafts at Chandler. (B) Section of a drilling in the top of the hill west of Jasper. (C) Section of Gage Hill, southwest of Maxville, Spencer County.
45. (A) Section made by combining outcrops with shaft section and a drilling at Newburg, Warrick County. (B) A generalized section of Cannelton, Perry County.
46. Generalized section of the Evansville-Henderson district, derived from shaft sections and drill records.
47. From a detailed diamond core drilling at Mount Vernon, Posey County.
48. Section obtained by Mr. F. W. DeWolf and the writer at Corydon, Ky.
49. Section obtained in the same way at Madisonville, Ky.



Drawing a Pillar in Green Valley Mine, near Jasonville, Ind.

REPORT OF THE STATE INSPECTOR OF MINES FOR THE YEAR 1908.

BY

JAMES EPPERSON

Office of Inspector of Mines,
Indianapolis, February 25, 1909.

PROF. W. S. BLATCHLEY, *State Geologist:*

Dear Sir—I have the honor to submit to you herewith my tenth annual report as Inspector of Mines, covering the calendar year of 1908, and being the Thirtieth Annual Report of this department and the eighteenth made to the Department of Geology and Natural Resources.

I trust it will receive your approval and be found worthy of consideration by the public.

JAMES EPPERSON,
Inspector of Mines.

CONTENTS.

	PAGE.
Letter of transmittal	154
Introduction	156
Summary	156
Conditions of coal trade	158
Average wage table	159
Strikes	161
Terre Haute agreement	163
Brazil agreement	173
Monthly table production wages	182
Changes in ownership	184
New Mines	185
Old Mines re-equipped	188
Improvements	188
Abandoned Mines	188
General table production wages	191
Employes table	205
Table showing kegs of powder used in block machine mines	210
Table showing kegs of powder used in Hand Mines	210
Table showing kegs of powder used in Bituminous machine mines	210
Table showing kegs of powder used in Bituminous hand mines	210
Geological table of mines	211
Examinations	218
Accidents to Mine employes	222
Table showing causes of accidents to employes	222
Summary of Fatal accidents	242
Comparative table of fatal accidents 1898 to 1908	244
Permanent accidents	245
Serious accidents	246
Table showing occupations of persons killed or injured	256
Table showing nationality of persons killed or injured	256
Legislation and its effect on Mine accidents	257
Accidents to mine property	267
Mine Directory	270

Thirtieth Annual Report of the Inspector of Mines for the State of Indiana.

STATISTICS OF COAL, LABOR AND MINE CASUALTIES, LEGISLATION AND GENERAL INFORMATION RELATING TO THE MINING INDUSTRY FOR THE YEAR ENDING DECEMBER 31, 1908.

In compiling this report we include only such matters as we think will be of interest to the general public. In many instances the subject and the manner in which it has been treated was suggested through numerous inquiries made of the department for certain information concerning Mines and Mining.

The various statistical tables relating to coal production, labor, wages, mules, powder and mine casualties have been given along the same general lines as in our former reports, including certain additional information and improvement on their arrangement.

In treating the subject of legislation we comment on certain mining laws enacted, amendments needed, the repeal of the drill bitt law and the effect mine legislation may have in preventing accidents to employes.

A reference to the various subjects included in the report will be found in the following summary, which contains most of the totals for the State for the year:

SUMMARY FOR THE YEAR 1908.

Number of coal producing counties	18
Number of counties having shipping mines	14
Number of coal seams operated in the State	6
Number of new coal companies organized	11
Total number of coal companies operating in the State	104
Number of new block coal mines opened	1
Number of new bituminous mines opened	11
Number of block coal mines abandoned	7
Number of bituminous mines abandoned	21
Number of old bituminous mines re-equipped	2
Number of block coal mines in operation	29
Number of block coal mines idle	2
Number of bituminous mines in operation	139
Number of bituminous mines idle	18
Number of electric chain machine mines	62

Number of compressed air punching machine mines	11
Total number of machine mines	73
Total number of hand mines	115
Total number of mines employing more than ten men	138
Number of pick miners block coal mines	1,207
Number of pick miners bituminous mines	7,452
Number of machine runners and helpers block mines	34
Number of machine runners and helpers bituminous mines	924
Number of loaders block coal mines	98
Number of loaders bituminous mines	3,819
Number of inside day and monthly men block mines	400
Number of inside day and monthly men bituminous mines	3,607
Number of outside day and monthly men block mines	166
Number of outside day and monthly men bituminous mines	1,385
Total number of employes	19,092
Number of kegs powder used in block coal mines	43,213
Number of kegs powder used in bituminous mines	358,134
Total number of kegs powder used in the State	401,347
Total number of days mines were operated	27,037
Tons hand mined block coal	736,668
Tons machine mined block coal	116,292
Total tons block coal	852,960
Tons screened coal, bituminous, hand mined	2,097,681
Tons slack and nut coal, bituminous, hand mined	1,302,909
Tons mine-run coal, bituminous, hand mined	2,491,135
Total tons hand mined bituminous coal	5,891,725
Tons screened coal, bituminous, machine mined	1,657,918
Tons slack and nut coal, bituminous, machine mined	900,014
Tons mine-run coal, bituminous, machine mined	2,694,687
Total tons machine mined bituminous coal	5,252,619
Total tons bituminous coal produced	11,144,344
Total production for the State	11,997,304
Tons block coal shipped outside the State	498,803
Tons block coal consumed in the State	354,157
Tons bituminous coal shipped outside the State	4,778,512
Tons bituminous coal consumed in the State	6,365,832
Total tons coal shipped outside the State	5,277,315
Total tons coal consumed in the State	6,719,989
Wages paid to miners	$6,947,641 79
Wages paid to inside employes	$2,391,528 77
Wages paid to outside employes	$965,698 88
Total wages paid to employes	$10,304,869 44
Total money expended on improvements	$75,000 00
Number of fatal accidents	45
Number of permanent accidents	3
Number of serious accidents	375
Number of minor accidents	452
Number of accidents to mine employes	875
Number of accidents to mine property	13

CONDITIONS OF COAL TRADE.

The demands for coal, market prices, mining conditions and the conditions of coal trade in general throughout the State for 1908 were exceptionally poor, as relating to both miners and operators. The slack trade was due to the large number of factory and other consmers of coal closing down and the low prices to the extremely sharp competition in securing trade. A number of the largest producing mines were closed down the entire year and a number operated less than half time. The wage scale being made a year previous when better mining conditions prevailed, was the highest in the history of the State, thus the operator faced the proposition of unusually slack market demands, high prices paid for labor and low prices for his product. The miner faced the proposition of a high wage scale and a slack demand for his services.

The total production for the year was 11,997,304 tons, or a decrease of 2,253,411 tons under 1907. Of this tonnage 11,144,344 tons were bituminous coal, a reduction of 1,231,138 tons of 9.9% under 1907; and 852,960 tons of block coal, a decrease of 22,273 tons or 2.6% under 1908.

The total wages reported for the bituminous coal was $9,268,-922.62, a cost of 83.1+ cents per ton for production. The total wages reported from the Block coal mines was $1,035,946.62, or a cost of $1.20 per ton for production. The selling prices for bituminous coal during the year, ranging from 95 cents to $1.20 for mine-run coal, a probable average would be $1.10 per ton. Block coal prices ranged from $2.00 to $2.75 per ton for screened coal F. O. B. cars at mine; a fair average would probably be $2.35 per ton.

Our report shows a total of 19,092 employes, an increase of 83 employes over 1907, and an aggregate of $10,304,869.44 in wages, or an average of $539.74 per mine employe, which shows a reduction of $76.69 per employe under 1907. Added to the large reduction in the average earnings of employes, the prices of living were much higher than in 1907.

The average wages of all classes of mine employes are given in the following table:

TABLE

Exhibiting the Number of Miners, the Number of Inside Day and Monthly Men, the Total Wages Earned by Same and Average Earnings per Employe, in the Block and Bituminous Mines, Each Exhibited Separately.

BLOCK COAL MACHINE MINES.

COUNTY.	Number of Miners.	Total Wages.	Average Wages.	Number of Inside Employes.	Total Wages.	Average Wages.	Number of Outside Employes.	Total Wages.	Average Wages.
Parke	68	$49,294 91	$724 92	37	$23,150 00	$625 67	12	$10,804 19	$900 35
Vigo	167	77,359 81	463 23	53	32,688 43	616 76	25	12,214 98	488 59
General average block machine mines	235	$126,654 72	$538 95	90	$55,838 43	$620 42	37	$23,019 17	$622 13

BLOCK COAL HAND MINES.

COUNTY.	Number of Miners.	Total Wages.	Average Wages.	Number of Inside Employes.	Total Wages.	Average Wages.	Number of Outside Employes.	Total Wages.	Average Wages.
Clay	792	$376,325 52	$475 15	208	$140,276 47	$674 40	94	$72,177 38	$767 84
Parke	342	150,953 03	441 38	102	57,714 97	565 83	35	32,986 93	942 48
General average hand block mines	1,134	$527,278 55	$464 97	310	$197,991 44	$638 68	129	$105,164 31	$815 22
General average block coal mines	1,369	$653,933 27	$477 67	400	$253,829 87	$634 57	166	$128,183 48	$772 18

TABLE EXHIBITING NUMBER OF MINERS, ETC.—Continued.

BITUMINOUS HAND MINES.

COUNTY.	Number of Miners.	Total Wages.	Average Wages.	Number of Inside Employes.	Total Wages.	Average Wages.	Number of Outside Employes.	Total Wages.	Average Wages.
Clay	321	$137,309 36	$427 77	94	$39,213 46	$417 16	35	$12,698 88	$362 53
Daviess	109	36,172 90	331 86	21	12,320 96	586 71	19	9,579 35	504 17
Fountain	39	11,463 36	293 93	12	6,023 96	501 99	5	980 88	196 17
Greene	533	210,576 83	395 07	146	55,749 33	381 84	60	29,320 70	488 67
Gibson	134	107,876 63	805 05	53	42,716 59	805 97	22	12,546 02	570 27
Knox	56	20,774 36	370 98	15	6,488 71	432 58	7	3,997 28	571 04
Parke	155	81,332 57	524 72	63	27,817 41	441 54	16	10,621 68	663 85
Perry	15	2,667 45	177 83	3	819 72	273 24	3	531 80	177 26
Pike	441	195,704 12	443 77	114	60,184 11	527 93	57	26,025 17	456 58
Sullivan	321	82,158 64	255 94	112	33,711 17	300 99	56	18,075 06	322 76
Vanderburgh	309	174,799 76	565 69	79	53,224 52	673 72	50	38,210 94	764 21
Vermillion	1,193	695,298 08	582 81	305	204,042 96	668 99	73	46,689 01	639 57
Vigo	2,014	1,114,578 72	553 41	514	340,957 62	663 34	163	112,703 88	691 43
Warrick	150	66,234 11	441 56	22	15,230 96	692 31	21	9,970 06	474 76
General average of bituminous hand mines	5,790	$2,937,046 89	$507 26	1,553	$898,541 48	$578 58	587	$331,950 67	$565 50

BITUMINOUS MACHINE MINES.

COUNTY.	Number of Miners.	Total Wages.	Average Wages.	Number of Inside Employes.	Total Wages.	Average Wages.	Number of Outside Employes.	Total Wages.	Average Wages.
Clay	347	$114,421 16	$329 74	83	$60,560 95	$729 65	39	$44,303 47	$1,135 98
Greene	1,859	1,002,139 93	539 07	603	341,186 61	565 81	198	28,961 98	146 27
Knox	347	173,869 31	501 05	154	57,051 83	370 46	52	36,777 62	707 26
Parke	187	122,810 30	656 73	68	53,320 70	784 12	24	19,118 87	796 61
Pike	83	39,791 33	479 41	19	14,250 91	750 04	15	10,010 42	667 36
Sullivan	2,300	1,331,548 91	578 93	813	537,850 07	661 56	314	190,207 00	605 75
Vermillion	72	45,662 54	634 20	15	17,024 15	1,134 94	9	3,326 25	369 58
Vigo	829	385,371 12	464 86	223	117,849 48	528 47	91	45,740 79	502 64
Warrick	351	141,047 03	401 84	76	40,062 72	527 14	56	27,118 33	484 25
General average Bituminous machine mines	6,375	$3,356,661 63	$526 53	2,054	$1,239,157 42	$603 28	798	$505,564 73	$633 53
Total general average Bituminous mines	12,165	$6,293,708 52	$517 36	3,607	$2,137,698 90	$592 65	1,385	$837,515 40	$604 70
Total general average per all mines	13,534	$6,947,641 79	$513 34	4,007	$2,391,528 77	$596 83	1,551	$965,698 88	$622 63

NOTE.—Machine runners, helpers and loaders are classed as miners.

STRIKES.

There were a number of strikes in different parts of the State during the year, but with two exceptions, they affected only individual mines and were of but a few days' duration.

The two exceptions noted were the general strike in the Bituminous fields and the Hudson Mine strike. We have been unable to secure complete data on these strikes and can give but a brief outline as to the cause and the adjustment of each difficulty.

STRIKE IN DISTRICT NO. 11.

The International Convention of the United Mine Workers of America convened in Indianapolis January 18th, at which meeting it was agreed that the members of the organization in different States or localities should open negotiations with the operators in their respective districts with a view to securing a new wage agreement to become effective at the expiration of the contract then in force.

Pursuant to the Indianapolis agreement, the block coal miners and operators comprising District No. 8 met in joint convention March the 28th and formulated a scale covering the ensuing two years, and work continued in that district without interruption.

The bituminous miners and operators of District No. 11 met in joint convention April 1st, but failed to reach an agreement.

During the time this conference was in progress International President W. T. Lewis succeeded in arranging for a joint conference of the miners and operators of Ohio, Indiana and Western Pennsylvania, to be held in Toledo, Ohio, April 17th. At this conference the mining rates, day wage scale and general prices in existence in 1908 were reaffirmed, internal differences, however, both as to prices and conditions, were referred for adjustment to the different districts affected. There were a number of differences, "mainly relating to conditions," existing between the Indiana operators and miners, and the endeavor to reach an agreement was continued either in convention or through the officers and committees of the two organziations, the mines continuing in operation pending the outcome.

This condition prevailed until May the 12th, when all negotiations were broken off by the miners voting in convention a strike to take effect the 15th following. The miners came out as per vote of the convention, and the strike continued until the 28th, at which time President Lewis succeeded in having the strike order rescinded. When this was done, negotiations were again opened between the contending parties, and after a three days' convention a contract was agreed upon, covering the period from April 1, 1908, to April 1, 1910.

Strike at the Hudson Mine.

During the month of August a controversy between one of the drivers and the mine boss at this mine arose over the former refusing to haul coal under a piece of slate which he claimed was loose and dangerous on one of the haulage roads; the mine boss contended that the slate was not dangerous, and discharged the driver for refusing to drive under it.

The miners demanded that the driver be reinstated, and on the mine boss refusing to conform to the demand, a strike was called. The Bituminous Operators' Association declared the strike was called in violation of contract provisions and notified the national officers of the Miners' Organization that contract relations would cease until the mine had resumed work, pending a settlement of the controversy through the proper channels as provided for in the contract between the two organizations.

In order that their relations be restored and the conditions of the contract be observed, National President Lewis requested of W. D. Van Horn, State President of the Miners' Organization, that he order the mine to resume work, after which they would take up the case in dispute in the proper manner. Van Horn refused to accede to the request, and President Lewis then appealed to the Hudson Mine Local Union, who also refused to be governed by their National President, whereupon President Lewis took away their charter.

The strike was continued until November 24th, when a settlement was arrived at by the company reinstating the discharged driver.

Agreements.

We give herewith copies of the Terre Haute and Brazil agreements made between the Operators and Miners of District 8 in the Block Coal field and District 11 in the Bituminous field:

TERRE HAUTE AGREEMENT

Arranged and adopted by and between the United Mine Workers of District 11 and the Indiana Bituminous Coal Operators' Association, effective during the scale years from April 1, 1908, to April 1, 1910.

It is hereby agreed:

ARTICLE I.

Section 1. That the bituminous coal district of Indiana shall pay fifty-five cents (55 cents) per ton for all mine-run coal loaded and shipped as such. All other coal mined in that district shall be passed over regulation screen and be paid for at the rate of ninety cents (90 cents) per ton of two thousand (2,000) pounds for screened lump.

Sec. 2. The standard height of coal in Indiana shall be 3 feet 3 inches in mines opened prior to April 1, 1901, and in mines opened since April 1, 1901, the standard height shall be 3 feet 6 inches. All coal less than 3 feet 3 inches in thickness and over 2 feet 9 inches, the price shall be 98 cents per ton for screened lump coal, and 64 cents per ton for mine-run coal. All coal less than 2 feet 9 inches and down to 2 feet 6 inches the price shall be 106 cents per ton for screened lump coal and 65 cents per ton for mine-run coal.

Sec. 3. That the screen hereby adopted for the bituminous district of Indiana shall be uniform in size, six (6) feet wide by twelve (12) feet long, built of flat or Akron-shaped bar, of not less than five-eighths (⅝) of an inch surface, with one and one-fourth (1¼) inches between bars, free from obstructions, and that such screens shall rest upon a sufficient number of bearings to hold the bars in proper position.

ARTICLE II.

MACHINE MINING.

Price Per Ton for Machine Mining for Punching Machine.

Vandalia track and north thereof:

Section 1. Screened Lump—Runner, 11½ cents; helper, 10½ cents; loading, shooting and timbering, 50 cents. Total, 72 cents.

Sec. 2. Run of Mine—Runner, 7½ cents; helper, 7 cents; loading, shooting and timbering, 30½ cents. Total, 45 cents.

South of Vandalia track:

Sec. 3. Screened Lump—Runner, 10½ cents; helper, 9 3/10 cents; loading, shooting and timbering, 52 2/10 cents. Total, 72 cents.

Sec. 4. Run of Mine—Runner, 6 6/10 cents; helper, 6 1/10 cents; loading, shooting and timbering, 32 3/10 cents. Total, 45 cents.

For Chain Machine.

Sec. 5. Screened Lump—Runner, 6¼ cents; helper, 6¼ cents; loading, shooting and timbering, 56 cents. Total, 68½ cents.

Sec. 6. Run of Mine—Runner, 4 cents; helper, 4 cents; loading, shooting and timbering, 34½ cents. Total, 42½ cents.

Sec. 7. Machine shovels shall be furnished by the operators, but when replaced the old shovels must be returned, and in case of careless breaking or destruction the helper shall pay for the shovel so destroyed. Coal companies shall also furnish coal shovels for the machines when the use of such shovels is demanded by the company.

Day Work for Punching Machines.

Sec. 8. Machine work, when paid for by the day, shall be for machine runner, $3.17; helper, $2.56.

Day Work, Chain or Cutter Bar Machine.

Sec. 9. When paid for by the day shall be, for machine runner, $3.01; helper, $3.01. Day work by machines shall apply only to opening new mines and defective work, such as horsebacks, etc.

ARTICLE III.

Yardage and Room Turning Machine.

Section 1. In entries 7 to 9 feet wide, $1.34; in entries 12 feet wide, ⅝ of price of narrow entries, or 83¼ cents. Narrow work after punching machines shall be sheared when demanded by the operator. Narrow work after the chain machine must be done in a workmanlike manner.

Sec. 2. Break-throughs between entries same as entry prices. Break-throughs between rooms shall be paid for at same price when similarly driven.

Sec. 3. In narrow entries and narrow break-throughs between entries in chain machine mines the loader shall receive $1.18 per yard and the machine runner and helper each 8 cents per yard, and in wide entries the same proportion. In entries and break-throughs between entries in punching machine mines the loaders shall receive $1.14 per yard and the runner and helper each 10 cents per yard, except where coal is sheared, in which case the runner and helper shall receive all the yardage, and where machines are worked by the day the loaders shall receive all the yardage.

Room Turning—Machine Mines.

Sec. 4. Room turning, $3.37½. Room necks to be driven 12 feet in and widened at an angle of 45 degrees when so desired by operators. Any distance in excess of above shall be paid for proportionately, but no room neck shall exceed 15 feet. When room necks are driven 12 feet wide, price shall be ⅝ of regular price, or $2.10.

ARTICLE IV.

Yardage and Room Turning—Pick Mines.

Section 1. Narrow entries 7 to 9 feet wide, $1.86¾ per yard. Wide entries 12 feet wide, $1.16½ per yard.

Sec. 2. Wide entries shall not be more than 13 feet nor less than 11 feet. In the event of a 10 or 11-foot entry being demanded by the operator, narrow entry prices shall be paid, if 14, 15, 16 or 17-feet entries are demanded the wide price shall be paid.

Sec. 3. Break-throughs between entries shall be paid for at entry prices. Break-throughs between rooms, when sheared or blocked, shall be paid for at entry prices, but no break-throughs shall be driven without consent of the operators. Nothing herein shall interfere with the law governing break-throughs.

Sec. 4. Room turning, $4.50. Room necks to be driven 12 feet in and widened at an angle of 45 degrees when so desired by the operator. Any distance in excess of above shall be paid for proportionately, but no room neck shall exceed 15 feet. When room necks are driven 12 feet wide the price shall be 5/8 of regular price, or $2.81¼, and the right of the operators to drive an 18-foot room when necessary shall not be questioned.

Sec. 5. The price for mining herein agreed to for pick and machine work shall include all labor necessary to cut the coal, drill and blast the same, load it on the miner's car and properly care for and timber the miner's working place, and no division of the scale shall carry any exception to this rule. In case a miner fails to properly timber, shoot and care for his working place so any of the company's property is injured, the miner whose fault has occasioned such damage shall repair the same without compensation. Provided, however, that where shot-firers are employed and partially paid by the company the condition shall continue during the life of this agreement.

Blacksmithing.

Sec. 6. Price of blacksmithing shall be 1¼ cents on the dollar. Sharpening shall be done in a workmanlike manner, and men shall not have to wait for their tools.

ARTICLE V.

Day Labor.

Section 1. The wages of inside day labor shall be $2.56 per day of eight hours where and when men are employed, except as herein provided.

Sec. 2. The wages of spike team drivers shall be $2.80 per day. The drivers shall take their mules to and from the stables, and the time required in so doing shall not include any part of the day's labor, their work beginning when they reach the change at which they receive empty cars, but in no case shall a driver's time be docked while he is waiting for such cars at the point named.

Sec. 3. The wages of motor men shall be $3.01 per day, and trappers $1.13 per day.

Sec. 4. The wages of outside men except as herein provided shall be $2.02½ per day of eight hours on and north of the B. & O. S. W. R. R., and south of the B. & O. S. W. R. R. the wages shall be 20¼ cents per hour.

Sec. 5. The blacksmith's wages shall be $2.94 per day of nine hours at all mines north of the B. & O. S. W. R. R., and in addition to his ordinary duties he shall do any other labor required of him by the mine management. Provided, however, that he shall receive his regular wages therefor.

Sec. 6. All day men shall at all times do and perform any and all kinds of labor required of them by the mine management. Provided, however, that on idle days men shall have an equal division of the work they usually perform when the mine hoists, and where men are employed as drivers, cagers and motor men they shall have an equal share of all extra work, such as cleaning roads, getting in rails, timber or any other work required of them, when the same does not interfere with the work of other men, and day work shall be done on idle days and in cases of emergency on overtime.

Sec. 7. In the absence of any driver, any miner who can drive shall be expected to do so when requested. Any miner leaving his place to drive shall be permitted to load one car for each day that he drives.

Sec. 8. All day laborers working at the mines, excepting weighmasters, head flat-trimmer, dumper, fire bosses and boss drivers, who shall be regarded strictly as company men, shall be recognized as members of the U. M. W. of A. In emergencies or in the absence of any regular employe the right of the operator to employ men not members of the U. M. W. of A. for outside day labor shall not be questioned. Any and all flat-trimmers shall dock for dirty coal.

Sec. 9. The above scale is based upon an eight-hour work day; that it is definitely understood that this shall mean eight hours' work at the face, exclusive of the noon time, six days in the week, and that no local ruling shall in any way deviate from this agreement or impose conditions affecting the same, but any class of day labor may be paid at the option of the operator for the number of hours and fraction thereof actually worked at the hour rate, based on one-eighth of the scale rate per day; provided, that when men go into the mine in the morning they shall be entitled to two hours' pay whether the mine works or not, excepting in event of a mine being closed down by action of any member or members of the U. M. W. of A. the two hours' pay shall be forfeited.

ARTICLE VI.

Engineers' Wages and Their Duties.

The engineers' wages shall be:

Section 1. First engineer, $84.37; second engineer, $73.13; third engineer, $67.50.

Sec. 2. Eight hours shall constitute a day's work, but the engineers shall outside of regular hours hoist and lower the men, and in addition shall perform all the duties which necessarily and usually pertain and belong to an engineer's position, and shall not receive any extra pay therefor. It is agreed further that no hoisting engineer shall be subjected to the interference or dictates of the mine committee nor the local unions, but all the differences between the engineer and his employer shall be adjusted by the officers of the U. M. W. of A. and employer interested.

Sec. 3. In case of either local or general suspension of mining, either at the expiration of this contract or otherwise, the engineers shall not suspend work, but shall, when mining is suspended, fully protect all of the company's property under their care, and operate fans and pumps, and lower and hoist such men, mules or supplies as may be required, and any and all coal required to keep up steam at the company's coal plants, but it is understood and agreed that the operators will not ask them to hoist any coal produced for sale on the market, and there shall be no change in engineers' wages during the suspension.

Sec. 4. All hoisting engineers at pick mines shall do the firing where the production does not exceed 300 tons of coal per day, and at machine mines in process of development until the production shall have reached 200 tons per day. Engineers shall do the firing on idle days at the option of operator, except when dynamos or compressors are being run to furnish power to operate mining machines to cut coal, but the services of the fireman shall not be dispensed with where a mine ceases hoisting coal in the midst of a shift.

Sec. 5. The wages of firemen shall be: Per day of 10 hours, $2.45; per month, $65; per night of 12 hours, $2.35; per month, $63.50. The day firemen shall do and perform any service required of them by the mine management, and shall be entitled to an equal division of labor with other outside day men on idle days at such labor as they are competent to perform, and the night fireman, or watchman, in addition to his other duties, shall be responsible for the pumps within a distance of 250 feet from the main shaft bottom, and shall go into the mine when necessary to start them.

ARTICLE VII.

Dead Work.

Section 1. It is agreed that the companies shall have the working places as dry as local conditions will permit, and said working places shall be in working condition at time of starting work in the morning. If any company shall fail to have said working places dry or reasonably so one hour after starting time two successive days, the company shall, if said failure is traceable to neglect or carelessness of the company's agent, give miner or miners so affected other work or pay him or them for time so lost.

Sec. 2. The question of slate in or over the coal shall be and is regarded a local question to be taken up and adjusted by the methods provided in the annual Terre Haute agreement for the settlement of disputes. Provided, however, that established usages and prevailing conditions shall not be changed except in new mines where they have not been considered and adjusted.

Sec. 3. Where bottom coal is excessively hard to take up the operator shall have the option. If he demands that it be taken up he shall pay extra therefor: Provided, that where coal so left shall exceed 4 inches in thickness it shall be taken up by the loaders and paid for by the machine men, but this shall not apply when caused by sulphur boulders, rock or any unusual condition. And whenever there shall arise a dispute between any loader and boss, or committee and boss as to whether the bottom coal in any room is "excessively hard," the company interested shall select a man who shall take up one-third of such bottom coal, and if by such test it requires more than forty minutes to take up all the bottom coal in such room then the loader shall be paid at the rate of 32 cents per hour for such time so required in excess of forty minutes. This is to apply to the No. 4 vein of Linton coal.

Sec. 4. In mines where it is necessary to remove top or bottom in working places, commonly known as brushing, the following scale shall be paid:

Sec. 5. When necessary to shoot top or bottom in entries 9 inches in thickness, 45 cents per yard, and 5 cents per inch per yard for any additional thickness. In rooms where necessary to shoot 9 inches in thickness, 36 cents per yard, and for each additional inch 4 cents.

Sec. 6. When brushing is necessary and can be done without shooting the price in entries shall be 4 cents per inch per yard, and in rooms 3 cents per inch per yard.

Sec. 7. No brushing shall be done nor paid for without ordered and amount specified by the mine boss. The miner doing the brushing in entries shall load or "gob" the same, as directed by the mine boss. In rooms the miner shall "gob" the refuse. Brushing shall be six feet wide in entries and five feet wide in rooms.

Where material is so hard that the drilling cannot be done with regular machine or churn drill the above scale does not apply.

ARTICLE VIII.

General.

Section 1. When the coal is paid for mine run it shall be mined in as good condition as when paid for on a screened lump basis, and when loaded on the miner's car it shall as nearly as possible be free from slate, bone coal or other impurities, and if any miner shall load impurities in such quantities as to indicate knowledge and intent he shall be discharged. In case of dispute the impurities shall be kept until the case has been disposed of.

Sec. 2. Wages shall be paid semi-monthly on or before the 10th and 25th of each month.

Sec. 3. The time of beginning work in the morning and the length of intermission at noon shall be considered a local question which must be so arranged as to secure eight hours' work per day.

Sec. 4. The duties of the mine committee shall be confined to the adjustment of disputes between the mine boss or superintendent and any of the members of the United Mine Workers of America working in and around the mines. The mine committee shall have no other authority, nor exercise any other control, nor in any way interfere with the operation of the mine, and for violation of this clause the committee or any member thereof shall be discharged.

Sec. 5. It is agreed that if any differences arise between an employer or employe in or about the mines an attempt shall be made to adjust the same by the person or persons affected, with the company's representative in immediate charge. If they fail to agree the question shall be referred to the mine boss and mine committee. If they fail to agree it shall be referred to the mine superintendent and mine committee. If they fail to agree it shall be referred to the president of District 11, U. M. W. of A., and the secretary of the Indiana Bituminous Coal Operators' Association, whose decision shall be final. It is imperative on the part of the two officials to reach an agreement on all questions referred to them and that the dispute shall be settled within five days, unless longer time is agreed to by the two officials named: Provided, that nothing in this clause shall prevent the district officers from taking up for adjustment any dispute with the officers of the company affected.

Sec. 6. That pending negotiations the miners shall not cease work because of any dispute, and an agreement reached at any stage of the proceedings shall be binding on both parties thereto, and not subject to review or revision of any other party or branch of either association.

Sec. 7. That under no circumstances will the operators recognize or treat with a mine committee or any representative of the United Mine Workers of America during the suspension of work contrary to this agreement.

Sec. 8. No restriction shall be placed on the amount of coal which machines may mine, nor upon the number of places in which machines may cut, nor upon the number of loaders that may work after one machine, nor upon the amount of narrow work that any machine runner may be required to do, nor upon the number of cars that any miner may load in any specified time.

Sec. 9. The operators shall have the privilege of working a night shift for cutting coal with machines. All men so employed shall be paid 28 cents extra for each eight hours' work at night in addition to the scale price per ton.

Sec. 10. Work on driving entries and drawing pillars may be by double shift at the option of the operator.

Sec. 11. This contract shall in no case be set aside because of any rules of any local union of the U. M. W. of A. Nor shall there be any rules made controlling or affecting the operations of the mines nor shall any change be made in accepted rules without the operators and miners first consulting and agreeing thereto.

Sec. 12. All local rules in violation of this contract shall be null and void, and no local union nor group of local unions shall pass any rules in violation, neither shall any company enforce any rule in violation of this contract.

Sec. 13. Coal may be dumped as slowly as the operator may find necessary to thoroughly screen it, even if the car is brought to a stop, but it shall not be dumped in such a way as to throw the coal over the car door or unnecessarily break it.

Sec. 14. Any miner knowing his place to be unsafe shall protect same without delay and shall go into the mine for that purpose outside of regular hours and on idle days.

Sec. 15. Men shall work double in wide entries at option of operator in developing the mine or for running entries for purpose of increasing production.

Sec. 16. Where three places are now given to two loaders the custom shall continue.

Sec. 17. No more than three places for two men nor two places for one man shall be allowed. In mines where the coal averages 6 feet high or over, rooms 30 feet wide or over equipped with two tracks shall be considered double places, and two loaders may be limited to two such places.

Sec. 18. In Sullivan County where men work double in two rooms 25 to 30 feet wide, with track up the center, the custom shall continue.

Sec. 19. Whenever a new mine is opened it shall be governed by the same rules existing in other contiguous mines in the same vein of coal.

Sec. 20. The price of powder per keg shall be $1.75. The miners agree to purchase the powder from their operators, provided it is furnished of standard grade and quality, that to be determined by the operators and expert miners jointly where there is a difference.

Sec. 21. It is further agreed that the operator shall deliver the powder to the working places of the miners, and will use all reasonable precautions to insure a safe delivery of same, and will co-operate with the mine committee in tracing powder lost in transit, but shall not in any way be responsible for powder lost, except in case where the loss is caused by the direct negligence of the operator or mine management, and in the event of kegs being broken or powder being caked, powder shall be replaced; provided, however, that where miners carry their powder from magazine to inlet the practice shall continue.

Sec. 22. All local rules regarding the number of cars required above the tipple south of the Vandalia are hereby abolished, and in lieu of which it is agreed that the operators shall blow the whistle at 8 o'clock in the evening when intending to work the following day, and again at 5 o'clock in the morning if cars are there or promised by the railroad company to be there at 7 o'clock, or starting time. If the company blows the whistle at 5 o'clock a. m. without the promise of cars and the miners report for work at 7 a. m., or starting time, and there are no cars the company shall pay to the local union a fine of $25.

Sec. 23. The U. M. W. of A. shall have no jurisdiction nor exercise any control over construction work, such as the erection of tipples or mine buildings, scales, machinery or screening apparatus necessary to hoist and prepare coal.

Sec. 24. Where dirt must be removed to prepare pillars the miner shall be paid as agreed upon by miner and mine boss, or company, to remove same.

Sec. 25. An employe absenting himself from work for three days without a reasonable excuse, or having notified the mine manager and obtained his consent, may be discharged. This shall mean starting time of the third day.

Sec. 26. All miners shall put down their points and last pair of rails in their working places, and shall nail one end of same, but are not expected to tie and permanently lay their road.

Sec. 27. The chief electrician shall be exempted from control of mine committee or local union, but in case of any dispute between him and the company the district officers shall adjust the same with officers of company involved.

Sec. 28. Where any company operate more than one mine on the same line of road and in the same vein of coal, the work between the respective mines shall be as nearly as business conditions will permit equally divided.

Sec. 29. All machine men shall work on idle days at operators' option to make up time lost on previous working day.

Sec. 30. Every miner shall be given an opportunity to load an equal turn with every other miner doing the same class of mining. Where pick and machine miners are working in the same mine the turn shall be in proportion to the ratio between pick mining prices and machine loading prices.

Sec. 31. The check weighman shall furnish the boss driver or mine boss from day to day a turn sheet, and he shall cause the turn to be regulated: Provided, further, that no run or entry in machine mines shall be permitted to get more than five cars in advance of another run or entry, and in pick mines not more than two cars, except in case of accident.

Sec. 32. It is further agreed that the operators shall offer no objection to the check-off for the check weighman, and for dues for the U. M. W. of A., provided that no check-off shall be made against any person until he shall have first given his consent in writing to his employer. This applies to all day work as well as miners.

ARTICLE IX.

Section 1. It is agreed that when miners come out or stay out of the mine for the purpose of redressing a grievance, real or supposed, thus entirely or partially shutting down mine or mines contrary to agreement, each employe so ceasing or refraining from work shall be fined in the sum of one dollar per day during such shut-down.

Sec. 2. Any mine manager, superintendent or mine boss who shall fail to comply with the expressed provisions of this contract shall be fined $5 for the first offense and for each and every subsequent offense. It is understood and agreed that the penalty imposed in this paragraph shall not apply to Section 31, Article 8, or to violation of local rules that have not been agreed to by mine manager and mine committee and reduced to writing and forwarded to the secretary of the operators and president of District 11. The fine thus assessed shall be deducted from each person so offending through the pay roll, and this agreement is the company's authority for making such deductions.

Sec. 3. It is agreed that any employe showing that he spoke against or was not present when a suspension of work was ordered or took place, fine shall be refunded to such employe furnishing such evidence, and all money collected as fines shall be divided equally between District 11, U. M. W. of A., and the Indiana Bituminous Coal Operators' Association.

Sec. 4. It is agreed that in the event of an inside employe being wrongfully discharged, and it is so discovered by methods herein provided, and by the same methods is reinstated, he shall be paid for time lost at the rate per day prevailing for inside day labor; provided, however, that the company shall have the option of permitting the accused to continue at work pending the investigation, and the same shall apply to outside day laborers, except the outside day labor scale shall be paid.

Sec. 5. Except in cases of fatal accidents in the mine the mine shall in no case be thrown idle because of any death or funeral; in the event of a fatal accident in the mine the employes may discontinue work for the remainder of the day, but work at the option of the operator shall be resumed the day following and continue thereafter. Nothing herein shall be construed to prevent an employe from absenting himself from work to attend the funeral of a fellow employe or member of his family.

Sec. 6. In consideration of the observances of the above rule and the enforcement of same it is agreed that the following schedule of death benefits shall be paid to all parties entitled to receive the same: For a man, $50; for an employe's wife, $50; for any member of the family over the age of fourteen years, excepting married children, $35; the company to pay one-half of the above amounts and the local union the remainder: Provided, however, that in the event of the mine being thrown idle on the day of any funeral by reason of an insufficient number of men reporting for work, then the company shall not be expected to pay any part of the amounts herein named.

In behalf of the U. M. W. of A.:

W. D. Van Horn, President,
District No. 11, U. M. W. of A.
Chas. Fox, Sec'y. and Treas.,
District No. 11, U. M. W. of A.
D. N. Curry, Vice-President,
District No. 11, U. M. W. of A.

In behalf of Indiana Bituminous Coal Operators' Association:

J. C. Kolsem, President.
P. H. Penna, Secretary.

Hugh Shirkie,
Jno. K. Seifert,
John Hewitt,
Committee.

Agreement of Roll Committee.

The undersigned having been appointed with authority of the joint convention May 29, 1908, to adopt a uniform method for the payment of rolls, which report was to become a part of the contract then adopted, agree:

1st. That the following conditions and rules shall govern the payment for rolls in the bituminous mines in the State of Indiana.

2d. That rolls in top or bottom coming up or down not to exceed six inches are not considered in this agreement, but when coming up or down from bottom or roof to exceed six inches, and it is not necessary to remove the same, the miner shall not be required to do so only for the width of the roadway.

3d. That all rolls shall be paid for by cubical contents to be measured on each rib, measurement to be from point where coal quits to a point where coal begins, and at right angles with roll, and in such way as to ascertain average thickness.

4th. All material from rolls shall be removed by the miner. In narrow places where gobbing the dirt is impracticable he shall load it in cars. In wider places where there is room to gob such material, and the company requires it gobbed, the miner shall do so, provided, however, that he shall not be required to handle any such material more than once. Such material shall be removed at a sufficient distance from the face to allow the machine to operate unimpeded.

5th. All men working in roll shall have at least an equal turn of cars with the others on the run. This applies to the regular coal cars.

6th. The miner shall make height for the roadway the height of the vein of coal when required to do so.

7th. The prices to be paid per cubic foot of roll for chain machine, rolls 3 feet and over, 2½ cents per cubic foot; rolls 18 inches to 3 feet, 3½ cents per cubic foot; rolls from 0 to 18 inches, 4 cents per cubic foot.

For punching machines, rolls 3 feet and over, 2¾ cents; rolls 18 inches to 3 feet, 3¾, and rolls 0 to 18 inches, 4¼ cents.

Pick mining, rolls 3 feet and over 3¼ cents per foot; rolls 18 inches to 3 feet, 4½ cents per foot; rolls 0 to 18 inches, 5¼ cents.

8th. These prices include the machine runner and loader, and shall be divided in the same proportion as regular work.

9th. The above scale does not apply to rolls that are so hard that they cannot be drilled with regular drilling machine. The thread bar to have not more than eight threads to the inch.

10th. Any dispute arising under this addition to our contract which cannot be settled by the means therein provided shall be referred to this committee for settlement.

Signed this 22d day of June, 1908.

In behalf of Indiana Bituminous Coal Operators' Association:

JNO. K. SEIFERT.
JOHN A. TEMPLETON.
THOMAS MCQUADE.

In behalf of District No. 11, U. M. W. of A.:

E. R. MONTAGUE.
J. W. BUCK.
CLINTON M. ALLEN.

CONTRACT.

PICK MINING SCALE FROM APRIL 1, 1908, TO APRIL 1, 1909.

BRAZIL BLOCK AGREEMENT.

1. Entered into this 28th day of March, 1908, between the operators' scale committee of the Brazil block coal district and the executive board of the United Mine Workers of America, representing district No. 8.

Pick Scale and Yardage.

2. The price for mining screened block coal in the block coal district of Indiana shall be $1 per ton of two thousand pounds, it being understood also that the price for digging unscreened coal shall be an equivalent of the price paid for screened coal.

3. Further details in the scale price for pick mining in the block coal district shall be as follows:

4. The payment for low coal shall be upon the following scale:

5. For all coal two feet ten inches and under three feet one inch, $1.05 per ton.

6. For all coal under two feet ten inches, $1.10 per ton.

7. The price of yardage shall be as follows:

Single yardage for coal three feet one inch and over	$1 00
Double yardage for coal three feet one inch and over	2 00
Gob entries in coal three feet one inch and over	1 50
Gob entries in coal three feet one inch and over without brushing	50
Single yardage for coal two feet ten inches and under three feet one inch	1 05
Double yardage for coal two feet ten inches and under three feet one inch	2 10
Gob entries in coal two feet ten inches and under three feet one inch	1 57½
Gob entries in coal two feet ten inches and under three feet one inch without brushing	52½
Single yardage in coal below two feet ten inches	1 10
Double yardage in coal below two feet ten inches	2 20
Gob entries in coal below two feet ten inches	1 65
Gob entries in coal below two feet ten inches without brushing	55

All entries to be driven when required by the operator 5½ feet in the clear in height (and the miners agree to gob the dirt when they are not required to take it more than the distance of six rooms back from the last break-through, and when the dirt is hauled by a mule then the miners agree to unload same at a distance of not more than eight rooms back from the last break-through from the face of the entry). This agreement shall apply to all the block mines in the block coal district with the exception of the present No. 1 and No. 2 Superior mines of the Zeller-McClellan Company, and in these two mines the same conditions shall continue as were in force during the year just ending, viz.: The miners shall continue to gob the break-throughs. Twenty-five cents per yard shall be paid extra for all double yardage when the same is worked double shift, and 12½ cents per yard for all single yardage when the same is worked double shift. Work on driving entries and drawing pillars may be by double shift at the option of the operator.

Day Men's Scale.

8. Inside day scale:

Track layers	$2 56
Trappers	1 13
Bottom cagers	2 56
Drivers	2 56
Trip riders	2 56
Water haulers	2 56
Timbermen, where such are employed	2 56
Pipemen for compressed air plants	2 50
All other inside day labor	2 56
Blacksmiths	2 85
All other outside day labor	2 02½

9. The firemen and night pumpers shall be paid at the rate of 25 3/10 cents per hour for their labor. The above wage is based ou an eight-hour workday, but in event the operator desires it, the firemen and night pump-

men are to work overtime to the extent of not more than two hours in any one day or shift. However, it is understood that in the event of an emergency the firemen and night pumpers will not limit their time but continue working till such emergency is past.

10. The firemen and night pumpers shall be subject to the same rules and regulations as top men, and be in their class, and may be laid off in case the mine shall work part of days, and the work of firemen and top men shall be interchanged if it is found to be in the interest of the employer so to do, for example: Where work can be performed by one man, the firing and any other work about the top shall be done by any one of the top men selected.

11. When the miner is working a deficient place and is being paid by the day, his pay shall be $2.56 per day, and if he uses his own tools during such time he shall be paid ten cents per day for the use of the same. The operator shall have the option of furnishing the tools for such work.

12. The price of blacksmithing shall be 1½ cents on the dollar.

13. The semi-monthly pay shall continue until constitutionality of the law providing for weekly pays shall have been passed upon by the Supreme Court of Indiana and of the United States.

14. A miner shall not be compelled to load his coal more than six feet from the face at beginning time.

15. Inside day work may be done upon idle days, and in case of emergency on overtime.

Hours of Work.

16. The hour beginning work in the morning shall be 7 a. m., with thirty minutes' stop for dinner, and begin shooting at 3:30 p. m. from April 1, 1908, to October 1, 1908, and from October 1, 1908, to April 1, 1909, the mines shall start at 7:30 a. m., with thirty minutes' stop for dinner, and begin shooting at 4 p. m., and no shooting shall be done at any other time except by mutual consent between the bank boss and the bank committee, and in the event that the mine is to work half a day only it shall be the duty of the mine boss to notify the bank committee of the fact.

The officers and miners' board of district No. 8 hereby agree and pledge themselves to see that the men in the mines carry out the contract by working eight hours per day, and that they will put in effect and maintain rules which will compel the men to be at their working places on time and remain at work until the expiration of eight hours.

17. Eight hours a day means eight hours' work in the mine at the usual working places for all classes of inside men. This shall be exclusive of the time required in reaching such working places in the morning and departing from the same at night.

18. The miners hereby agree to do all the propping in their rooms except setting the props required to break the bottom in shooting the same, and if any props are loosened or displaced, thereby endangering the safety of the workmen, the miners agree to reset the same.

Setting Long Props.

19. The miners working at Zeller & McClellan's No. 4 mine and the Indiana Block Coal Company's mine at Saline shall set all the props in their rooms and shall set all the props along the roadway. When bottom is blasted for the road and long props are made necessary along the roadway the miners agree to reset them. And the operators agree to pay therefor 3 cents each for all long props so set by them. The companies above named shall provide the props of required length.

20. It is also agreed on the part of the operators not to require the miners to put down their own road, and bottom shooters may lay the road in the rooms when required.

21. The operators agree to give each miner as near as possible an equal turn of cars for coal, and not to allow any day hands to load coal on idle days, but in no case shall a turn apply to the handling of dirt, but the operators agree to put in the mines a sufficient number of mules to remove all the coal and dirt therefrom. It is agreed that nothing herein shall conflict with the gobbing of dirt as herein before provided. The operators will give an equal turn of work to all inside day men as near as practicable who are competent, excepting track layers and timber men, adjustment of turns to be semi-monthly.

22. No miner shall be discharged or discriminated against because of his refusal to do work by the day when called upon by the pit boss. If, by the absence or refusal to work of any day man or men, work is likely to be interfered with, the mine committee when called upon shall assist the mine boss to furnish competent men in case he fails to secure them at the scale rate, so that the mine shall continue work.

23. It is also agreed not to require miners to load or clean falls unless they are caused by some fault of the miner not properly timbering his working place, or his having shot or otherwise caused his timber to become insecure, in which case it will be the duty of the miner to put his place in good order again.

24. Should the mine boss or superintendent at any time discharge a miner or mine laborer, and upon investigation by the mine committee they believe there were not good and sufficient causes for so doing, they shall at once notify such boss or superintendent of their decision, and pending the matter being decided upon by the final board as provided in such cases the management may at their option retain in their employ such person so discharged pending the final decision. If said board finds the man was discharged without sufficient cause he shall be reinstated, and shall be paid his regular wage for all time lost by such discharge, but days which the mine was not in operation during this period shall not be reckoned as lost.

Settlement of Differences.

25. It is further agreed that if any differences arise between the operator or miners at any pit, settlement shall be arrived at without any stopping of work. If the parties immediately affected cannot reach an adjustment between themselves the question shall be referred to the executive board of the United Mine Workers of America representing district No.

8 and an equal number of operators, whose action shall be final, but no operator or miner interested in the difference shall be a member of said committee. The officers and miners' board of district No. 8, United Mine Workers of America, hereby agree and pledge themselves to put in effect at the different locals of the district certain rules and regulations requiring men to be fined one dollar per day for the violation of the above clause, said fine to be checked off by the operators and turned over to district No. 8. On failure of said officers and board to accomplish their agreement to see that this part of the contract is observed, the following clause shall become effective, and from that time on it shall be binding and have full force and be a part of this contract, viz.: It is understood and agreed that when any of the workmen in and about a mine stops the same for the purpose of redressing a grievance, real or supposed, thus shutting the mine down contrary to this agreement, each employe shall pay to the owner of said mine the sum of $1 per day during such shut-down. The payment shall be deducted from each person through the pay roll, and this agreement is authority for making such deduction. It is further agreed that no coal company because of any grievance with an employe, real or supposed, shall stop the mine, and any company so shutting down its mine shall pay to each workman in and about the mine $1 per day during such shut-down.

26. The duties of the mine committee shall be confined to the adjustment of disputes between the mine boss or superintendent and any members of the United Mine Workers of America working in and around the mines, excepting the engineer working at such mine. In no case shall the mine committee have power to send day men home when needed by the operator, but the mine committee may bring any grievance before the joint board through their district officials.

Drivers' Rules.

27. Regarding drivers:

They shall take their mules to and from the stables, and the time required in so doing shall not include any part of the day's labor, their work beginning when they reach the parting at which they receive empty cars, and in no case shall the driver's time be docked while he is waiting for such cars at the point named, but when the men go into the mine in the morning they shall be entitled to two hours' pay whether or not the mine works the full two hours, and after the first two hours the men shall be paid for every hour thereafter by the hour, or for each hour's work or fractional part thereof. If for any reason the regular routine of work cannot be furnished inside labor for a portion of the first two hours the operators may furnish other than the regular labor for the unexpired time.

28. But under no circumstances will the operators recognize or treat with the mine committee or any representative of the United Mine Workers of America during the suspension of work contrary to this agreement.

29. The block coal district of Indiana may continue the use of the diamond bar screen, the screen to be 72 feet superficial area, of uniform size, 1¼ inches between the bars, free from obstructions, and that such

screen shall rest upon a sufficient number of bearings to hold the bars in proper position.

30. It is hereby further agreed that track layers may begin work on top before the usual time for hoisting coal in getting the track material ready to send down on the cage, and that the time required in doing so shall be a part of the eight hours' work.

31. In case of emergency work the mine boss shall consult with the mine committee, and if they approve of the work being done on overtime the men engaged thereon shall not be required to lay off until their time is equalized with the others working in such mine.

32. The Crawford Coal Company in their mines at Center Point may continue to do the brushing in the entries where the coal is three feet one inch and under in thickness.

33. The wages of the blacksmith shall be $2.85 per day at all the mines, and in addition to his ordinary duties he shall do any other labor and shall work at any mine owned by the company when required of him by the mine management, provided that he shall receive his regular wages therefor.

34. All local rules regarding the number of cars required above the tipple to be abolished.

35. In the event of death by accident in the mine the miners shall have the privilege of discontinuing work for the remainder of that day, but at the option of the operators work shall be resumed on the following day:

36. The miners shall not stop work on the day of a funeral where death is the result of an accident in the mine or otherwise, but instead men may absent themselves from work for the purpose of attending the funeral, and except in case of fatal accidents as above the mine shall not in any case be thrown idle because of any death or fuueral.

Funeral Benefits.

37. On consideration of the enforcement of this agreement, referring to funerals of employes only of any particular mine, and not otherwise, it is mutually agreed that an assessment of 3 cents per month shall be deducted on the pay rolls from each employe of district No. 8, members of the United Mine Workers of America. Said deduction, when made, shall be turned over to the secretary-treasurer of district No. 8, together with an equal sum to be paid by the operators of said district. Said fund shall be deposited in the Citizens' National Bank, Brazil, Indiana. On the death of an employe only the sum of $40 shall be paid from said fund to the family of the deceased or to the legal representative thereof. Said payment shall be made by checks only, and said checks shall be countersigned by the operators' commissioner of district No. 8. In the event that the above named assessment of 3 cents per man per month is insufficient to pay $40 to each party entitled thereto, an increase in such assessment shall be made by the joint board of miners and operators convened for that purpose. Also, should the assessment prove to accumulate a fund greater than is necessary to pay the funeral benefits required, the assessment shall be suspended for a time till the fund is reduced to the sum of $80, or two funeral benefits.

Hoisting Engineers' Scale.

38. On and after April 1, 1908, until April 1, 1909, the scale of hoisting engineers throughout the block coal district, or district No. 8, shall be as follows: Where one engineer is employed the compensation shall be eighty-four dollars and thirty-seven cents ($84.37) per month, and where two engineers are required the first engineer shall receive eighty-four dollars and thirty-seven cents ($84.37) per month, the second seventy-three dollars and twelve cents ($73.12) per month, and when they change week about seventy-eight dollars and seventy-five cents ($78.75) per month.

39. It is agreed on the part of engineers to be at their work in time to lower the men and mules and remain a sufficient time after the regular working hour to hoist the men and mules from the mine. Also to keep up all repairs on the machinery, including pumps in the mine.

40. It is also mutually agreed that a licensed engineer shall be employed at all times when steam is required at the throttle: Provided, however, that in all cases where the mine is not hoisting coal or the machines are not operated then in all such cases the engineers are required to do their own firing, it being understood that this provision does not apply to any case where the work of the mine may be stopped in the midst of any one shift. Nor does it cover any case where the fireman is required to assist in the washing or cleaning out of the boilers on Sunday.

41. It is fully understood and agreed upon the part of the United Mine Workers of America that the engineers will not under any circumstances allow affiliation with any labor organization to interfere with or prevent their being on duty at any and all times required by the operators, and that they will not suspend work in sympathy with any organization; and further, that they will during the continuance of this contract, at all times fully protect all the company's property under their care, and that they will operate fans and pumps, and lower and hoist such men or supplies as may be required to protect the company's property, and any and all coal that may be required to keep up the steam at the company's plant. But it is understood that the operators will not ask them during this period to hoist any coal produced by nonunion labor for sale on the market.

42. No engineer shall lay off or exchange shifts without the consent of the operators.

43. It is also agreed that in case of sickness or unexpected absence of the engineer any other engineer or engineers shall perform his duty; and if desired by them his wages for time so absent shall revert to the engineer performing such duty.

44. It is further agreed no hoisting engineer shall be subject to the interference or dictation of the mine committee, nor the local unions, but all differences between the engineer and his employer shall be adjusted by the officers of the United Mine Workers of America and employer interested.

45. It is also agreed upon the part of the operators that they will enforce a rule forbidding the entering of the engine room by loafers and disinterested parties, and that they will have cards printed and placed in conspicuous places to this effect.

46. This contract is entered into in good faith by both parties, and

there is to be no deviation from it by the operators, miners, laborers or any local union.

Committee on behalf of the operators for the block coal district:

J. H. McCLELLAND.
WILLIAM M. ZELLER.
W. W. RISHER.
W. E. EPPERT.
JOHN CHESTERFIELD, JR.
E. F. McGRANAHAN.
H. W. JENKINS.
W. PAUL ZIMMERMAN.
M. J. MURPHY.

Executive committee district No. 8, United Mine Workers of America, for block coal miners:

PATRICK GOLDEN.
RICHARD OWENS.
JOHN PATTISON.
HOMER FRANCE.
JOHN FOGG.

MACHINE MINING SCALE.

Contract Between the Machine Operators of the Block Coal District No. 8, United Mine Workers of America, Governing Prices and Conditions of Mining in Machine Mines, Block Coal District.

Entered into this 28th day of March, 1908, and continuing until April 1, 1909, between the operators of machine mines of the block coal district and the executive board of the United Mine Workers of America, representing district No. 8.

The price for loading, shooting, timbering, taking care of all draw slate that is four (4) inches and under in thickness, in rooms and entries, shall be fifty-three and one-half (53½) cents per ton.

Price for entry driving, 6 to 9 feet wide, fifty-three and one-half (53½) cents per yard.

Price for entry driving, 9 to 12 feet wide, thirty-two and one-half (32½) cents per yard.

The loaders agree to keep the bug dust and draw slate back 14 feet from the working face.

All entries more than twelve (12) feet in width shall be paid same as rooms.

Machine runners and helpers to be paid twenty-five (25) cents per ton, and when working by the day, machine runner to be paid $3.03¾ per day. Helpers, $2.70 per day. Motormen, $3.03¾.

Entry driving, 6 to 9 feet wide, machine runner to be paid 25 cents per yard.

Entry driving, 9 to 12 feet wide, machine runner to be paid 16 cents per yard.

It is further agreed that where there is not sufficient room to gob the bug dust and draw slate, the loader will load it in the bank cars and the company will unload it.

It is understood that there shall be nothing paid for room turning or low coal, and there shall be nothing charged for blacksmithing.

There shall be no discrimination against any employe.

That the system of loading coal in machine mines be on the following basis, to wit:

1. That one man shall have the right to two places where he can take care of the same.

2. That two men shall have the right to three places where they can take care of the same.

3. All others one place.

When a man is off work more than one day the mine boss shall have the right to put a man in the places if it is necessary, providing the man leaves the places in the same condition as near as possible as he found them.

The block coal district of Indiana may continue the use of the diamond bar screen, the screen to be seventy-two (72) feet superficial area, of uniform size, one and one-quarter (1¼) inches between the bars, free from obstructions, and that such screen shall rest upon a sufficient number of bearings to hold the bars in proper position.

This agreement to become a part of the agreement entered into the 28th day of March, 1908, between the operators' scale committee of the block coal district and the executive board of the United Mine Workers of America, representing district No. 8.

On behalf of the machine operators of the block coal district:

JOHN CHESTERFIELD, JR.
W. E. EPPERT.
E. F. MCGRANAHAN.

On behalf of the executive board, district No. 8, United Mine Workers of America:

PATRICK GOLDEN.
RICHARD OWENS.
JOHN PATTISON.
HOMER FRANCE.
JOHN FOGG.

TABLE

Showing by Months and by Counties the Number of Tons Mined and Wages Paid to Employes for the Year 1908 at Mines Employing More Than Ten Men.

MONTH.	Clay County.		Daviess County.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	102,793	$95,031 28	6,364	$7,610 46
February	95,330	100,496 43	6,600	6,779 15
March	157,769	105,388 86	6,549	7,111 74
April	57,611	46,763 47	1,114	461 45
May	53,297	53,500 91	1,890	1,930 47
June	73,326	58,098 08	2,769	3,643 70
July	85,115	66,632 16	1,986	3,234 07
August	71,778	72,161 87	2,034	4,972 60
September	97,468	71,671 52	3,421	5,421 81
October	70,544	78,968 85	3,747	6,144 26
November	84,442	81,476 76	3,514	5,023 45
December	79,688	77,096 46	3,197	5,740 05
Total	1,029,161	$997,286 65	43,185	$58,073 21

MONTH.	Fountain County.		Gibson County.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	4,072	$3,757 94	20,540	$18,640 49
February	3,131	3,296 51	18,160	16,206 34
March	3,409	3,817 27	18,326	15,436 89
April	2,094	2,649 24	8,028	8,616 41
May	601	1,075 60	7,190	9,031 37
June	940	1,356 94	11,266	12,324 28
July	122	572 01	11,636	12,645 60
August	296	576 00	11,362	11,682 48
September	500	720 00	12,610	12,260 42
October	484	657 29	17,837	15,934 25
November	....	....	14,029	12,949 50
December	....	....	19,437	17,451 21
Total	15,849	$18,468 20	170,421	$163,179 24

MONTH.	Greene County.		Knox County.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	220,120	$180,082 41	73,594	$29,207 56
February	238,446	190,450 10	51,219	26,707 93
March	216,163	217,390 50	24,314	37,793 79
April	85,700	102,727 03	28,469	14,087 36
May	114,890	95,595 82	37,666	20,421 76
June	133,150	98,690 40	29,362	29,422 36
July	138,435	122,892 52	32,264	17,830 48
August	137,060	123,218 91	34,678	19,326 78
September	203,486	143,439 91	34,995	20,029 94
October	248,646	183,492 56	36,177	25,897 01
November	228,391	148,852 72	22,261	26,091 11
December	293,159	161,102 50	23,000	32,143 03
Total	2,257,646	$1,767,935 38	427,999	$298,959 11

TABLE SHOWING BY MONTHS AND BY COUNTIES THE NUMBER OF TONS MINED, ETC.—Continued.

MONTH.	Parke County.		Perry County.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	52,660	$53,780 92	767	$800 09
February	57,290	54,607 47	850	1,095 00
March	61,337	62,936 02	961	1,000 85
April	13,338	19,755 29	834	954 68
May	26,650	33,750 41	317	369 09
June	46,181	52,303 12	....	....
July	55,128	57,072 22	....	....
August	57,820	63,556 95	....	....
September	55,713	65,825 84	....	....
October	69,295	67,010 26	....	....
November	48,962	52,341 18	....	....
December	58,571	56,975 84	....	....
Total	602,945	$639,925 52	3,729	$4,018 97

MONTH.	Pike County.		Sullivan County.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	41,951	$36,736 50	245,710	$208,607 26
February	42,313	37,553 19	292,779	234,722 73
March	46,406	41,352 70	349,083	282,023 10
April	18,747	17,698 12	149,366	118,583 37
May	14,173	13,058 69	138,425	114,406 66
June	24,494	24,741 36	165,533	145,504 26
July	25,006	18,514 32	156,491	136,956 75
August	25,442	25,141 39	165,914	140,343 57
September	48,030	32,314 70	219,853	190,994 27
October	45,240	36,211 83	219,098	206,442 05
November	45,823	35,574 74	230,870	202,165 01
December	47,340	37,068 72	252,871	213,401 82
Total	424,965	$345,966 06	2,585,993	$2,193,550 85

MONTH	Vanderburgh County.		Vermillion County.	
	Tonnage.	Wages.	Tonnage	Wages.
January	28,784	$30,534 89	116,290	$101,643 73
February	29,824	27,963 46	105,211	102,135 12
March	25,195	25,741 24	154,638	125,422 94
April	10,625	14,362 31	75,795	59,173 98
May	11,500	13,819 02	57,509	49,912 64
June	8,057	13,730 30	64,232	81,985 18
July	11,612	14,889 42	81,072	72,721 24
August	17,286	19,610 03	51,816	58,857 62
September	25,682	24,545 30	84,577	72,457 33
October	32,867	29,618 62	109,032	90,811 61
November	25,501	25,982 57	115,560	95,507 99
December	26,841	25,438 06	123,937	101,513 61
Total	253,774	$266,235 22	1,139,669	$1,012,142 99

TABLE SHOWING BY MONTHS AND BY COUNTIES THE NUMBER OF TONS MINED, ETC.—Continued.

MONTH.	Vigo County.		Warrick County.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	247,346	$217,268 32	47,188	$32,232 76
February	264,018	212,092 93	54,283	37,014 51
March	307,381	257,260 07	45,678	32,670 40
April	95,626	92,514 70	31,395	19,791 23
May	104,373	99,904 59	17,691	23,883 80
June	153,078	143,624 67	22,851	25,023 75
July	210,926	171,279 88	22,776	13,441 42
August	195,392	166,709 69	27,980	17,917 35
September	229,346	191,038 14	36,170	21,696 55
October	270,970	234,432 65	43,120	26,811 81
November	247,772	215,234 55	39,045	26,485 22
December	291,687	238,104 64	35,876	22,694 41
Total	2,617,915	$2,239,464 83	424,053	$299,663 21

CHANGES IN OWNERSHIP.

Changes in management and changes in ownership of mining properties were made during the year as follows:

The Gifford No. 1 and 2 mines, formerly owned by the Collins Coal Co., went into the hands of a receiver March 6th, Mr. Wm. C. Hall, of Brazil, being appointed receiver. The property was sold at receiver's sale during the summer to John C. Ricksbery, of Chicago, Ill., and was sold by him a short time later to O. S. Richardson, of Chicago, one of the original owners.

The Block Coal Co's. lower vein mine No. 1 was purchased July 2d, by the Nick Schefferman Coal Co., and was later dismantled and abandoned.

The P. & I. mine, located in Greene County, formerly owned by the Pennsylvania & Indiana Coal Co., has had a varied experience. The mine was leased in February to a co-operative company composed of seventy miners, former employes, and the original coal company. This company operated until April, when the mine was leased by the G. G. Hadley Coal Co. This company failed about June 1st, and the property was sold June 29th at sheriff's sale to satisfy labor and other outstanding indebtedness.

July 2d the Mooney & Donnelly mine, located in Stockton Township, Greene County, was purchased by the Enterprise Coal Co.

August 22d, J. K. Seifert, of Chicago, was appointed receiver for the Southern Indiana Coal Co. This company owned the Lattas Creek, Tower Hill and Hoosier No. 1 mine in Green County, and the Mammoth and Semi-Block mines in Sullivan County. Under the new management the Tower Hill and Hoosier mines, in Greene County, and the Semi-Block, in Sullivan, were recently dismantled and abandoned.

The Bicknell mine, located at Bicknell, Knox County, owned by the Bicknell Coal Co., was leased in March to a company of former employes, who operate under the name of the Home Coal Co.

Hartwell No. 1 & 2 mines, located at Hartwell, Pike County, formerly owned by the Binghamton Trust Co., were purchased May 1st, by J. W. Welsh, of New York. This valuable property sold at the remarkably low purchase price of $50,000.

The Winslow Gas Coal Co. property, located near Winslow, Pike County, was purchased in March by the Cedar Creek Coal Co., of St. Louis, Mo. Two mines are opened on this property, but neither of them have been in operation the past three years.

The Keystone mine, located at Shelburn, Sullivan County, owned by C. C. Heison, of Chicago, Ill., changed hands in August, at which time it was leased to the Gregory Coal Mining Co., who cleaned up the mine and began hoisting coal in September.

The Atherton mine, located at Atherton, Vigo County, owned by the Charles F. Keeler Coal Co., of Chicago, Ill., was purchased in July by the Atherton Splint Coal Co., whose offices will be located at Atherton.

NEW MINES.

Twelve new mines were opened and reported to this department in 1908, located in the different counties as follows: Clay County, one block, hand; Green County, one bituminous, hand, and one electric chain; Parke County, one bituminous, hand; Pike County, one bituminous, hand; Vigo County, three bituminous, electric chain machine, and one bituminous, hand; and Warrick County, three bituminous, two of which are compressed-air punching machine and one hand. The annexed table shows the names by which each mine is known, the geological number of each seam of coal mined, thickness of coal seam in feet and inches, character of coal, depth of overlying strata in feet, size of hoisting shaft, whether mining is done by hand or by machine, date of first shipment of coal, location of mine—that is, county, section, township and range; also the nearest town or city and the railroads on which the mines are located.

TABLE OF NEW MINES.

CLAY COUNTY.

NAME OF COMPANY.	Name of Mine.	Geological Number of Seam.	Thickness of Seam.	Character of Coal.	Depth of Shaft.	Size of Shaft.	Pick or Machine.	Date of First Shipment.	Location of Mine.	Railroad.
Harrison Coal Co......	Harrison No. 4.	IV	3″	Block..........	70	9x16	Pick.................	11-29-08	3 miles east of Clay City in Harrison Tp......	E. & I.

GREENE COUNTY.

NAME OF COMPANY.	Name of Mine.	Geological Number of Seam.	Thickness of Seam.	Character of Coal.	Depth of Shaft.	Size of Shaft.	Pick or Machine.	Date of First Shipment.	Location of Mine.	Railroad.
Vandalia Coal Co......	Vandalia No. 20	V	6′6″	Bituminous.....	101	9x16	Electric chain.........	9- 1-08	Sec. 19, T. 7 n. R. 7. w., Stockton Tp	I. & V. br. Vandalia
Robertson Bros.Coal Co.	Cherry Hill....	IV	5′	Bituminous.....	45	6x13	Pick.................	9- 0-08	Sec. 25, T. 7 n. R. 7 w., Stockton Tp	S. I.

PARKE COUNTY.

NAME OF COMPANY.	Name of Mine.	Geological Number of Seam.	Thickness of Seam.	Character of Coal.	Depth of Shaft.	Size of Shaft.	Pick or Machine.	Date of First Shipment.	Location of Mine.	Railroad.
Fairview Coal Co......	Fairview......	Minsh'll	5′	Bituminous.....	240	8x17	Pick.................	10- 1-08	2 miles east of Mecca in Sec. 16, T. 15 n. R. 8 w., Wabash Tp.......................	C. & E. I.

PIKE COUNTY.

NAME OF COMPANY.	Name of Mine.	Geological Number of Seam.	Thickness of Seam.	Character of Coal.	Depth of Shaft.	Size of Shaft.	Pick or Machine.	Date of First Shipment.	Location of Mine.	Railroad.
Peacock Coal & Min. Co.	Peacock No. 2..	VI	6′6″	Bituminous.....	Slope.	......	Comp. air punch. mach.	11-22-08	3 miles n. of Oakland City, Sec. 4, T. 2 s. R. 8 w., Patoka Tp.........................	E. & I.

VIGO COUNTY.

Miami Coal Co.........	Miami No. 4...	III	6'6"	Bituminous.....	55	6x18	Pick.................	7- 1-08	½ mile So. Ehrmandale in ½ Sec. 3 T. 13 n. R. 8 w., Nevins Tp	C. & E. I.
Glen Ayr Coal Co......	Glen Ayr......	IV	5'	Bituminous.....	92	8x18	Electric chain machine..	2-14-08	Sec. 21 T. 12 n. R. 8 w., Lost Creek Tp......	M. L. Vandalia.
Grant Coal & Mining Co.	Grant No. 3...	III	6'6"	Bituminous.....	40	8x12	Comp. air punch. mach.	7- 6-08	Sec. 26 T. 13 n. R. 8 w., Nevins Tp..........	C. & E. I.
Deep Vein Coal Co.....	Deep Vein.....	V	4'6"	Bituminous.....	170	8x16	Pick.................	-05	Sec. 18 T. 12 n. R. 9 w., Sugar Creek Tp......	Vandalia.
			4'3"	Bituminous.....	280	8x16	Electric machine......	8- 1-08		

WARRICK COUNTY.

J. Wooley Coal Co.....	Polk No. 5.....	V	7'	Bituminous.....	2 slope	......	Comp. air punch. mach.	2-14-08	Sec. 17, T. 5 s. R. 7. w., Boone Tp...........	3½ mile off M.L.So.
Epworth Coal Co......	Epworth......	V	4'	Bituminous.....	114	8x16	Pick.................	1- 1-08	Sec. 32, T. 6 s. R. 9 w. Ohio Tp.............	E.S. & W.
Big Four Coal Co......	Big Four No. 2.	V	6'	Bituminous.....	Slope	......	Comp. air punch. mach.	8- 1-09	Sec. 36, T. 5 s. R. 8 w., Boone Tp...........	Evansville Div. So.

OLD MINES RE-EQUIPPED.

The Francisco mine, located at Francisco, Gibson County, formerly worked on a small scale, employing less than ten men, has been re-equipped, a manway put down, and is now employing about thirty persons. The company was also reorganized and is now known as the Wyoming Coal Co.

The Star No. 1 mine, located at Newburg, Warrick County, formerly operated by the Jno. Archibald Coal Co., abandoned and dismantled three years ago, has been reopened and equipped by the Red Shaft Coal Co.

IMPROVEMENTS.

A total of $75,000 was expended on improvements of various kinds in and about the mines in the State during the year.

The following shows some of the more important improvements made:

The Green Valley Coal Co. has installed electric traction motor haulage and made other improvements, expending $20,000.

The New Summit Coal & Mining Co. installed a new fan at a cost of $900, which has greatly improved the ventilation.

. The Sunflower Coal Co. expended $500 in building a concrete arch 250 feet in length over one of the entries. This is the first experiment of the kind in the coal mines of Indiana, and from all accounts it has proven a success.

The Dering Coal Co. built a new motor road at a cost of $952.

The Mutual Mining Co. installed a system of rope haulage in their Mutual mine at a cost of $4,180.

The Coal Bluff Mining Co. installed electric mining machines in their Wabash mine, using eight Morgan-Gardner chain machines. The cost of installation was $14,000.

The Crescent Coal Co. installed electric motor haulage, traction type, in their Unity mine. The cost of the haulage plant and other improvements made amounted to $20,000.

The remainder of the sum aggregate was expended on new cages, haulage roads and general improvements in and around different mines.

ABANDONED MINES.

Twenty-eight mines were abandoned during the past year, located in ten different counties, as follows:

In Clay County there were five block coal hand mines and six bituminous, two of which were electric chain and four hand.

Daviess County, one bituminous, hand; Greene County, three bituminous, hand; Gibson County, one bituminous, hand; Knox County, one bituminous, hand; Parke County, two block, hand; Perry County, one bituminous, hand; Pike County, one bituminous, hand; Sullivan County, five bituminous, two electric chain and three hand; and Vigo County, one hand and one compressed-air punching machine, both bituminous mines.

The following table exhibits by counties the names of the abandoned mines, the names of the companies owning them, the month the mines were abandoned and the railroad on which the mines were located:

TABLE OF ABANDONED MINES.

CLAY COUNTY.

NAME OF COMPANY.	Name of Mine.	Month of Abandonment.	Railroad.
O. S. Richardson Coal Co	Gifford No. 1	March	C. & I. C.
Continental Brick Works	Fortner	April	M. L. Vandalia.
Vandalia Coal Co	Vandalia No. 60	May	Vandalia.
C. E. Ehrlich	Klondyke	July	M. L. Vandalia.
Raccoon Manufacturing Co	Raccoon	July	C. & E. I.
Harrison Coal Co	Harrison No. 4	September	E. & I.
Jasonville Coal Co	Gold Knob	September	S. I.
Brazil Block Coal Co	Brazil No. 7	September	M. L. Vandalia.
Lower Vein Coal Co	Lower Vein No. 1	September	E. & I.
Clay Product Co	Continental	September	Vandalia.
Coal Bluff Mining Co	Glen No. 1	December	C. & E. I.

DAVIESS COUNTY.

Daviess County Coal Co	Montgomery No. 3	March	B. & O. S. W.

GREENE COUNTY.

Southern Indiana Coal Co	Hoosier No. 1	Not operated since 1907	S. I.
Vulcan Coal Co	Vulcan	April	I. C.
Southern Indiana Coal Co	Tower Hill	October	S. I.

GIBSON COUNTY.

Peacock Coal Co	Massy	March	E. & I.

KNOX COUNTY.

Big Muddy Coal Co	Pine Knot	September	I. & V. Br., Vandalia.

PARKE COUNTY.

Zeller-McClellan Co	Superior No. 1	April	C. & E. I.
Bridgeton Coal & Mining Co	Bridgeton	January	C. & E. I.

TABLE OF ABANDONED MINES—Continued.

PERRY COUNTY.

NAME OF COMPANY.	Name of Mine.	Month of Abandonment.	Railroad.
Bergenroth Bros	Troy	June	Shipped on Ohio River.

PIKE COUNTY.

NAME OF COMPANY.	Name of Mine.	Month of Abandonment.	Railroad.
Central Indiana Coal Co	Aberdeen	June	Southern.

SULLIVAN COUNTY.

NAME OF COMPANY.	Name of Mine.	Month of Abandonment.	Railroad.
Indiana Southern Coal Co	Washington	January	I. C.
Indiana Southern Coal Co	Cummins	June	S. I.
Vandalia Coal Co	West Linton	January	I. & V.
Dering Coal Co	Dering No. 12	January	E. & T. H.
Southern Indiana Coal Co	Semi-Block	October	S. I.

VIGO COUNTY.

NAME OF COMPANY.	Name of Mine.	Month of Abandonment.	Railroad.
Grant Coal and Mining Co	Grant No. 2	June	Big Four, Logansport.
Parke County Coal Co	Parke No. 10	June	Vandalia.

TABLE

Showing by Counties the Name of Mine, Number of Tons of Screened, Slack, Nut and Mine Run Coal, Total Tons of all Grades of Coal Produced and the Distribution Thereof, the Production of Block and Bituminous Coal, Each Being Shown Separately, as Is the Machine and Pick or Hand-Mined Coal.

BLOCK COAL MACHINE MINES.

PARKE COUNTY.

NAME OF MINE.	MACHINE MINED.				PICK MINED.				DISTRIBUTION.		WAGES PAID.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of All Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of All Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Mary	51,861	5,117	....	56,978	6,788	565	....	7,353	30,000	34,331	$49,294 91	$23,150 00	$10,804 19	$83,249 10
Total	51,861	5,117	....	56,978	6,788	565	....	7,353	30,000	34,331	$49,294 91	$23,150 00	$10,804 19	$83,249 10

VIGO COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of All Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of All Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Plymouth No. 1	20,029	6,503	....	26,532	21,800	7,392	....	29,192	17,910	37,814	$42,987 65	$13,894 30	$5,225 35	$62,107 30
Domestic Block No. 1	25,315	3,916	3,551	32,782	3,952	1,707	....	5,659	....	38,441	34,372 16	18,794 13	6,989 63	60,155 92
Total	45,344	10,419	3,551	59,314	25,752	9,099	....	34,851	17,910	76,255	$77,359 81	$32,688 43	$12,214 98	$122,263 22
Total machine mined block coal	97,205	15,536	3,551	116,292	32,540	9,664	....	42,204	47,910	110,586	$126,654 72	$55,838 43	$23,019 17	$205,512 32

BLOCK HAND OR PICK MINES.

CLAY COUNTY.

NAME OF MINE.	Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of All Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Brazil No. 1	12,572	2,428		15,000	5,762	9,238	$14 270 62	$6,772 37	$5,372 96	$26,415 95
Brazil No. 4	45,828	14,205		60,033	17,362	42,671	52,661 66	17,537 29	8,474 23	78,673 18
Brazil No. 7	8,473	1,708		10,181	3,502	6,679	9,461 59	2,047 01	3,775 79	15,284 39
Rebstock	2,968	730		3,698	1,911	1,787	2,969 00	1,711 90	752 60	5,433 50
Superior No. 4	29,019	7,050	237	36,306	24,204	12,102	34,838 33	14,174 81	6,658 57	55,671 71
Crawford No. 2	17,753	3,665	306	21,724	7,842	13,882	20,033 17	12,403 46	4,851 64	37,288 27
Crawford No. 6	18,221	3,950	51	22,222	6,325	15,897	19,950 79	8,970 10	3,545 78	32,466 67
Crawford No. 8	9,425	2,125		11,550	3,801	7,749	10,487 00	4,083 93	2,463 34	17,034 27
Crawford No. 9	32,924	7,265		40,189	21,285	18,904	35,472 29	16,003 19	6,797 38	58,272 86
Crawford No. 10	10,526	2,295		12,821	3,695	9,126	14,501 84	6,337 75	3,180 62	24,020 21
Plymouth No. 2	27,147	7,685		34,832	1,959	32,873	29,525 05	9,190 18	3,730 95	42,446 18
Glenn No. 1	7,465	1,127		8,592	782	7,810	8,657 70	2,681 35	2,286 65	13,625 70
Monarch			7,406	7,406	7,406		11,950 52	3,652 62	1,575 85	17,178 99
Eureka No. 5	38,284	8,828		47,112	16,845	30,263	42,214 17	11,286 16	6,100 06	59,600 39
Treager	5,797	964	222	6,983	6,983		6,045 23	992 35	775 00	7,812 58
Schefferman (Idle)										
Wizard	27,908	3,693	1,251	32,852	26,776	6,076	31,721 71	6,039 51	3,418 61	41,179 83
Pyrah	4,502	186		4,688	4,688		5,657 52	2,139 30	2,373 66	10,170 48
Indiana No. 1	8,248	1,587	4,946	14,781	6,225	8,556	12,449 25	4,935 78	3,160 40	20,545 43
Progressive	113,136	5,204	12,151	130,491	63,497	66,994	11,369 12	8,795 17	2,414 09	22,578 38
Continental			2,176	2,176	2,176		2,088 96	522 24	469 20	3,080 40
Total	420,196	74,695	28,746	523,637	233,030	290,607	376,325 52	$140,276 47	$72,177 38	$588,779 37

PARKE COUNTY.

Brazil No. 9	12,980	2,600	....	15,580	6,431	9,149	$14,065 95	$7,505 68	$5,548 42	$27,120 05
Brazil No. 12	12,129	2,435	....	14,564	2,143	12,421	15,418 49	6,465 20	6,009 35	27,893 04
Superior No. 1	839	175	....	1,014	1,014	....	744 15	175 25	248 13	1,167 53
Superior No. 2	30,815	7,450	674	38,939	13,629	25,310	35,738 92	12,890 74	6,378 89	55,008 55
Superior No. 3	27,766	9,599	....	37,365	20,000	17,365	30,940 76	13,675 09	6,619 40	51,235 25
Superior No. 5	50,565	12,800	....	63,365	30,000	33,365	54,044 76	17,003 01	8,182 74	79,230 51
Moore (Idle)	....	....	....	....	....	....	....	....	....	....
Total	135,094	35,059	674	170,827	73,217	97,610	$150,953 03	$57,714 97	$32,986 93	$241,654 93
Total pick mined block coal	555,290	109,754	29,420	694,464	306,247	388,217	$527,278 55	$197,991 44	$105,164 31	$830,434 30

BITUMINOUS MACHINE MINES.

CLAY COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Tons of screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Gifford No. 1	52	16	....	68	1,056	124	....	1,180	1,180	68	$1,159 06	$978 90	$742 60	$2,880 56
Gifford No. 2	1,529	298	....	1,827	4,622	2,495	....	7,117	3,773	5,171	6,090 46	3,105 26	8,108 56	17,304 28
Lewis	26,026	47,915	14,837	88,778	....	....	....	....	43,674	45,104	25,920 92	19,518 98	19,391 01	64,830 91
Vivian No. 2	28,180	11,588	30,433	70,203	3,099	1,181	3,699	7,979	52,164	26,018	34,431 39	21,839 94	8,620 03	64,891 36
Island Valley No. 4	50,874	25,763	13,294	89,931	4,916	2,191	1,014	8,121	57,131	40,921	46,819 33	15,117 87	7,441 27	69,378 47
Total	106,661	85,580	58,566	250,807	13,693	5,991	4,713	24,397	157,922	117,282	$114,421 16	$60,560 95	$44,303 47	$219,285 58

BITUMINOUS MACHINE MINES—Continued.

GREENE COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Black Creek	25,546	11,909	9,498	46,953	40,183	18,400	13,209	71,792	74,031	44,714	$71,646 78	$25,065 35	$10,400 76	$107,112 89
Dickason	1,864	1,119	1,368	4,351	6,724	4,035	4,267	15,026	12,418	6,959	10,703 20	4,162 78	2,702 11	17,568 09
Vandalia No. 2	....	....	58,979	58,979	....	....	25,180	25,180	80,474	3,685	45,459 03	19,551 78	6,678 51	71,689 32
Vandalia No. 5	51,296	35,358	13,713	100,367	50,456	30,590	11,057	92,103	151,756	40,714	108,465 69	36,675 66	15,798 55	160,939 90
Vandalia No. 8	89,780	53,853	58,491	202,124	9,093	4,952	4,347	18,392	194,781	25,735	116,642 16	38,255 81	12,572 09	167,470 06
Vandalia No. 9	51,999	18,402	101,707	172,108	6,913	3,048	16,043	26,004	191,767	6,345	102,280 32	31,829 25	9,789 42	143,898 99
Vandalia No. 21	18,303	8,515	115,299	142,117	....	....	....	....	142,117	....	66,962 97	15,084 06	10,044 18	92,091 21
Lattis Creek	39,012	36,701	95,758	171,471	15,438	....	11,513	26,951	....	198,422	108,569 58	38,501 27	12,720 45	159,791 30
Gilmour	....	....	81,643	81,643	....	....	4,700	4,700	28,789	57,554	58,085 00	21,185 00	7,478 00	86,748 00
Summitt No. 2	52,995	32,846	85,034	170,875	....	....	....	....	170,875	....	78,176 82	37,305 75	9,062 78	124,545 35
Green Valley	35,400	15,970	98,647	150,017	....	....	....	....	90,883	59,134	71,580 30	22,341 64	9,933 73	103,855 67
North West	72,644	42,956	18,146	133,746	18,511	11,278	4,328	34,117	125,274	42,589	77,599 43	24,888 76	8,356 73	110,844 92
Twin No. 4	25,439	12,920	9,833	48,192	1,245	495	30	1,770	39,962	10,000	26,858 55	12,414 85	3,728 70	43,002 10
Twin No. 5	34,028	14,347	67,027	115,402	1,488	555	2,104	4,147	90,000	29,549	57,732 55	13,513 45	9,283 75	80,529 75
Vandalia No. 20	....	....	2,439	2,439	....	....	62	62	2,501	....	1,377 55	411 20	412 22	2,200 97
Total	498,306	284,896	817,582	1.600,784	150,051	73,353	96,840	320,244	1,395,628	525,400	$1,002,139 93	$341,186 61	$128,961 98	$1,472,288 52

KNOX COUNTY.

Knox	16,245	2,353	52,932	71,530	534	172	4,863	5,569	42,606	34,493	$34,147 13	$14,982 40	$8,741 46	$57,870 99
Lynn	10,074	4,686	34,479	49,239	1,455	815	3,884	6,154	55,393	....	25,770 19	11,046 18	6,673 06	43,489 43
Freeman	19,728	7,031	103,389	130,148	....	....	....	....	98,216	31,932	61,321 18	19,263 11	11,620 16	92,204 45
Tecumseh	19,827	9,278	99,878	128,983	....	....	....	....	90,735	38,248	52,630 81	11,760 14	9,742 94	74,133 89
Total	65,874	23,348	290,678	379,900	1,989	987	8,747	11,723	286,950	104,673	$173,869 31	$57,051 83	$36,777 62	$267,698 76

PARKE COUNTY.

Parke No. 11			89,474	89,474			49,278	49,278	115,312	23,440	$74,178 60	$30,453 35	$10,648 28	$115,280 23
Lyford No. 1	17,035	10,835	80,082	107,952					11,143	96,809	48,631 70	22,867 35	8,470 59	79,969 64
Total	17,035	10,835	169,556	197,426			49,278	49,278	126,455	120,249	$122,810 30	$53,320 70	$19,118 87	$195,249 87

PIKE COUNTY.

Ayrshire No. 5	17,134	11,861	5,491	34,486					19,526	14,960	$18,622 30	$7,374 58	5,030 50	$31,027 38
Blackburn No. 2			8,941	8,941			30,731	30,731	39,672		21,169 03	6,876 33	4,979 92	33,025 28
Total	17,134	11,861	14,432	43,427			30,731	30,731	59,198	149,60	$39,791 33	$14,250 91	$10,010 42	$64,052 66

SULLIVAN COUNTY.

Rainbow			66,454	66,454					24,554	41,900	$43,940 00	$13,344 00	$7,065 00	$64,349 00
Phoenix No. 4			67,684	67,684					12,775	54,909	43,505 00	18,610 00	6,131 00	68,246 00
Hocking			82,631	82,631					22,043	60,588	50,806 00	22,004 00	8,846 00	81,656 00
Citizens			4,402	4,402			5,231	5,231	6,331	3,302	6,308 00	2,462 00	1,731 00	10,501 00
Sunflower	66,622	26,933	12,214	105,769					5,283	100,486	55,093 18	8,868 64	15,905 05	79,866 87
Consolidated No. 25	43,217	22,396	30,449	96,062	43	21		64	16,213	79,913	49,223 71	20,774 68	8,328 74	78,327 13
Consolidated No. 26	Idle													
Consolidated No. 28	Idle													
Consolidated No. 30	36,824	20,807	3,141	60,772					20,032	40,740	32,117 95	13,732 21	7,974 49	53,824 65
Consolidated No. 32	Idle													
Consolidated No. 33	71,284	29,831	59,627	160,742	10,138	4,951	8,569	23,658	71,023	113,377	93,552 92	36,072 49	12,110 33	141,735 74
Vandalia No. 10	59,847	23,181	153,531	236,559	173	66	398	637	230,290	6,906	115,816 04	49,956 45	12,295 49	178,067 98
Jackson Hill No. 2	78,367	28,178	87,011	193,556						193,556	93,575 58	32,505 79	10,319 94	136,401 51
Jackson Hill No. 4	106,754	64,097	2,547	173,398						173,398	86,091 91	29,648 90	9,944 23	125,685 04
Dering No. 13	28,762	14,395	58,493	101,650						101,650	51,795 95	26,306 92	7,053 10	85,155 97
Dering No. 14	95,632	68,686	1,143	165,461						165,461	87,506 98	49,113 56	13,874 28	150,494 82
Mammoth Vein	31,729	20,146	41,105	92,980	135		41	176	3,187	89,969	50,961 94	18,760 92	8,248 85	77,971 71
Shirley Hill No. 1	39,686	13,229	27,365	80,280	25,514	9,220	12,062	46,796	127,076		81,403 41	27,671 53	6,296 46	115,371 40
Shirley Hill No. 3	14,128	8,305	30,596	53,029	429	150	1,120	1,699	54,728		30,245 74	12,402 74	5,118 07	47,766 55
Little Giant	14,333	6,456	89,731	110,520	26,306	7,123	90,147	123,576	234,096		133,410 50	47,641 43	10,339 97	191,391 90
Clover Leaf	43,885	29,151	28,340	101,376	24,374	19,388	13,994	57,756	159,132		94,941 69	47,312 45	7,763 66	150,017 80
Reliance	49,137	23,612	3,259	76,008	5,664	1,939	228	7,831	4,478	79,361	48,980 98	21,585 93	9,086 24	79,653 15
Diamond No. 1	194	150	52	396	17,027	9,711	14,182	40,920	4,721	36,595	24,054 39	6,728 13	4,359 33	35,141 85
Viola	10,189	6,718	30,104	47,011					38,785	8,226	25,182 53	14,553 83	10,092 43	49,828 79
Kettle Creek	37,209	18,790	5,727	61,726	1,778	525	178	2,481	50,739	13,468	33,034 51	17,793 47	7,323 34	58,151 32
Black Hawk	Idle													
Total	827,799	425,061	885,606	2,138,466	111,581	53,094	146,150	310,825	1,085,486	1,363,805	$1,331,548 91	$537,850 07	$190,207 00	$2,059,605 98

BITUMINOUS MACHINE MINES—Continued.

VERMILLION COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Crown Hill No. 3......	31,793	9,942	24,697	66,432	....	....	....	....	16,313	50,119	$45,662 54	$17,024 15	$3,326 25	$66,012 94
Total............	31,793	9,942	24,697	66,432	....	....	....	....	16,313	50,119	$45,662 54	$17,024 15	$3,326 25	$66,012 94

VIGO COUNTY.

NAME OF MINE.	Machine Mined: Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Pick Mined: Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Distribution: Indiana.	Other States.	Wages Paid: To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Parke No. 10.........	....	....	21,272	21,272	....	....	39,464	39,464	43,125	17,611	$24,292 20	11,000 48	$4,242 61	$39,535 29
Forrest............	....	....	66,451	66,451	....	....	50,743	50,743	60,504	56,690	67,086 00	20,195 00	9,592 00	96,873 00
Atherton............	1,815	1,110	444	3,369	1,651	1,078	505	3,234	256	6,347	3,564 64	2,217 53	561 69	6,343 86
Wabash............	42,798	14,332	59,689	116,819	18,357	13,794	48,464	80,615	150,256	47,178	106,084 40	26,155 60	7,178 55	139,418 55
Vandalia No. 69......	6,137	3,441	1,186	10,764	54,865	39,683	6,146	100,694	109,013	2,445	67,972 37	23,501 91	6,307 14	97,781 42
Deep Vein..........	311	193	474	978	30,971	19,163	24,494	74,628	63,253	12,353	47,505 08	12,444 10	6,571 28	66,520 46
Grant No. 3..........	20,615	16,866	7,972	45,453	....	....	....	....	....	45,453	22,082 42	11,215 26	6,113 50	39,411 18
Glen Ayr............	8,033	3,540	3,629	15,202	24,385	13,860	24,099	62,344	57,206	20,340	46,784 01	11,119 60	5,174 02	63,077 63
Total............	79,709	39,482	161,117	280,308	130,229	87,578	193,915	411,722	483,613	208,417	$385,371 12	$117,849 48	$45,740 79	$548,961 39

WARRICK COUNTY.

Big Four	7,730	5,204	77,983	90,917	....	....	....	....	90,917	....	$42,546 80	$8,262 26	$10,350 72	$61,159 78
Chandler	....	....	13,413	13,413	....	....	9,408	9,408	8,984	13,837	12,294 51	3,459 02	1,935 58	17,689 11
DeForrest	5,280	3,415	3,785	12,480	....	....	....	....	12,480	....	5,173 78	2,123 79	1,457 44	8,755 01
Electric	....	....	41,024	41,024	....	....	....	....	22,493	18,531	17,435 18	7,239 55	3,142 18	27,816 91
Dawson	597	390	52,645	53,632	....	....	....	....	11,790	42,042	26,030 28	7,807 95	3,203 72	37,041 95
Erie Canal	....	....	37,153	37,153	....	....	....	....	27,355	9,798	15,811 93	6,314 65	2,666 24	24,792 82
Polk No. 5	....	....	46,450	46,450	....	....	....	....	46,450	....	21,754 55	4,855 50	4,362 45	30,972 50
Total	13,607	9,009	272,453	295,069	....	....	9,408	9,408	220,269	84,208	$141,047 03	$40,062 72	$27,118 33	$208,228 08
Total bituminous machine mined coal	1,657,918	900,014	2,694,687	5,252,619	407,543	221,003	539,782	1,168,328	3,831,834	2,589,113	$3,356,661 63	$1,239,157 42	$505,564 73	$5,101,383 78

BITUMINOUS HAND OR PICK MINES.

CLAY COUNTY.

NAME OF MINE.	PICK MINED.				DISTRIBUTION.		WAGES PAID.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of All Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Vandalia No. 60	13,177	7,784	327	21,288	21,288	....	$12,345 58	$4,440 38	$1,837 57	$18,623 53
Vandalia No. 65	56,895	25,600	86,011	168,506	168,506	....	102,231 97	28,791 95	8,564 60	139,588 52
Vivian No. 1 (Idle)	....	....	....	....	....	....	....	....	....	....
Klondyke	19,232	14,107	7,187	40,526	20,263	20,263	22,731 81	5,981 13	2,296 71	31,009 65
Total	89,304	47,491	93,525	230,320	210,057	20,263	$137,309 36	$39,213 46	$12,698 88	$189,221 70

BITUMINOUS HAND OR PICK MINES—Continued.

DAVIESS COUNTY

NAME OF MINE.	Pick Mined. Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of All Kinds of Coal Produced.	Distribution. Indiana.	Other States.	Wages Paid. To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Horney	....	....	9,445	9,445	9,445	....	$5,407 25	$1,281 71	$1,885 45	$8,574 41
Stucky (Idle)	....	....	....	....	....	....	....	....	....	....
Montgomery No. 3	....	....	6,430	6,430	6,430	....	4,421 40	1,670 25	1,673 90	7,765 55
Mutual	8,780	2,750	15,780	27,310	17,550	9,760	26,344 25	9,369 00	6,020 00	41,733 25
Mandabach (Idle)	....	....	....	....	....	....	....	....	....	....
Winklepeck (Idle)	....	....	....	....	....	....	....	....	....	....
Total	8,780	2,750	31,655	43,185	33,425	9,760	$36,172 90	$12,320 96	$9,579 35	$58,073 21

FOUNTAIN COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of All Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Indio	9,164	3,435	3,250	15,849	14,940	909	11,463 36	6,023 96	980 88	$18,468 20
Total	9,164	3,435	3,250	15,849	14,940	909	$11,463 36	$6,023 96	$980 88	$18,468 20

GIBSON COUNTY.

NAME OF MINE.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of All Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Oswald	40,713	50,677	65,702	157,092	157,092	....	$98,494 08	$40,191 48	$10,051 43	$148,736 99
Massey	2,190	4,934	462	7,586	7,586	....	5,278 18	1,243 18	1,203 14	7,724 50
Fort Branch	1,514	1,435	2,794	5,743	5,743	....	4,104 37	1,321 93	1,291 45	6,717 75
Total	44,417	57,046	68,958	170,421	170,421	....	$107,876 63	$42,756 59	$12,546 02	$163,179 24

GREENE COUNTY.

Queen	10,771	10,260	33,056	54,087	54,087	....	$33,095 59	$8,389 76	$4,283 55	$45,768 90
North Linton (Idle)	....	....	....	....	....	....	....	....	....	....
Sponsler	18,562	8,179	61,462	88,203	59,975	28,228	55,887 04	12,727 52	6,843 28	75,457 84
Antioch	10,457	6,190	27,804	44,451	28,527	15,924	29,073 84	9,962 74	6,300 96	45,337 54
Vandalia No. 3	20,385	9,841	27,430	57,656	56,573	1,083	35,134 18	10,816 52	4,115 05	50,065 75
Vandalia No. 4	10,188	4,794	13,344	28,326	28,326	....	17,056 00	4,832 38	2,110 53	23,998 91
Vandalia No. 6	826	415	3,729	4,970	4,935	35	3,124 40	1,037 37	692 59	4,854 36
Tower Hill	24,429	12,062	2,547	39,038	....	39,038	25,553 65	5,476 16	3,050 97	34,080 78
Letsinger (Idle)	....	....	....	....	....	....	....	....	....	....
P. & I.	4,517	2,392	9,988	16,897	4,719	12,178	10,132 13	1,811 88	1,463 77	13,407 78
Enterprise	....	....	2,990	2,990	2,990	....	1,520 00	695 00	460 00	2,675 00
Total	100,135	54,133	182,350	336,618	240,132	96,486	$210,576 83	$55,749 33	$29,320 70	$295,646 86

KNOX COUNTY.

Bicknell	8,512	6,555	2,932	17,999	17,999	....	$9,707 69	$1,918 38	$1,202 45	$12,828 52
Wheatland	....	....	18,377	18,377	18,377	....	11,066 67	4,570 33	2,794 83	18,431 83
Total	8,512	6,555	21,309	36,376	36,376	....	$20,774 36	$6,488 71	$3,997 28	$31,260 35

PARKE COUNTY.

Mecca No. 13	27,657	13,457	8,840	49,954	11,390	38,564	$31,186 20	$10,754 30	$4,595 29	$46,535 79
Harrison (Idle)	....	....	....	....	....	....	....	....	....	....
Vandalia No. 316	38,101	22,555	10,473	71,129	67,836	3,293	50,146 37	17,063 11	6,026 35	73,235 83
Total	65,758	36,012	19,313	121,083	79,226	41,857	$81,332 57	$27,817 41	$10,621 64	$119,771 62

BITUMINOUS HAND OR PICK MINES—Continued.

PIKE COUNTY.

NAME OF MINE.	Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of All Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Aryshire No. 3	20,159	12,588	10,928	43,675	27,998	15,677	$24,273 21	$7,246 90	$3,755 12	$35,275 23
Ayrshire No. 4	72,844	57,905	14,117	144,866	61,933	82,933	83,353 49	25,414 54	10,510 66	119,278 69
Muren	....	....	28,987	28,987	28,987	....	11,179 86	4,170 00	2,680 36	18,030 22
Blackburn No. 1	5,809	8,370	18,328	32,507	25,107	7,400	18,313 27	4,957 88	2,471 82	25,742 97
Littles	31,757	45,705	8,110	85,572	57,471	28,101	48,984 29	15,294 79	5,517 21	69,796 29
Petersburg (Idle)	....	....	....	....	....	....	....	....	....	....
Winslow No. 4 (Idle)	....	....	....	....	....	....	....	....	....	....
Winslow No. 5 (Idle)	....	....	....	....	....	....	....	....	....	....
Aberdeen	....	....	15,200	15,200	15,200	....	9,600 00	3,100 00	1,090 00	13,790 00
Hartwell No. 1 and 2 (Idle)	....	....	....	....	....	....	....	....	....	....
Total	130,569	124,568	95,670	350,807	216,696	134,111	$195,704 12	$60,184 11	$26,025 17	$281,913 40

PERRY COUNTY.

Troy	....	....	3,729	3,729	3,729	....	$2,667 45	$819 72	$531 80	$4,018 97
Total	....	....	3,729	3,729	3,729	....	$2,667 45	$819 72	$531 80	$4,018 97

SULLIVAN COUNTY.

Keystone	4,573	2,251	....	6,824	4,440	2,384	$4,637 99	$1,596 76	$1,902 39	$8,137 14
Cummins	....	....	7,832	7,832	2,300	5,532	5,110 00	1,508 00	696 00	7,314 00
Freeman	29,386	14,872	3,354	47,612	29,751	17,861	32,150 81	9,842 82	6,153 85	48,147 48
Hudson	29,184	22,495	17,534	69,213	69,213	....	37,009 83	18,385 96	7,152 44	62,548 23
Bellevue	1,770	1,267	2,184	5,221	5,058	163	3,250 01	2,377 63	2,170 38	7,798 02
Total	64,913	40,885	30,904	136,702	110,762	25,940	$82,158 64	$33,711 17	$18,075 06	$133,944 87

VANDERBURGH COUNTY.

Diamond	21,239	13,486	5,708	40,433	40,433	....	$28,024 39	$6,161 36	$6,433 14	$40,618 89
Ingleside	7,316	768	37,228	45,312	45,312	....	32,069 70	10,668 20	6,704 03	49,441 93
Sunnyside	20,565	6,942	4,533	32,040	26,825	5,215	21,975 89	8,820 48	9,692 23	40,488 60
Unity	26,727	22,020	49,258	98,005	98,005	....	66,770 46	20,575 26	9,816 90	97,162 62
First Avenue	20,398	11,487	6,099	37,984	37,984	....	25,959 32	6,999 22	5,564 64	38,523 18
Total	96,245	54,703	102,826	253,774	248,559	5,215	$174,799 76	$53,224 52	$38,210 94	$266,235 22

VERMILLION COUNTY.

Dering No. 5	31,801	21,331	30,287	83,419	....	83,419	$52,557 83	$20,657 56	$3,329 66	$76,545 05
Dering No. 7	30,554	21,736	88,711	141,001	....	141,001	82,771 39	30,089 09	6,140 42	119,000 90
Dering No. 8	50,113	53,673	28,526	132,312	....	132,312	74,456 51	36,836 46	6,867 91	118,160 88
Eureka	....	....	6,053	6,053	6,053	....	3,989 55	2,009 35	1,130 86	7,129 76
Crown Hill No. 1	61,844	20,628	81,801	164,273	60,072	104,201	129,826 43	31,026 00	4,075 25	164,927 68
Crown Hill No. 2	33,894	11,304	58,747	103,945	28,301	75,644	88,415 88	20,880 12	2,619 80	111,915 80
Oak Hill	3,511	2,290	13,720	19,521	....	19,521	12,009 03	5,265 40	1,999 80	19,274 23
Maple Valley	8,940	8,180	46,934	64,054	....	64,054	36,767 24	10,794 15	3,911 00	51,472 39
Buckeye No. 2	23,305	18,520	249,754	291,579	....	291,579	171,466 73	35,929 05	10,656 15	218,051 93
Prince	739	400	65,941	67,080	....	67,080	43,137 49	10,555 78	5,958 16	59,651 43
Total	244,701	158,062	670,474	1,073,237	94,426	978,811	$695,398 08	$204,042 96	$46,689 01	$946,130 05

BITUMINOUS HAND OR PICK MINES—Continued.

VIGO COUNTY.

NAME OF MINE.	Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of All Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Lawton	83,364	45,328	14,241	142,933	124,598	18,335	$81,067 15	$25,873 15	$10,298 40	$117,238 70
Victor	48,961	32,649	6,386	87,996	87,996	....	51,600 95	11,726 40	6,037 05	69,364 40
Minshall	25,216	13,272	37,221	75,709	65,639	10,070	50,354 60	10,793 55	5,446 70	66,594 85
Lower Vein No. 1	62,073	35,919	39,005	136,997	136,997	....	87,709 51	21,223 52	8,261 23	117,194 26
Vandalia No. 6	62,610	51,547	6,826	120,983	118,016	2,967	66,324 62	25,774 56	6,599 18	98,698 36
Vandalia No. 67	71,668	37,944	94,140	203,752	198,943	4,809	124,772 51	30,007 91	9,338 14	164,118 56
Vandalia No. 81	40,225	29,827	5,866	75,918	53,140	22,778	45,617 67	14,204 14	6,785 88	66,607 69
Miami No. 1	92,364	54,040	19,754	166,158	....	166,158	100,193 45	35,710 95	8,712 74	144,617 14
Miami No. 2	87,206	55,245	40,574	183,025	....	183,025	113,698 27	34,360 04	13,606 01	161,664 32
Miami No. 3	80,542	47,015	17,214	144,771	....	144,771	88,514 33	23,883 09	5,101 11	117,498 53
Miami No. 4	4,985	4,055	1,395	10,435	....	10,435	9,561 84	4,586 21	2,383 12	16,531 17
Fauvre No. 1	15,299	11,291	14,741	41,331	41,331	....	19,473 23	10,101 08	4,270 15	33,844 46
Fauvre No. 2	26,752	16,891	5,707	49,350	49,350	....	28,055 71	10,077 65	2,895 25	41,028 61
Ray No. 2	39,603	18,557	41,897	100,057	45,478	54,579	66,887 90	20,667 75	6,308 34	93,863 99
Chicago No. 6 (Idle)	....	....	....	....	....	....	....	....	....	....
Grant No. 2	2,805	1,278	31,705	35,788	....	35,788	20,440 73	10,375 55	4,237 76	35,054 04
Sugar Valley	9,742	4,841	8,503	23,086	22,894	192	14,703 61	3,810 84	3,329 22	21,843 67
Dering No. 6	57,296	26,084	138,760	222,140	....	222,140	139,968 34	45,842 85	6,965 54	192,776 73
National	4,085	2,810	4,396	11,291	11,291	....	5,634 30	1,938 38	2,128 06	9,700 74
Total	814,796	488,593	528,331	1,831,720	955,673	876,047	$1,114,578 72	$340,957 62	$112,703 88	$1,568,240 22

WARRICK COUNTY.

Red Shaft (Idle)	....	....	....	....	....	....	....	....	....	....
Castle Garden	....	....	60,943	60,943	60,943	....	$32,708 95	$5,783 15	$3,753 50	$42,245 60
Brizius	11,426	7,156	8,323	26,905	26,905	....	16,130 24	3,247 27	1,964 64	21,342 15
Elberfeld	....	....	22,109	22,109	22,109	....	12,159 95	5,570 33	2,794 83	20,525 11
Epworth	1,418	517	7,684	9,619	9,619	....	5,234 97	630 21	1,457 09	7,322 27
Total	12,844	7,673	99,059	119,576	119,576	....	$66,234 11	$15,230 96	$9,970 06	$91,435 13
Total bituminous pick mined coal	1,690,138	1,081,906	1,951,353	4,723,397	2,533,998	2,189,399	$2,937,046 89	$898,541 48	$331,950 67	$4,167,539 04

RECAPITULATION.

Showing Total Production and Wages of Indiana Mines for 1908.

TOTAL PRODUCTION OF BLOCK COAL.

	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of All Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of All Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Total mach. mined block coal	97,205	15,536	3,551	116,292	32,540	9,664	....	42,204	47,910	110,586	$126,654 72	$55,838 43	$23,019 17	$205,512 32
Total pick mined block coal.......	....	....	....	....	555,290	109,754	29,420	694,464	306,247	388,217	527,278 55	197,991 44	105,164 31	830,434 30
Total block coal..	97,205	15,536	3,551	116,292	587,830	119,418	29,420	736,668	354,157	498,803	$653,933 27	$253,829 87	$128,183 48	$1,035,946 62

TOTAL PRODUCTION OF BITUMINOUS COAL.

	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of All Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of All Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Total bituminous machine mined coal............	1,657,918	900,014	2,694,687	5,252,619	407,543	221,003	539,782	1,168,328	3,831,834	2,589,113	$3,356,661 63	$1,239,157 42	$505,564 73	$5,101,383 78
Total bituminous pick mined coal..	....	....	....	....	1,690,138	1,081,906	1,951,353	4,723,397	2,533,998	2,189,399	2,937,046 89	898,541 48	331,950 67	4,167,539 04
Total bituminous coal..........	1,657,918	900,014	2,694,687	5,252,619	2,097,681	1,302,909	2,491,135	5,891,725	6,365,832	4,778,512	$6,293,708 52	$2,137,698 90	$837,515 40	$9,268,922 82

Summary.

	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of All Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine Run Coal.	Total Tons of All Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Total machine mined coal......	1,755,123	915,550	2,698,238	5,368,911	440,083	230,667	539,782	1,210,532	3,879,744	2,699,699	$3,483,316 35	$1,294,995 85	$528,583 90	$5,306,896 10
Total pick mined coal............	....	....	....	....	2,245,428	1,191,660	1,980,773	5,417,861	2,840,245	2,577,616	3,464,325 44	1,096,532 92	437,114 98	4,997,973 34
Grand total......	4,440,634	2,337,877	5,218,793	11,997,304	....	....	....	....	6,719,989	5,277,315	$6,947,641 79	$2,391,528 77	$965,698 88	$10,304,869 44

TABLE

Showing Number of Miners, Machine Runners and Helpers, Loaders, Inside Day and Monthly Men, Persons Employed Outside; Total Number of Employes at Each Mine, Number of Days Worked and Number of Mules Used; Totals by Counties.

CLAY COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Brazil No. 1	23	....	....	8	3	34	270	5	1,204
Brazil No. 4	103	....	....	29	11	143	178	12	1,417
Brazil No. 7	26	....	....	4	4	34	143	2	272
Redstock	35	....	....	12	5	52	75	5	231
Superior No. 4	66	....	....	18	6	90	185	6	2,452
Crawford No. 2	40	....	....	19	7	66	160	5	976
Crawford No. 6	60	....	....	18	6	84	123	9	1,460
Crawford No. 8	28	....	....	6	4	38	181	2	816
Crawford No. 9	63	....	....	17	6	86	231	8	3,056
Plymouth No. 2	51	....	....	10	5	66	220	3	3,128
Monarch	20	....	....	6	2	28	277	4	1,216
Eureka No. 5	83	....	....	19	7	109	180	8	2,034
Treager	11	....	....	1	1	13	191	2	422
Schefferman (Idle)	....	....	....	....	....	....	....	....	....
Wizard	58	....	....	10	5	73	158	3	1,504
Crawford No. 10	30	....	....	10	6	46	137	3	1,202
Pyrah	10	....	....	3	3	16	204	1	359
Indiana No. 1	35	....	....	6	5	46	127	3	824
Progressive	38	....	....	9	5	52	166	5	1,201
Gifford No. 1	21	....	....	9	5	35	19	3	110
Gifford No. 2	19	2	10	7	5	43	83	2	494
Lewis	36	18	56	19	11	140	135	8	1,446
Vivian No. 2	7	16	61	22	7	113	174	10	1,165
Gold Knob (Idle)	....	....	....	....	....	....	....	....	....
Island Valley No. 4	11	14	76	26	11	138	106	14	1,066
Vandalia No. 60	54	....	....	22	11	87	76	5	457
Vandalia No. 65	174	....	....	50	15	239	245	19	5,971
Glenn No. 1	24	....	....	5	4	33	139	3	719
Vivian No. 1 (Idle)	....	....	....	....	....	....	....	....	....
Klondyke No. 2	69	....	....	17	5	91	111	7	1,471
Continental	12	....	....	3	3	18	77	2	74
Total	1,207	50	203	385	168	2,013	4,371	159	39,437

DAVIESS COUNTY.

Horney	16	....	....	2	2	20	143	1	245
Stueky. (Idle)	....	....	....	....	....	....	....	....	....
Montgomery No. 3	31	....	....	8	9	48	84	5	570
Mutual	62	....	....	11	8	81	177	6	1,765
Mandabach. (Idle)	....	....	....	....	....	....	....	....	....
Winklepeck (Idle)	....	....	....	....	....	....	....	....	....
Total	109	....	....	21	19	149	404	12	2,580

FOUNTAIN COUNTY.

Indio	39	....	....	12	5	56	119	6	869
Total	39	....	....	12	5	56	119	6	869

TABLE SHOWING NUMBER OF MINERS, ETC.—Continued.

GREENE COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Black Creek	74	6	34	44	9	167	234	14	3,845
Bickason	57	4	14	24	8	105	44	8	782
Vandalia No. 2	95	14	28	41	12	190	144	17	2,094
Vandalia No. 5	95	30	67	63	25	280	234	14	3,908
Vandalia No. 8	17	22	127	63	17	246	229	16	2,579
Vandalia No. 9	27	14	104	56	14	215	213	14	2,690
Vandalia No. 21	1	28	78	22	14	143	248	8	1,496
Lattas Creek	65	32	123	65	22	307	156	13	3,945
Gilmour	31	14	87	49	16	197	108	15	3,153
Summit No. 2	11	18	97	50	10	188	180	22	1,868
Green Valley	....	16	84	35	11	146	185	15	1,683
Queen	56	....	....	13	6	75	195	6	3,089
North West	31	12	65	33	14	155	197	10	2,424
Twin No. 4	12	26	29	20	7	94	197	6	561
Twin No. 5	11	10	78	23	10	132	161	9	1,199
North Linton (Idle)	....	....	....	....	....	....	....	....	....
Sponsler	83	....	....	20	7	110	204	13	3,745
Antioch	59	....	....	19	9	87	163	6	2,879
Vandalia No. 3	72	....	....	25	9	106	89	10	2,213
Vandalia No. 4	95	....	....	29	9	133	50	9	1,118
Vandalia No. 6	68	....	....	2	2	72	12	1	183
Tower Hill	100	....	....	37	14	151	35	7	1,472
Letsinger (Idle)	....	....	....	....	....	....	....	....	....
P. & I.	45	....	....	12	8	65	65	18	727
Enterprise	11	....	....	2	2	15	52	2	138
Vandalia No. 20	....	6	9	2	3	20	61	1	21
Total	1,116	252	1,024	749	258	3,399	3,456	254	47,812

GIBSON COUNTY.

Oswald	94	....	....	47	11	152	253	18	6,404
Peacock No. 2	28	....	....	3	7	38	58	5	451
Fort Branch	12	....	....	3	4	19	89	2	230
Total	134	....	....	53	22	209	400	25	7,085

KNOX COUNTY.

Knox	10	14	60	82	13	179	149	7	1,038
Lynn	7	8	31	18	9	73	197	8	847
Freeman	8	18	85	36	17	164	180	9	1,668
Bicknell	12	....	....	4	2	18	145	4	1,045
Wheatland	44	....	....	11	5	60	72	6	927
Tecumseh	....	32	74	18	13	137	180	6	1,752
Total	81	72	250	169	59	631	923	40	7,277

TABLE SHOWING NUMBER OF MINERS, ETC.—Continued.

PARKE COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Brazil No. 9	27	....	....	13	5	45	170	5	896
Brazil No. 12	36	....	....	8	4	48	167	4	1,274
Superior No. 1	6	....	....	1	3	10	54	1	40
Superior No. 2	85	....	....	22	8	115	144	11	2,605
Superior No. 3	85	....	....	24	7	116	180	9	2,348
Superior No. 5	103	....	....	34	8	145	153	10	4,520
Mary	12	14	42	37	12	117	244	12	567
Mecca No. 3	44	....	....	22	6	72	165	7	1,656
Parke No. 11	31	26	47	37	12	153	234	10	2,834
Lyford No. 1	....	28	55	31	12	126	209	12	1,492
Harrison (Idle)	....	....	....	....	....	....	....	....	....
Moore....... (Idle)	....	....	....	....	....	....	....	....	....
Vandalia No. 316	111	....	....	41	10	162	169	18	2,803
Total	540	68	144	270	87	1,109	1,889	99	21,035

PERRY COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Troy	15	....	....	3	3	21	82	1	178
Total	15	....	....	3	3	21	82	1	178

PIKE COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Ayrshire No. 5	2	6	21	10	7	46	216	4	826
Ayrshire No. 3	56	....	....	13	10	79	147	7	1,768
Ayrshire No. 4	141	....	....	37	22	200	213	16	7,323
Muren	44	....	....	12	8	64	140	5	1,535
Blackburn No. 1	14	....	....	5	4	23	135	3	993
Littles	146	....	....	42	10	198	173	15	4,307
Petersburg (Idle)	....	....	....	....	....	....	....	....	....
Winslow No. 4 (Idle)	....	....	....	....	....	....	....	....	....
Winslow No. 5 (Idle)	....	....	....	....	....	....	....	....	....
Aberdeen	40	....	....	5	3	48	75	2	280
Blackburn No. 2	44	2	8	9	8	71	161	2	2,217
Hartwell No. 1 (Idle)	....	....	....	....	....	....	....	....	....
Hartwell No. 2 (Idle)	....	....	....	....	....	....	....	....	....
Total	487	8	29	133	72	729	1,260	54	18,969

TABLE SHOWING NUMBER OF MINERS, ETC.—Continued.

SULLIVAN COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Ouistde Day Men.	Total Em-ployes.	Days Worked.	Mules Used.	Powder.
Rainbow		16	92	26	16	150	90	13	2,476
Phoenix No. 4	1	20	110	47	15	193	110	16	2,707
Hocking		16	77	41	17	151	133	10	3,047
Citizens	12	8	35	9	7	71	124	5	442
Sunflower		12	84	23	12	131	136	11	875
Consolidated No. 25		20	68	31	13	132	185	9	1,365
Consolidated No. 26	(Idle)								
Consolidated No. 28	(Idle)								
Consolidated No. 30		12	51	23	13	99	145	9	727
Consolidated No. 32	(Idle)								
Bellevue	29			5	4	38	43	2	310
Vandalia No. 10	3	20	133	72	18	246	201	16	2,325
Jackson Hill No. 2		20	109	36	14	179	188	19	1,191
Jackson Hill No. 4		20	107	35	16	178	172	18	1,031
Keystone	40			6	4	50	52	2	302
Dering No. 13	2	14	65	31	14	126	194	15	1,276
Dering No. 14	7	18	94	58	20	197	204	19	1,717
Mammoth Vein	7	14	95	52	23	191	120	12	1,711
Shirley Hill No. 1	42	10	54	32	12	150	222	12	3,555
Little Giant	140	12	81	69	20	322	225	17	7,924
Reliance	15	12	64	36	12	139	223	9	1,138
Diamond No. 1	60			25	12	97	102	6	1,699
Black Hawk (Idle)									
Clover Leaf	23	14	80	50	11	178	239	16	3,190
Shirley Hill No. 3		6	38	13	10	67	228	3	808
Viola	35	6	24	25	21	111	160	5	1,631
Cummins	35			15	15	65	51	7	312
Freeman	45			18	9	72	187	6	2,466
Hudson	112			42	12	166	137	15	3,413
Consolidated No. 33	35	24	136	74	19	288	150	18	2,402
Kettle Creek	5	12	70	31	11	129	124	14	701
Total	648	306	1,667	925	370	3,916	4,345	304	50,429

VANDERBURGH COUNTY.

Diamond	51			9	10	70	144	5	1,713
Ingleside	60			15	12	87	287	8	2,350
Sunnyside	36			11	7	54	204	8	1,658
Unity	116			36	13	165	201	14	5,950
First Avenue	46			8	8	62	248	5	1,914
Total	309			79	50	438	1,084	40	13,585

VERMILLION COUNTY.

Dering No. 5	143			47	9	199	110	19	5,935
Dering No. 7	139			47	11	197	196	14	8,925
Dering No. 8	83			30	7	120	226	9	7,194
Eureka	12			3	2	17	95	3	291
Crown Hill No. 1	215			39	9	263	230	20	11,777
Crown Hill No. 2	164			32	12	208	225	15	8,793
Oak Hill (not reported)									
Maple Valley	108			32	8	148	109	15	3,735
Buckeye No. 2	264			59	11	334	206	26	19,558
Klondyke	65			16	4	85	251	4	4,270
Crown Hill No. 3		28	44	15	9	96	234	4	1,081
Total	1,193	28	44	320	82	1,667	1,882	129	72,700

TABLE SHOWING NUMBER OF MINERS, ETC.—Continued.

VIGO COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Vandalia No. 81	59			24	12	95	263	8	3,976
Parke No. 10	103	4		41	15	163	44	12	1,796
Forrest	67	22	42	40	20	191	178	14	5,216
Atherton	21	12	20	19	10	82	54	6	176
Lawton	153			38	14	205	248	28	4,910
Plymouth No. 1	41	6	26	15	7	95	215	5	2,797
Victor	92			17	9	118	250	6	3,148
Wabash	55	14	91	33	9	202	253	12	7,603
Lower Vein No. 1	162			39	10	211	200	12	8,012
Vandalia No. 66	111			45	12	168	232	12	4,892
Vandalia No. 67	180			55	18	253	243	19	6,716
Miami No. 1	113			34	10	157	229	15	5,346
Miami No. 2	186			26	9	221	252	13	6,216
Miami No. 3	203			34	9	246	151	17	5,056
Fauvre No. 1	37			14	7	58	195	6	2,212
Fauvre No. 2	71			15	9	95	129	5	2,603
Vandalia No. 69	105	4	10	42	11	172	229	13	5,005
Deep Vein	94	2	8	18	10	132	179	10	3,997
Ray No. 2	228			44	10	282	188	19	4,303
Chicago No. 6 (Idle)									
Grant No. 2	85			35	11	131	89	17	1,781
Sugar Valley	26			4	3	33	230	2	1,250
Dering No. 6	207			67	7	281	168	28	12,924
Minshall	62			14	6	82	229	5	3,302
Domestic Block No. 1	20	14	60	38	18	150	106	10	909
Miami No. 4	14			6	5	25	123	2	567
Grant No. 3		18	40	15	8	81	155	5	639
National	25			3	2	30	142	2	655
Glen Ayr	48	8	41	15	8	120	165	5	3,087
Total	2,568	104	338	790	279	4,079	5,139	308	108,494

WARRICK COUNTY

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Big Four		14	43	10	16	83	223	7	1,332
Chandler	35	6	14	7	5	67	121	4	879
DeForrest		6	17	6	4	33	99	3	194
Electric	17	6	36	22	9	90	120	11	986
Dawson		16	30	11	6	63	248	7	817
Erie Canal	11	8	40	13	7	79	107	7	679
Red Shaft (Not reported)									
Castle Garden	64			11	9	84	135	6	2,982
Brizius	34			5	5	44	203	4	1,261
Elberfeld	40			5	5	50	117	4	526
Epworth	12			1	2	15	160	1	801
Polk No. 5		14	38	7	9	68	151	3	440
Total	213	70	218	98	77	676	1,683	57	10,897
Grand total	8,659	958	3,917	4,007	1,551	19,092	27,037	1,488	401,347

TABLE

Showing by Counties the Total Number of Miners and Total Number of Kegs of Powder Used in 1908, the Number of Kegs per Miner, the Total Tons of Coal Produced and the Number of Tons Produced per Keg of Powder.—The Block and Bituminous Mines Each Shown Separately, as Are the Machine and Hand Mines.—Also a General Average of Tons Produced per Keg in All the Mines in the State Combined.

BLOCK COAL MACHINE MINES.

COUNTY.	No. Tons Produced.	Kegs of Powder.	No. of Miners.	Kegs per Miner.	Tons Per Keg.
Parke	64,331	567	54	10.5	113.4
Vigo	94,165	3,706	147	25.2	25.4
General average	158,496	4,273	201	21.2	37

BLOCK COAL HAND MINES.

COUNTY.	No. Tons Produced.	Kegs of Powder.	No. of Miners.	Kegs per Miner.	Tons Per Keg.
Clay	523,637	27,257	792	34.4	19.2
Parke	170,827	11,683	342	34.1	14.6
General average	694,464	38,940	1,134	34.3	17.8
Total general average bloek mines	852,960	43,213	1,335	32.3	19.7

BITUMINOUS MACHINE MINES.

COUNTY.	No. Tons Produced.	Kegs of Powder.	No. of Miners.	Kegs per Miner.	Tons Per Keg.
Clay	275,204	4,281	297	14.4	64.2
Greene	1,921,028	32,248	1,607	20.6	59.5
Knox	391,623	5,305	275	19.2	73.8
Parke	246,704	4,326	133	32.5	57
Pike	74,158	3,043	75	40.5	24.3
Sullivan	2,449,291	42,239	1,994	21.2	57.9
Vermillion	66,432	1,081	44	24.5	61.4
Vigo	692,030	27,519	745	36.8	25.1
Warrick	304,477	5,327	281	18.9	57.1
General average	6,420,947	125,369	5,451	22.9	51.2

BITUMINOUS HAND MINES.

COUNTY.	No. Tons Produced.	Kegs of Powder.	No. of Miners.	Kegs per Miner.	Tons Per Keg.
Clay	230,320	7,899	321	24.6	29.1
Daviess	43,185	2,580	109	23.6	16.7
Fountain	15,849	869	39	22.2	18.2
Greene	336,618	15,564	533	29.2	21.6
Gibson	170,421	7,085	134	52.8	24
Knox	36,376	1,972	56	35.3	18.4
Parke	121,083	4,459	155	28.7	27.1
Perry	3,729	178	15	11.8	20.9
Pike	350,807	15,926	441	36.1	22
Sullivan	136,702	8,190	321	25.5	16.6
Vanderburgh	253,774	13,585	309	43.9	18.6
Vermillion	1,073,237	71,619	1,193	60	14.9
Vigo	1,831,720	77,269	2,014	38.3	23.7
Warrick	119,576	5,570	150	37.1	21.4
General average	4,723,397	232,765	5,790	40.2	20.2
Total general average bituminous mines	11,144,344	358,134	11,241	31.8	31.1

RECAPITULATION.

COUNTY.	No. Tons Produced.	Kegs of Powder.	No. of Miners.	Kegs per Miner.	Tons Per Keg.
General average block hand mines	694,464	38,940	1,134	34.3	17.8
General average bloek machine mines	158,496	4,273	201	21.2	37
General average bituminous hand mines	4,723,397	232,765	5,790	40.2	20.2
General average bituminous machine mines	6,420,947	125,369	5,451	22.9	51.2
Total general average for the State	11,997,304	401,347	12,576	31.9	29.8

TABLE

Exhibiting the Names of Coal Companies, Names of Mines Operated by Them, the Geological Number of the Different Coal Seams Mined, Character and Thickness of Seam in Feet and Inches, Depth From Surface to Coal, and Railroads on Which Each Mine is Located; Also Location of Mine by Section, Range and Township, and Surface Elevation Above Sea Level Where Same Could be Obtained.

CLAY COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Location.	Geological Number.	Character of Coal.	Thickness of Coal in Feet and Inches.	Depth from Surface to Coal.	Elevation Above Sea Level.
Brazil Block Coal Co	Brazil No. 1	C. & E. I.	Sec. 26, T. 13 n. R. 7 w., Brazil Tp	IV	Block	3′ 6″	96	......
Brazil Block Coal Co	Brazil No. 4	C. & E. I.	Sec. 10, T. 13 n. R. 7 w., Brazil Tp	III	Block	3′ 4″	146	......
				Rider.		3′ 6″	75	
Superior Block Coal Co	Rebstock	C. & E. I.	Sec. 21, T. 13 n. R. 7 w., Dick Johnson Tp	IV	Block	4′ 8″	95	......
Zeller-McClellan Co	Superior No. 4	E. & I.	Sec. 13, T. 12 n. R. 7 w., Posey	IV	Block	4′ 2″	85	......
Crawford Coal Co	Crawford No. 2	Vandalia, Center Point branch.	Sec. 32, T. 12 n. R. 6 w., Jackson Tp	IV	Block	3′ 2″	42	......
Crawford Coal Co	Crawford No. 6	Vandalia, Center Point branch.	Sec. 4, T. 11 n. R. 6 w., Sugar Ridge Tp	III	Block	3′ 4″	106	......
Crawford Coal Co	Crawford No. 8	E. & I.	Sec. 31, T. 12 n. R. 6 w., Jackson Tp	IV	Block	3′ 1″	50	......
Crawford Coal Co	Crawford No. 9	C. & E. I.	Sec. 36, T. 13 n. R. 7 w., Brazil Tp	IV	Block	3′ 6″	99	......
Crawford Coal Co	Crawford No. 10	C. & E. I.	Sec. 21, T. 13 n. R. 7 w., Dick Johnson Tp	IV	Block	3′10″	120	......
Indiana Block Coal Co	Indiana No. 1	E. & I.	Sec. 25, T. 11 n. R. 7 w., Sugar Ridge Tp	IV	Block	2′10″	56	......
Coal Bluff Mining Co	Plymouth No. 2	C. & E. I.	Sec. 4, T. 13 n. R. 7 w., Dick Johnson Tp	III	Block	3′ 7″	115	......
American Clay Manufacturing Co.	Monarch	Product consumed at factory	Sec. 25, T. 13 n. R. 7 w., Brazil Tp	IV	Block	2′ 6″	75	......
Eureka Block Coal Co	Eureka No. 5	Big Four	Sec. 10, T. 13 n. R. 7 w., Dick Johnson Tp	III	Block	3′ 3″	115	......
Treager Coal Co	Treager	Wagon mine	Sec. 30, T. 13 n. R. 7 w., Brazil Tp	IV	Block	3′ 6″	64	......
Harrison Coal Co	Harrison No. 4	E. & I.	Sec. 27, T. 10 n. R. 6 w., Harrison Tp	IV	Block	4′ 6″	70	......
Nick Schefferman	Schefferman	Wagon mine	Sec. 4, T. 12 n. R. 6 w., Jackson Tp	III	Block	4′ 2″	67	......
Hall & Zimmerman	Wizard	Central Indiana	Sec. 19, T. 13 n. R. 6 w., Van Buren Tp	III	Block	3′ 4″	45	......
Sam Pyrah	Pyrah	Wagon mine	Sec. 1, T. 12 n. R. 7 w., Dick Johnson Tp	IV	Block	3′ 6″	35	......
Progressive Coal & Mining Co	Progressive	Vandalia, main line	Sec. 6, T. 12 n. R. 6 w., Jackson Tp	IV	Block	3′10″	101	......
Big Vein Mining Co	Lewis	S. I.	Sec. 30, T. 9 n. R. 7 w., Lewis Tp	V	Bituminous.	8′	80	......
Vivian Colliers Co	Vivian No. 1	S. I.	Sec. 34, T. 9 n. R. 7 w., Lewis Tp	III	Bituminous.	5′10″	160	......
Vivian Colliers Co	Vivian No. 2	S. I.	Sec. 34, T. 9 n. R. 7 w., Lewis Tp	IV	Bituminous.	4′ 2″	34	......
O. S. Richardson Coal Co	Gifford No. 2	C. & E. I.	Sec. 33, T. 13 n. R. 7 w., Dick Johnson Tp	III	Bituminous.	4 3″	77	......
				Minshall.				
Vandalia Coal Co	Vandalia No. 65	Vandalia, main line	Sec. 18, T. 12 n. R. 7 w., Posey Tp	III	Bituminous.	7′ 2″	99	......
				Minshall.				
United Fourth Vein Coal Co	Island Valley No. 4	S. I.	Sec. 33, T. 9 n. R. 7 w., Lewis Tp	IV	Bituminous.	4′10″	104	......

TABLE EXHIBITING THE NAMES OF COAL COMPANIES, ETC.—Continued.

DAVIESS COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Location.	Geological Number.	Character of Coal.	Thickness of Coal in Feet and Inches.	Depth from Surface to Coal.	Elevation Above Sea Level.
Horney & Winterbottom	Horney No. 3	Wagon mine	Sec. 9, T. 2 n. R. 7 w., Washington Tp	Minshall.	Bituminous.	3' 9"	40	....
Mutual Mining Co.	Mutual	B. & O. S. W.	Sec. 23, T. 3 n. R. 5 w., Barr Tp	Minshall.	Bituminous.	3' 9"	100	....
Winklepeck & Overton	Winklepeck	Wagon mine	....	Minshall.	Bituminous.	3'	drift	....
Mandabach Bros.	Mandabach	Wagon mine	Sec. 6, T. 2 n. R. 7 w., Washington Tp	V	Bituminous.	5' 6"	97	....
River Island Coal Co	River Island	Wagon mine	Sec. 8, T. 5 n. R. 6 w., Elnora Tp	Minshall.	Bituminous.	3' 6"	113	....

FOUNTAIN COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Location.	Geological Number.	Character of Coal.	Thickness of Coal in Feet and Inches.	Depth from Surface to Coal.	Elevation Above Sea Level.
Rush Coal Co	Indio	Clover Leaf	Sec. 9, T. 18 n. R. 8 w	III?	Bituminous.	4' 6"	50	....

GREENE COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Location.	Geological Number.	Character of Coal.	Thickness of Coal in Feet and Inches.	Depth from Surface to Coal.	Elevation Above Sea Level.
United Fourth Vein Coal Co	Black Creek	S. I.	Secs. 9, 10, 15 and 16, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	4' 6"	83	....
United Fourth Vein Coal Co	Dickason	S. I.	Secs. 10, 15, and 16, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	4' 6"	81	....
United Fourth Vein Coal Co	Sponsler	S. I.	Secs. 35 and 36, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	5' 3"	50	....
United Fourth Vein Coal Co	Antioch	S. I., Sullivan division	Secs. 29, 30 and 31, T. 8 n. R. 7 w., Wright Tp.	IV	Bituminous.	4' 4"	168	....
United Fourth Vein Coal Co	North Linton	S. I.	Secs. 10 and 11, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	4'	64	....
Vandalia Coal Co	Vandalia No. 2	I. & V., Coal branch	Sec. 26, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	5'	66-6"	....
Vandalia Coal Co	Vandalia No. 3	I. & V., Coal branch	Sec. 26, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	5'	82	....
Vandalia Coal Co	Vandalia No. 4	I. & V., Coal branch	Sec. 23, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	5'	55	....
Vandalia Coal Co	Vandalia No. 5	I. & V., Coal branch	Sec. 22, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	5'	91	....
Vandalia Coal Co	Vandalia No. 6	I. & V., Coal branch	Sec. 27, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	5'	75	....
Vandalia Coal Co	Vandalia No. 8	I. & V., Coal branch	Sec. 17, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	5' 6"	130	....
Vandalia Coal Co	Vandalia No. 9	I. & V., Coal branch	Sec. 17, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	5'	129	....

Vandalia Coal Co	Vandalia No. 20	I. & V., Coal branch	Sec. 19, T. 7 n. R. 7 w., Stockton Tp	V	Bituminous.	6′ 6″	100	....
Vandalia Coal Co	Vandalia No. 21	I. & V., Coal branch	Sec. 19, T. 7 n. R. 7 w., Stockton Tp	V	Bituminous.	7′	112	....
Indiana Southern Coal Co	Gilmour	S. I	Sec. 18, T. 8 n. R. 7 w., Wright Tp	IV	Bituminous.	5′ 2″	155	....
Summit Coal & Mining Co	Summit No. 2	I. & V., Coal branch	Sec. 21, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	5′ 6″	150	....
Green Valley Coal Co	Green Valley	S. I	Sec. 5, T. 8 n. R. 7 w., Wright Tp	IV	Bituminous.	5′	160	605-1
Southern Indiana Coal Co	Lattas Creek	S. I	Sec. 7, T. 8 n. R. 7 w., Wright Tp	IV	Bituminous.	5′ 4″	153	....
Queen Coal Co	Queen	S. I	Sec. 4, T. 8 n. R. 7 w., Wright Tp	IV	Bituminous.	3′ 9″	90	....
Calora Coal Co	North West	S. I	Sec. 3, T. 8 n. R. 7 w., Wright Tp	IV	Bituminous.	4′ 4″	84	....
Coal Bluff Mining Co	Twin No. 4	S. I	Sec. 5, T. 7 n. R. 7 w., Stockton Tp	V	Bituminous.	4′ 4″	160	....
Coal Bluff Mining Co	Twin No. 5	S. I	Sec. 5, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	6′ 4″	60	....
Cherry Hill Coal Co	Cherry Hill	S. I	Sec. 25, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	5′	45	....
Letsinger Coal Co	Letsinger	S. I	Secs. 8 and 9, T. 8 n. R. 7 w., Wright Tp	III	Bituminous.	7′	200	....
Moorehead Coal Co	P. & I	S. I	Sec. 27, T. 8 n. R. 7 w., Wright Tp	III	Bituminous.	6′ 6″	216	....
Enterprise Coal Co	Lyons	I. & V., Coal branch	Sec. 36, T. 7 n. R. 7 w., Stockton Tp	IV	Bituminous.	5′ 6″	45	....

GIBSON COUNTY.

Princeton Coal & Mining Co	Oswald	Southern	Sec. 1, T. 2 s. R. 10 w., Patoka Tp	V	Bituminous.	6′10″	440	....
Fort Branch Coal & Mining Co	Fort Branch	E. & T. H	Sec. 19, T. 2 s. R. 10 w., Johnson Tp	VI	Bituminous.	4′ 6″	265	....
Wyoming Coal Co	Francisco	Southern	Sec. 18, T. 2 s. R. 9 w., Center Tp	VI	Bituminous.	4′	132	....

KNOX COUNTY.

Knox Coal Co	Knox	I. & V., Vandalia	Sec. 20, T. 4 n. R. 8 w., Washington Tp	V	Bituminous.	7′	207	....
Lynn Coal Co	Lynn	I. & V., Vandalia	Sec. 16, T. 4 n. R. 8 W., Vigo Tp	V	Bituminous.	5′	185	....
Freeman Coal Co	Freeman	I. & V., Vandalia	Sec. 21, T. 4 n. R. 8 w., Vigo Tp	V	Bituminous.	7′ 6″	240	....
Home Coal Co	Bicknell	I. & V., Vandalia	Sec. 21, T. 4 n. R. 8 w., Vigo Tp	VI	Bituminous.	4′ 6″	98	....
Tecumseh Coal & Mining Co	Tecumseh	I. & V., Vandalia	Sec. 22, T. 4 n. R. 8 w., Vigo Tp	V	Bituminous.	5′ 6″	154	....
Washington-Wheatland Coal Co	Wheatland	B. & O. S. W	Donation 106, T. 3 n. R. 8 w., Steen Tp	V	Bituminous.	5′	122	....
				VII	....	5′	238	....

TABLE EXHIBITING THE NAMES OF COAL COMPANIES, ETC.—Continued.

PARKE COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Location.	Geological Number.	Character of Coal.	Thickness of Coal in Feet and Inches.	Depth from Surface to Coal.	Elevation Above Sea Level.
Brazil Block Coal Co	Brazil No. 9	C. & E. I	Sec. 34, T. 14 n. R. 7 w., Raccoon Tp	IV	Block	4′ 3″	121	......
Brazil Block Coal Co	Brazil No. 12	C. & E. I	Sec. 34, T. 14 n. R. 7 w., Raccoon Tp	III	Block	3′ 6″	136	......
Zellar-McClellan & Co	Superior No. 2	C. & E. I	Sec. 35, T. 14 n. R. 7 w., Raccoon Tp	IV III	Block Block	4′ 4″ 3′ 4″	90 123	....
Zellar-McClellan & Co	Superior No. 3	C. & E. I	Sec. 35, T. 14 n. R. 7 w., Raccoon Tp	IV III	Block Block	4′ 4″ 3′ 3″	55 85	....
Zellar-McClellan & Co	Superior No. 5	C. & E. I	Sec. 26, T. 14 n. R. 7 w., Raccoon Tp	III	Block	3′ 4″	150	......
Otter Creek Coal Co	Mary No. 1	C. & E. I	Sec. 26, T. 14 n. R. 7 w., Raccoon Tp	III	Block	3′	154	......
United Coal & Mining Co	Mecca No. 3	C. & E. I	Sec. 21, T. 15 n. R. 8 w., Wabash Tp	Minshall.	Bituminous.	4′ 6″	160	......
Parke County Coal Co	Parke No. 2	Vandalia, Logansport branch	Sec. 33, T. 14 n. R. 8 w., Florida Tp	III	Bituminous.	6′ 6″	125	......
Fairview Coal Co	Fairview	C. & E. I	Sec. 16, T. 15 n. R. 8 w., Wabash Tp	Minshall.	Bituminous.	5′	240	......
Vivian Colliers Co	Lyford No. 1	C. & E. I	Sec. 13, T. 14 n. R. 9 w., Florida Tp	III	Bituminous.	6′	160	......
Vandalia Coal Co	Vandalia No. 316	Vandalia, Logansport branch	Sec. 18, T. 14 n. R. 8 w., Raccoon Tp	Minshall.	Bituminous.	4′ 6″	154	......
James Moore	Moore	Wagon mine	Sec. 9, T. 17 n. R. 7 w., Sugar Creek Tb	IV	Block	4′	24	......
W. P. Harrison	Harrison	Wagon mine	Sec. 34, T. 16 n. R. 7 w., Washington Tp	Minshall.	Bituminous.	3′ 5″	Slope	......

PIKE COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Location.	Geological Number.	Character of Coal.	Thickness of Coal in Feet and Inches.	Depth from Surface to Coal.	Elevation Above Sea Level.
Ayrshire Coal Co	Ayrshire No. 3	Main Line Southern	Sec. 6, T. 2 s. R. 7 w., Patoka Tp	V	Bituminous.	5′	26	470
Ayrshire Coal Co	Ayrshire No. 4	Main Line Southern	Sec. 6, T. 2 s. R. 7 w., Patoka Tp	V	Bituminous.	5′	Drift	......
Ayrshire Coal Co	Ayrshire No. 5	Main Line Southern	Sec. 1, T. 2 s. R. 8 w., Patoka Tp	V	Bituminous.	5′	Slope	......
Central Indiana Coal & Mining Co	Muren	Main Line Southern	Sec. 10, T. 2 s. R. 8 w., Patoka Tp	V	Bituminous.	4′	Slope	......
S. W. Littles Coal Co	Blackburn No. 1	E. & I	Sec. 12, T. 1 n. R. 8 w., Washington Tp	V	Bituminous.	7′ 6″	Slope	......
S. W. Littles Coal Co	Blackburn No. 2	E. & I	Sec. 14, T. 1 n. R. 8 w., Washington Tp	V	Bituminous.	6′	70	......
S. W. Littles Coal Co	Littles	E. & I	Sec. 27, T. 1 n. R. 8 w., Patoka Tp	V	Bituminous.	6′	80	......
Peacock Coal & Mining Co	Peacock No. 2	E. & I	Sec. 4, T. 2 n. R. 8 w., Patoka Tp	VI	Bituminous.	7′ 6″	Slope	......
Muncie Coal & Mining Co	Petersburg	E. & I	Sec. 27, T. 1 n. R. 8 w., Washington Tp	V	Bituminous	5′	40	......
Winslow Gas Coal Co	Winslow No. 4	Southern Main Line		V	Bituminous.			......
Winslow Gas Coal Co	Winslow No. 5	Southern Main Line	......	V	Bituminous.	......	......	......
J. W. Welsh	Hartwell No. 1	Southern Main Line	Sec. 22, T. 2 s. R. 7 w	V	Bituminous.	4′ 8″	Drift	......
J. W. Welsh	Hartwell No. 2	Southern Main Line	Sec. 22, T. 2 s. R. 7 w	V	Bituminous.	4′ 8″	Drift	......

SULLIVAN COUNTY.

Indiana Southern Coal Co.	Rainbow	I. S.	Sec. 31, T. 8 n. R. 8 w., Cass Tp.	VI	Bituminous.	5'	92	
Indiana Southern Coal Co.	Phoenix No. 4	E. & T. H.	Sec. 34, T. 9 n. R. 9 w., Curry Tp.	VI	Bituminous.	5' 6"	202	
Indiana Southern Coal Co.	Hocking	E. & T. H.	Sec. 13, T. 9 n. R. 9 w., Curry Tp.	VI	Bituminous.	5' 2"	219	
Indiana Southern Coal Co.	Citizens	S. I.	Sec. 35, T. 8 n. R. 9 w., Hamilton Tp.	VI	Bituminous.	5'	163	
Sunflower Coal Co.	Sunflower	I. C.	Sec. 1, T. 7 n. R. 8 w., Cass Tp.	VI	Bituminous.	5' 9"	104	
Consolidated Indiana Coal Co.	Consolidated No. 25	E. & T. H.	Sec. 22 T. 8 n R. 9 w., Hamilton Tp.	VI	Bituminous.	5'	221	
Consolidated Indiana Coal Co.	Consolidated No. 26	E. & T. H.	Sec. 22, T. 8 n. R. 9 w., Hamilton Tp.	VI	Bituminous.	5' 5"	197	
Consolidated Indiana Coal Co.	Consolidated No. 28	S. I.	Sec. 11, T. 8 n. R. 9 w., Hamilton Tp.	VI	Bituminous.	5' 6"	197	
Consolidated Indiana Coal Co.	Consolidated No. 30	S. I.	Sec. 25, T. 9 n. R. 9 w., Curry Tp.	VI	Bituminous.	5' 6"	187	
Consolidated Indiana Coal Co.	Consolidated No. 32	S. I.	Sec. 33, T. 9 n. R. 8 w., Jackson Tp.	V	Bituminous.	7'	108	
Consolidated Indiana Coal Co.	Consolidated No. 33	E. & T. H.	Sec. 33, T. 9 n. R. 8 w., Jackson Tp.	V	Bituminous.	6'	103	
Vandalia Coal Co.	Vandalia No. 10	I. & V., Coal branch	Sec. 10, T. 7 n. R. 8 w., Cass Tp.	IV	Bituminous.	5' 6"	260	
Larsh Coal Co.	Larsh	Wagon mine	Sec. 1, T. 9 n. R. 9 w., Curry Tp.	VI	Bituminous.	5' 3"	104	
Jackson Hill Coal & Coke Co.	Jackson Hill No. 2	E. & T. H., Coal branch	Sec. 9, T. 8 n. R. 8 w., Jackson Tp.	VI	Bituminous.	5' 6"	105	
Jackson Hill Coal & Coke Co.	Jackson Hill No. 2	E. & T. H., Coal branch	Sec. 1, T. 8 n. R. 8 w., Curry Tp.	VI	Bituminous.	5' 8"	165	
Gregory Coal & Mining Co.	Keystone	E. & T. H., Main line	Sec. 10, T. 6 n. R. 9 w., Haddon Tp.	V	Bituminous.	5'	305	
Dering Coal Co.	Dering No. 13	E. & T. H.	Sec. 12, T. 8 n. R. 9 w., Hamilton Tp.	VI	Bituminous.	5' 8"	144	
Dering Coal Co.	Dering No. 14	E. & T. H.	Sec. 30, T. 9 n. R. 8 w., Jackson Tp.	VI	Bituminous.	6'	103	
Southern Indiana Coal Co.	Mammoth Vein	S. I.	Sec. 2, T. 9 n. R. 9 w., Hamilton Tp.	VI	Bituminous.	5' 2"	177	
Shirley Hill Coal Co.	Shirley Hill No. 1	C. I. & L.	Sec. 16, T. 7 n. R. 8 w., Cass Tp.	VI	Bituminous.	5' 6"	111	
Shirley Hill Coal Co.	Shirley Hill No. 3	I. & V. Vandalia	Sec. 9, T. 7 n. R. 8 w., Cass Tp.	VI	Bituminous.	5' 6"	104	
Shirley Hill Coal Co.	Little Giant	C. I. & L.	Sec. 36, T. 7 n. R. 8 w., Jefferson Tp.	VI	Bituminous.	5' 9"	109	
Shirley Hill Coal Co.	Clover Leaf	I. S.	Sec. 34, T. 8 n. R. 8 w., Cass Tp.	IV	Bituminous.	5'	313	
Kettle Creek Coal Co.	Pearl	S. I.	Sec. 35, T. 9 n. R. 9 w., Curry Tp.	VI	Bituminous.	5'10"	170	
Peabody-Alwart Coal & Mining Co.	Reliance	E. & T. H.	Sec. 4, T. 8 n. R. 9 w., Hamilton Tp.	VI	Bituminous.	5' 6"	228	
Hamilton Coal Co.	Hamilton	E. & T. H.	Sec. 3, T. 8 n. R. 8 w., Jackson Tp.	III	Bituminous.	6'	254	
United Fourth Vein Coal Co.	Black Hawk	S. I.	Sec. 25, T. 9 n. R. 8 w., Jackson Tp.	III	Bituminous.	6'	229	
Carlisle Coal & Clay Co.	Viola	E. & T. H.	Sec. 4, T. 6 n. R. 9 w., Haddon Tp. (donation)	V	Bituminous.	4' 8"	305	
Sullivan County Coal Co.	Freeman	I. C.	Sec. 2, T. 7 n. R. 8 w., Cass Tp.	VI	Bituminous.	5' 6"	110	
Hudson Coal & Mining Co.	Hudson	S. I.	Sec. 6, T. 9 n. R. 8 w., Curry Tp.	VII	Bituminous.	5'	112	
Bellevue Coal Co.	Bellevue	E. & T. H., Main line	Sec. 33, T. 6 n. R. 9 w., Haddon Tp.	V	Bituminous.	5'	335	

VANDERBURGH COUNTY.

Diamond Coal Co.	Diamond	Wagon mine	Sec. 17, T. 6 s. R. 10 w.	V	Bituminous.	4'	247	
D. Ingle Coal Co.	Ingleside	L. & N.	Sec. 26, T. 6 s. R. 11 w., Pigeon Tp.	V	Bituminous.	4'	265	
Sunnyside Coal Co.	Sunnyside	L. & N.	Sec. 24, T. 6 s. R. 11 w., Pigeon Tp.	V	Bituminous.	4'	268	
Crescent Coal Co.	Unity	L. & N.	Sec. 13, T. 6 s. R. 11 w. Pigeon Tp.	V	Bituminous.	4'	265	
Banner Coal Co.	First Avenue	Wagon mine	Sec. 18, T. 6 s. R. 10 w., Pigeon Tp.	V	Bituminous.	4'	261	

TABLE EXHIBITING THE NAMES OF COAL COMPANIES, ETC.—Continued.

VERMILLION COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Location.	Geological Number.	Character of Coal.	Thickness of Coal in Feet and Inches.	Depth from Surface to Coal.	Elevation Above Sea Level.
Dering Coal Co.	Dering No. 5	C. & E. I.	Sec. 28, T. n. R. 9 w., Clinton Tp.	V	Bituminous.	4′10″	81	......
Dering Coal Co.	Dering No. 7	C. & E. I.	Sec. 21, T. 14 n. R. 9 w., Clinton Tp.	III	Bituminous.	5′ 6″	217	......
Dering Coal Co.	Dering No. 8	C. & E. I.	Sec. 33, T. 14 n. R. 9 w., Clinton Tp.	IV	Bituminous.	5′ 3″	200	......
Cayuga Brick & Coal Co.	Eureka	Use all coal in brick yard	Sec. 7, T. 17 n. R. 9 w., Eugene Tp.	Minshall.	Bituminous.	4′ 6″	110	......
Clinton Coal Co.	Crown Hill No. 1	C. & E. I., Coal branch	Sec. 21, T. 14 n. R. 9 w., Clinton Tp.	V	Bituminous.	4′10″	165	......
Clinton Coal Co.	Crown Hill No. 2	C. & E. I., Coal branch	Sec. 17, T. 14 n. R. 9 w., Clinton Tp.	V	Bituminous.	4′10″	155	......
Clinton Coal Co.	Crown Hill No. 3	C. & E. I., Coal branch	Sec. 21, 14 n. R. 9 w., Clinton Tp.	III	Bituminous.	6′	345	......
Oak Hill Coal Co.	Oak Hill	C. & E. I., Coal branch	Sec. 28, T. 14 n. R. 9 w., Clinton Tp.	V	Bituminous.	4′10″	57	......
Oak Hill Coal Co.	Maple Valley	C. & E. I., Coal branch	Sec. 16, T. 14 n. R. 9 w., Clinton Tp	V	Bituminous.	5′ 6″	225	......
Oak Hill Coal Co.	Buckeye No. 2	C. & E. I., Coal branch	Sec. 7, T. 14 n. R. 9 w., Clinton Tp.	V	Bituminous.	4′ 8″	149	......
Oak Hill Coal Co.	Klondyke No. 2	C. & E. I., Coal branch	Sec. 8, T. 14 n. R. 9 w., Clinton Tp.	III	Bituminous.	7′	300	......

VIGO COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Location.	Geological Number.	Character of Coal.	Thickness of Coal in Feet and Inches.	Depth from Surface to Coal.	Elevation Above Sea Level.
Vandalia Coal Co.	Vandalia No. 66	Vandalia, Main line	Sec. 11, T. 12 n. R. 8 w., Lost Creek Tp.	III	Bituminous.	5′	102	......
Vandalia Coal Co.	Vandalia No. 67	Vandalia, Main line	Sec. 13, T. 12 n. R. 8 w., Lost Creek Tp.	III	Bituminous.	7′ 6″	100	......
Vandalia Coal Co.	Vandalia No. 69	Vandalia, Main line	Sec. 10, T. 12 n. R. 8 w., Lost Creek Tp.	III	Bituminous.	5′	120	......
Vandalia Coal Co.	Vandalia No. 81	Vandalia, Main line	Sec. 24, T. 12 n. R. 10 w., Sugar Creek Tp.	III	Bituminous.	4′ 6″	64	......
Indiana Southern Coal Co.	Forrest	Big Four	Sec. 31, T. 13 n. R. 8 w., Otter Creek Tp.	III	Bituminous.	6′ 6″	159	......
Otter Creek Coal Co.	Mary No. 2	C. & E. I.	Sec. 1, T. 13 n. R. 8 w., Nevins Tp.	IV	Block	3′ 9″	257	......
Atherton-Splint & Coal Co.	Atherton	C. & E. I.	Sec. 1, T. 13 n. R. 9 w., Otter Creek Tp.	III	Bituminous.	6′	158	......
Coal Bluff Mining Co.	Lawton	Big Four	Sec. 24, T. 13 n. R. 8 w., Nevins Tp.	III	Bituminous.	6′ 9″	116	......
Coal Bluff Mining Co.	Plymouth No. 1	Big Four	Sec. 7, T. 13 n. R. 7 w., Nevins Tp.	III	Block	3′11″	224	......
Coal Bluff Mining Co.	Victor	Big Four	Sec. 7, 13 n. R. 7 w., Nevins Tp	III	Bituminous.	6′	55	......
Coal Bluff Mining Co.	Wabash	Big Four	Sec. 8, T. 12 n. R. 9 w., Sugar Creek Tp.	IV	Bituminous.	5′ 4″	300	......
Coal Bluff Mining Co.	Minshall	Big Four	Sec. 7, T. 13 n. R. 7 w., Nevins Tp.	Minshall.	Bituminous.	5′	175	......
Lower Vein Coal Co.	Lower Vein No. 1	Big Four	Sec. 18, T. 11 and 12 n. R. 9 and 10 w., Sugar Creek Tp.	V	Bituminous.	4′ 8″	192	......
Miami Coal Co.	Miami No. 1	C. & E. I.	Sec. 12, T. 12 n. R. 8 w., Lost Creek Tp.	III	Bituminous.	6′	36	......
Miami Coal Co.	Miami No. 2	C. & E. I.	Sec. 36, T. 13 n. R. 8 w., Nevins Tp.	III	Bituminous.	6′	55	......

Miami Coal Co	Miami No. 3	C. & E. I.	Sec. 12, T. 12 n. R. 8 w., Lost Creek Tp	III	Bituminous.	6′	92	....
Miami Coal Co	Miami No. 4	C. & E. I.	Sec. 36, T. 13 n. R. 8 w., Nevins Tp	III	Bituminous.	6′ 6″	55	....
Fauvre Coal Co	Fauvre No. 1	Vandalia, Main line	Sec. 24, T. 12 n. R. 10 w., Sugar Creek Tp	VII	Bituminous.	5′	100	....
Fauvre Coal Co	Fauvre No. 2	Vandalia, Main line	Sec. 24, T. 12 n. R. 10 w., Sugar Creek Tp	V	Bituminous.	4′ 6″	219	....
Deep Vein Coal Co	Deep Vein	Vandalia	Sec. 18, T. 12 n. R. 9 w., Sugar Creek Tp.	V	Bituminous.	4′ 3″	280	
			(one mile west Terre Haute)	VII	Bituminous.	4′ 6″	170	....
Vigo County Coal Co	Ray No. 2	Vandalia	Sec. 12, T. 12 n. R. 8 w., Lost Creek Tp	III	Bituminous.	7′	97	....
M. D. West Coal Co	Chicago No. 6	C. & E. I.	Sec. 17, T. 13 n. R. 7 w., Nevins Tp	III	Bituminous.	6′	8	....
Grant Coal & Mining Co	Grant No. 3	C. & E. I.	Sec. 26, T. 13 n. R. 8 w., Nevins Tp	III	Bituminous.	6′ 6″	35	....
Sugar Valley Coal Co	Sugar Valley	Wagon mine	Sec. 24, T. 12 n. R. 10 w., Sugar Creek Tp	V	Bituminous.	4′ 4″	140	....
Dering Coal Co	Dering No. 6	C. & E. I.	Sec. 16, T. 13 n. R. 9 w., Fayette Tp	V	Bituminous.	4′ 8″	111	....
Domestic Block Coal Co	Domestic Block No. 1	C. & E. I.	Sec. 29, T. 13 n. R. 7 w., Nevins Tp	IV	Block	3′ 8″	110	....
National Coal Fuel Co	National	Vandalia	Sec. 36, T. 12 n. R. 10 w., Sugar Creek Tp	VII	Bituminous.	4′ 8″	42	....
Glen Ayr Coal Co	Glen Ayr	Vandalia, Main line	Sec. 21, T. 12 n. R. 8 w., Lost Creek Tp	IV	Bituminous.	5′	90	....

WARRICK COUNTY.

Big Four Coal Co	Big Four	Southern, Evansville division	Sec. 36, T. 5 s. R. 8 w., Boone Tp	V	Bituminous.	6′ 6″	Slope	....
Chandler Coal Co	Chandler	Southern, Evansville division	Sec. 35, T. 5 s. R. 9 w., Campbell Tp	V	Bituminous.	4′ 5″	120	....
Chas. Menden Coal Co	De Forrest	Southern, Evansville division	Sec. 32, T. 5 s. R. 8 w., Boone Tp	V	Bituminous.	6′	65	....
T. D. Scales Coal Co	Electric	Southern, Evansville division	Sec. 25, T. 5 s. R. 8 w., Boone Tp	V	Bituminous.	6′ 5″	45	....
Caladonia Mining Co	Dawson	Southern, Evansville division	Sec. 31, T. 5 s. R. 8 w., Boone Tp	V	Bituminous.	5′	86	....
Erie Canal Coal Co	Erie Canal	Southern, Evansville division	Sec. 25, T. 5 s. R. 9 w., Campbell Tp	V	Bituminous.	4′ 5″	130	....
Red Shaft Coal Co	Red Shaft (Old Star No. 1.)	Southern, Evansville division (Electric)	Sec. 34, T. 6 s. R. 9 w., Ohio Tp	V	Bituminous.	4′	180	....
J. Woolley Coal Co	Polk No. 5	Southern, Evansville division	Sec. 17, T. 5 s. R. 7 w., Skelton Tp	V	Bituminous.	6′ 6″	Slope	....
J. Woolley Coal Co	Castle Garden	Southern, Evansville division	Sec. 3, T. 6 s. R. 9 w., Ohio Tp	V	Bituminous.	4′ 2″	80	....
Worshem-Newburg Coal Co	Brizius	E. E. Electric	Sec. 33, T. 6 s. R. 9 w., Ohio Tp	V	Bituminous.	4′	128	....
Elberfeld Coal Co	Elberfeld	E. & I.	Sec. 30, T. 4 s. R. 9 w., Greer Tp	V	Bituminous.	5′	196	....
Epworth Coal Co	Epworth	E. E. Electric	Sec. 32, T. 6 s. R. 9 w., Ohio Tp	V	Bituminous.	4′	114	....

NOTE.—The geological number of the seam mined in the vicinity of Seeleyville along the Main Line Vandalia Railroad and at West Terre Haute, Clinton Atherton, Parke No. 11, Grant No. 3, Miami Nos. 1, 2, 3 and 4 and other points has been changed from No. VI to III. This and other changes in the geological number of seams from that given in former reports was made in conformance to the Supplementary Coal Survey made during the year by Professor G. H. Ashley and his assistants, the results of which are given in the first paper of the present Geological Report.

EXAMINATIONS.

Examinations of applicants for certificates of competency to serve as mine bosses, fire bosses and hoisting engineers were held at three different time during the year in the city of Terre Haute. The annexed table shows the date on which each examination was held, the number of applicants examined each time, the number passing a successful examination and the number who failed:

Date.	Total Applicants.			Passed.			Failed.		
	M. B.	F. B.	H. E.	M. B.	F. B.	H. E.	M. B.	F. B.	H. E.
May 20 and 21	38	17	18	27	8	9	11	9	9
September 2 and 3	21	31	8	13	17	2	8	14	6
November 18 and 19	35	14	14	20	6	6	15	8	8
Totals	94	62	40	60	31	17	34	31	23

The above table shows that nearly sixty-four per cent of applicants for mine boss certificates, fifty-eight per cent of fire boss and forty-two and five-tenths per cent of applicants for hoisting engineers' certificates passed a successul examination and were granted certificates. We give herewith the name and address of each person receiving a certificate and number of each certificate and the per cent grade made by the holder thereof:

MINE BOSS.

Examination held in Terre Haute, May 20 and 21, 1908.

Total number of candidates, 38. Total number passed, 27.

Certificate No.	*Name and Address.*	*Per Cent.*
1.	Thomas Harrop, Linton, Ind	86
2.	Samuel McClain, Coal Bluff, Ind	82
3.	John Aitken, Fontanet, Ind	78
4.	William W. Muir, Shelburn, Ind	76
5.	Thomas Stevenson, Cass, Ind	84
6.	Charles Claymeyer, Elberfeld, Ind	82
7.	Thomas Leppeatt, Dugger, Ind	76
8.	Robert Simpson, Jasonville, Ind	80
9.	Nat Hagerman, Linton, Ind	80
10.	Charles Flynn, Terre Haute, Ind	80
11.	Herman Kunze, Terre Haute, Ind	79
12.	Jas. Shirkie, Clinton, Ind	84
13.	Jesse Palm, Brazil, Ind	83

Certificate No.	Name and Address.	Per Cent.
14.	J. O. Willson, Shelburn, Ind	76
15.	William Brown, Chandler, Ind	79
16.	Hugh Rice, Linton, Ind	82
17.	Tim Pool, Linton, Ind	80
18.	Wm. Sherry, Brazil, Ind	79
19.	Clay Pigg, Dugger, Ind	76
20.	Wm. E. Bledsoe, Shelburn, Ind	82
21.	Henry Surmont, Sullivan, Ind	87
22.	Arthur Debarge, Paxton, Ind	82
23.	Albert J. Ward, Terre Haute, Ind	77
24.	Wm. Strachan, Linton, Ind	78
25.	James Burk, Linton, Ind	82
26.	John Richards, Dugger, Ind	76
27.	Jno. W. Cooper, Evansville, Ind	76

FIRE BOSS.

Examination held in Terre Haute, May 20 and 21, 1908.

Total number of candidates, 17. Total number passed, 8.

Certificate No.	Name and Address.	Per Cent.
1.	George F. Archibold, Evansville	82
2.	James Owens, Clay City	84
3.	John Wm. Mass, West Terre Haute	82
4.	Charles Clayton, Fontanet	82
5.	James Lewis, Dugger	80
6.	Charles Wilder, Boonville	80
7.	T. A. Oxley, Linton	86
8.	Frank Leveck, Sullivan	84

HOISTING ENGINEER.

Examination held in Terre Haute, May 20 and 21, 1908.

Total number of candidates, 18. Total number passed, 9.

Certificate No.	Name and Address.	Per Cent.
1.	Harvey Sanders, Carlisle	81
2.	Eugene Ransford, Sullivan	80
3.	Elijah Powers, Boonville	80
4.	Matthaus Bader, Brazil	80
5.	Gus Wiggins, Shelburn	78
6.	Wm. Garrison, West Terre Haute	81
7.	J. M. Kohlmeyer, Elberfeld	84
8.	F. G. Schultz, Elberfeld	81
9.	John W. Slites, Sullivan	85

MINE BOSS.

Examination held in Terre Haute, September 2 and 3, 1908.
Total number of candidates, 21. Total number passed, 13.

Certificate No.	*Name and Address.*	*Per Cent.*
28.	George W. Higgens, Clinton	89
29.	Fred W. Armstrong, Mecca	76
30.	Joseph Robinson, Mecca	77
31.	William Brumett, Cass	79
32.	Everet Rollison, Linton	80
33.	Wm. C. Campbell, Gilmour	78
34.	George W. Briggs, Winslow	78
35.	Mahlon Ellingsworth, Jasonville	77
36.	F. I. Pearce, Brazil	85
37.	Homer Cargal, Bicknell	77
38.	Adolph Belval, Linton	79
39.	James Morris, Brazil	77
40.	Freeman Shell, Cayuga	76

FIRE BOSS.

Examination held in Terre Haute, September 2 and 3, 1908.
Total number of candidates, 31. Total number passed, 17.

Certificate No.	*Name and Address.*	*Per Cent.*
9.	James S. Deeble, Carlisle	86
10.	Edward Church, Linton	80
11.	James M. Scully, Coalmont	80
12.	Samuel Roebuck, Dugger	82
13.	John McKain, Chandler	80
14.	John Thompson, Bicknell	82
15.	Herman Kunce, Atherton	81
16.	Theodore Mason, Boonville	85
17.	Gustave Mollet, Diamond	86
18.	Thomas Derby, West Terre Haute	77
19.	George Came, Brazil	77
29.	Wellington O'Connor, Terre Haute	90
30.	Albert A. Sames, Chandler	90
31.	John A. Kelly, Boonville	88
32.	Wm. Woolley, Boonville	88
33.	Julien O'Connor, Boonville	89
34.	Jonathan Thomas, Brazil	90

HOISTING ENGINEER.

Examination held in Terre Haute, September 2 and 3, 1908.
Total number of candidates, 8. Total number passed, 2.

Certificate No.	*Name and Address.*	*Per Cent.*
10.	Wm. Kelley, Edwards	81
11.	Millard McPherson, Terre Haute	84

MINE BOSS.

Examination held in Terre Haute, November 18 and 19, 1908.
Total number of candidates, 35. Total number passed, 20.

Certificate No.	*Name and Address.*	*Per Cent.*
41.	James Kerr, Sullivan	78
42.	George E. Soliday, Switz City	77
43.	George Came, Brazil	89
44.	Henry Taylor, Vicksburg	79
45.	E. V. Benjamin, Terre Haute	78
46.	Henry Willoughby, Sullivan	80
47.	George C. Richardson, Linton	76
48.	Sol. Davis, West Terre Haute	80
49.	Thomas Richardson, Linton	78
50.	D. E. Suthard, Jasonville	80
51.	Edward Keers, Jasonville	80
52.	W. B. Beattee, Petersburg	83
53.	Maurice W. Conners, Shelburn	81
54.	Dan Thomas, Clinton	89
55.	Charles Barker, Terre Haute	77
56.	Richard Owens, Terre Haute	83
57.	William Ross, Fontanet	78
58.	J. H. Riffle, Terre Haute	80
59.	Isaac Womeldorf, Linton	86
60.	Joseph Davison, Linton	79

FIRE BOSS.

Examination held in Terre Haute, November 18 and 19, 1908.
Total number of candidates, 14. Total number passed, 6.

Certificate No.	*Name and Address.*	*Per Cent.*
35.	A. L. Rogers, Linton	86
36.	James Harper, Linton	83
37.	Ebenezer Davies, Carlisle	80
38.	F. I. Pearce, Brazil	90
39.	Maxwell Derby, West Terre Haute	79
40.	Frank Zib, Linton	92

HOISTING ENGINEER.

Examination held in Terre Haute, November 18 and 19, 1908.
Total number of candidates, 14. Total number passed, 6.

Certificate No.	*Name and Address.*	*Per Cent.*
12.	Daniel Reynolds, Center Point	79
13.	Ira Bray, Linton	83
14.	William Hess, Bicknell	78
15.	C. H. Day, Burnett	83
16.	Lemuel Brewer, Bicknell	80
17.	Frank D. Kenman, Petersburg	79

ACCIDENTS TO MINE EMPLOYES.

In treating this subject we class accidents to mine employes under four heads, viz, fatal, permanent, serious and minor accidents, each class being treated separately. Under the head of fatal accidents we include persons killed outright and those whose injuries proved fatal. Under permanent injuries we include accidents resulting in the amputation of a limb, the loss of both eyes, a broken spine or other injuries unfitting persons to follow their usual occupation. Under the head of serious accidents we report accidents resulting in broken or dislocated limbs, internal injuries, cuts, bruises or other injuries of a nature serious enough to call for special mention.

The minor accidents include persons who have suffered only slight cuts or bruises or injuries that entail but little loss of time. Through the reports of coal companies, mine bosses and reports of inspections made to this office during the year 1908, we show a total of eight hundred and seventy-five accidents to mine employes, classed as follows: Fatal, 45; permanent, 3; serious, 375; minor, 452. The different causes of these accidents are shown in the annexed table:

TABLE

Showing the Number of Fatal, Permanent, Serious and Minor Accidents Occurring in the Mines of Indiana During the Year 1908, the Different Causes of Such Accidents, and Whether the Mine in Which the Accident Occurred was a Machine or Hand Mine.

CAUSE OF ACCIDENT.	MACHINE MINES.					HAND MINES.					Grand Total.
	Fatal.	Permanent.	Serious.	Minor.	Total.	Fatal.	Permanent.	Serious.	Minor.	Total.	
Falling slate	10	1	67	58	136	10	1	47	38	96	232
Falling coal	1	......	16	15	32	1	......	*28	32	61	93
Falling down shaft	1	......	2	......	3	......	......	1	......	1	4
Mine car	3	......	83	109	195	2	......	45	60	107	302
Mining machine	......	1	11	32	44	......	......	......	......	......	44
Mine motor	1	......	2	4	7	......	......	......	1	1	8
R. R. cars	......	......	2	1	3	......	......	1	1	2	5
Ascending cage	2	......	......	......	2	1	......	2	......	3	5
Descending cage	......	......	......	......	......	......	......	......	......	......	......
Explosion fire damp	1	......	1	4	6	......	......	7	1	8	14
Explosion of powder	......	......	2	......	2	......	......	1	......	1	3
Blown out shots	......	......	......	......	......	......	......	9	9	9	9
Windy shots	......	......	1	......	1	4	......	6	4	14	15
Shots blowing through pillars	......	......	......	......	......	......	......	1	......	1	1
Premature shots	1	......	2	......	3	1	......	4	......	5	8
Delayed shots	2	......	......	......	2	2	......	3	......	5	7
Electricity	1	......	3	2	6	......	......	......	1	1	7
Coal falling down shaft	......	......	......	......	......	......	......	1	3	4	4
Kicked by mule	1	......	5	20	26	......	......	5	19	24	50
Miscellaneous	......	......	18	28	46	......	......	8	10	18	64
Total	24	2	215	273	514	21	1	160	179	361	875

FATAL ACCIDENTS.

We give herewith by months and by counties a brief description of the above fatal accidents, with a statement of facts and circumstances attendant thereto, as adduced by investigation made by this department acting in conjunction with the coroners of the various counties in which the accidents occurred.

The first mine casualty for the year occurred on January 8th, in the Oswald mine, Gibson County. About 7:30 p. m., while the shots were being fired in the east workings of the mine, a terrific explosion took place, caused by a blown-out shot. As a result of this explosion two shot firers, McClelland St. Clair and Solomon Lawrence, were both killed instantly. A careful inspection of the affected area of the mine was made the morning following the accident by Assistant Inspector Irving and myself. We also assisted the coroner of Gibson County in examining witnesses and conducting a rigid inquiry as to the causes that produced the explosion. Our inspection of the mine, together with the testimony of witnesses examined, evidenced gross negligence both on part of the mine management and the employes, and to this fact the explosion and two deaths may be attributed.

The east workings of this mine comprise the main east entry and the air course and two pair of north-and-south cross-entries. The main entry and air course had been driven through a heavy squeeze, which had closed off tight all the workings for a distance of about one thousand feet. When the end of the squeeze was reached the main entry and air course were driven a distance of one hundred and fifty feet before the cross-entries were turned, thus leaving a solid block of coal one hundred feet wide between them and the squeeze. The cross-entries were driven a probable distance of two hundred feet, and two or three rooms turned on each entry. None of the rooms, however, were driven in far enough to have been connected with break-throughs, hence all the force of concussion, powder smoke, flame from shots, gases generated in blasting, coal dust, etc., could find vent only through the main entry and air course, each but about seven feet wide. This part of the mine was also very dry, and varying quantities of finely-powdered dust had accumulated along the roadways, on the timbers, and entry sides. Miners tamped their shots with coal slack or the drill dust; shots were drilled past the cutting or loose end; kegs of powder opened with a pick were permitted to sit along the sides of the entries or in break-throughs, within easy distance of the flame from shots, and a small per cent of gas was given off at times in some of the working faces. All of these dangerous conditions were known to the mine boss, and it was his duty to guard against such accidents as did happen by wetting or removing the fine dust, by providing tamping, seeing that no shots were improperly placed, overcharged or drilled past the cutting or loose end, and that nothing but noninflammable materials be used for tamping; also that too many shots were not fired in rapid succession and that all kegs of powder were kept beyond the range of flame from shots. Apparently little consideration was given any of those safeguards either by the mine boss, miners or shot firers.

In our inspection we found that almost every shot that had been fired was excessively overcharged; we also found three badly laid shots. One of these shots was located in the face of the fifth south entry, drilled twenty-four inches past the cutting or loose end; one located in a room neck on the fifth south drilled thirty inches past the cutting or loose end, both excessively overcharged, and one in Room No. 1, on the fifth south. This shot was drilled eight feet deep, was seven feet wide at the point and three feet wide at the heel, measured at right angles to the drill hole. This shot was prepared on the 7th by a miner named Harry Whitman, and fired that same evening by the shot firers. The shot failed to bring down the coal, merely breaking or cracking the seam from top to floor, leaving what miners term a "tight shot." On the morning of the 8th Whitman recharged this same shot, filling up six feet of the drill hole (which was not less than three inches in diameter) with powder, on which he placed twelve inches of tamping, leaving it for the shot firers to fire. The shot firers commenced firing the shots on the return air, that is, the first room on the fifth north, firing against the air around the sixth south, finishing at Room No. 1, on the fifth south. Eighteen shots, all fired in quick succession, probably three or four exploding simultaneously, were fired on the evening of the explosion, generating a large volume of explosive gas in the form of carbon monoxide, due to the excessive quantity of powder burned. Add to this mixture a quantity of finely-powdered dust brought in suspension from the floor and sides by the concussion of shots, and a large quantity of heated dust used for tamping thrown into the air by the shots and we have an explosive mixture at just the right temperature to be lighted from the large volume of flame, the only possible result to obtain from the shot in Room No. 1, on the fifth south, the last shot fired. Nine empty powder kegs burst from the inside, evidently burst by powder exploding in them, were found scattered along the roadways, thus proving powder to have been a powerful agent in the explosion. The shot firers were both practical miners and knew the results most likely to follow the firing of the shot in Room No. 1, on fifth south, the second time, they having fired it on both occasions, which proves the fact that they gave their own safety about as little consideration as did the mine boss or the person who prepared the shot. Both men were of American nationality. St. Clair was thirty-six years of age and is survived by a wife and four children; Lawrence was thirty-eight years of age and leaves a wife.

January 14th, Greene County, Gilmour Mine.—Alonzo Ragsdale, mine boss, forty-seven years of age, nationality American, survived by a wife and two children, was killed by falling slate. At the time he met his death decedent and his boss driver, Wm. Recktor, were engaged in cleaning up a fall of slate which occurred on one of the cross-entries. Before commencing work on the fall they examined and found the roof above where they intended working was loose. Recktor advised setting some temporary timbers to secure themselves from the loose rocks above, but Ragsdale objected, saying he thought the place was safe and that as soon as they had cleaned up the fall they would do the timbering permanently. About 1:50 p. m. they were engaged breaking and cleaning away the fallen slate when the roof above them began to chip and small particles fall off, which should have been sufficient warning of their danger. Both men stopped to listen to the slate chipping, but resumed work without making any examination whatever. About five minutes later a large mass of the slate gave way, falling on Ragsdale, killing him instantly. From the foregoing it is evident that decedent, who was mine boss and in charge of the work, was not only negligent of his own safety but also that of a fellow-employe working under his direction.

January 23d, Greene County, P. & I. Mine.—Enoch P. Venable, miner, twenty-two years of age, single, was killed by falling coal and draw slate. The coal seam in this mine is divided into two benches, the upper 4 feet and lower 3½ feet thick, being separated by a six-inch binder of slate and bone coal. The two benches of coal are each mined separately. On the evening of the 22d decedent and his buddy fired a shot in the lower bench in their working place. They were loading out this shot the following day. About 12:15 noon they were engaged loading a car when about two tons of coal, overlaid with four inches of draw slate, gave way from the upper bench, falling on Venable, killing him instantly.

January 24th, Black Creek Mine.—Julian Maurice, miner, twenty-five years of age, nationality French, single, was killed instantly by ascending cage. There were no eye-witnesses to this accident. The mine boss testified that, thinking all of the employes were out of the mine, he had started home and had gone but a short distance when he heard the signal given to hoist the cage. On returning to the shaft he found the engineer had hoisted the north cage to the surface landing empty; he then descended the shaft and found Maurice lying dead in the south sump with his head crushed. The distance from the signal lever to the cage is about five feet, and a car of coal had been dumped in the north sump just at quitting time, which prevented the cage floor from coming down level with the mine floor by about eleven inches. It is presumed that decedent gave the signal to hoist and was slow in getting on the cage before the engineer started to hoist, probably due to the slightly elevated position of the cage, and was caught against the brow timber and was dragged off into the south sump, crushing his head against the timber.

January 25th, Vigo County, Minshall Mine.—David Black, driver, age thirty-eight years, American, was killed by a blast. In addition to his duties as a driver, Black was employed to go through the mine after firing time and extinguish any mine fires that might have ignited from the shots. There were no eye-witnesses to this accident. When found decedent was lying near the face of Room No. 1, on the second northeast cross-entry, dead, partially covered with coal. The miners in this mine do their own shot firing and on the above date Charles Evans, the miner who worked No. 1 room in which decedent was found, had charged and tamped a shot which for some reason he decided not to fire until the following day. It is presumed that Black in making his rounds discovered this shot, and attempted to fire it; in doing so his light was extinguished and he was unable to reach a place of safety before the shot exploded, with the result above mentioned. Decedent is survived by a wife and one child.

January 27th, Sullivan County, Clover Leaf.—Asa Sargent, timberman, age twenty-seven years, nationality American, fatally injured by falling draw slate. About 3 p. m. of the above date decedent had knocked the props out from under some loose slate which he intended taking down. After knocking out the props he for some reason stepped under the loose slate to do some work, when a large piece of the slate suddenly gave way, falling on him and crushing his ankle. His injury at the time was known to be serious, but it was thought his life was in no danger. On February 7th he was taken to the Union Hospital in Terre Haute and his foot amputated. He was removed to his home in Linton on the 10th and died on the 15th from blood poisoning due to the injury received. He leaves a wife and one child.

January 29th, Greene County, P. & I. Mine.—A second fatal accident occurred in this mine. James Philips, miner, sixty-five years of age, American, single, was fatally injured by a blast. From evidence adduced at the investigation of this accident it was learned that on the evening he met his death decedent had four shots, all tamped on fuse ready to fire in his working place. At 3:30 p. m., firing time, he lighted one of these shots, and in doing so his light in some way was extinguished. In order to procure a light he must travel twenty feet in the dark, back to the break-through between his and an adjoining room. This he did, and over the protest of his neighbor workmen returned to the face of his own room and lighted a second shot without waiting for the one first lighted to explode. In lighting the second shot his light was again in some way extinguished, presumably from the powder in the end of the fuse, and being in the dark he was unable to reach a place of safety when his shot first lighted exploded. The flying coal from this shot knocked him down, and by reason of another shot being lighted his neighbor workmen did not dare venture to his assistance until it had exploded. The coal flying from this shot also struck him. The injuries received from one or both shots proved fatal. He died three days later in the St. Anthony Hospital in Terre Haute.

The statute provides that it shall be unlawful to light more than one shot at a time in any one working place. This statute decedent absolutely disregarded, as well as all common-sense or mining law, and the result was but what could be expected.

February 12th, Sullivan County, Jackson Hill No. 4 Mine.—Frank Bishluk, loader, age thirty-six years, nationality Polander, was killed instantly by falling slate at about 3:20 p. m. There were no eye-witnesses to this accident. Decedent's buddy had removed some tools to an adjoining room when he heard the slate fall which caught Bishluk. On rushing into the room he found decedent lying under a large piece of slate, 10 feet in length, 8 feet wide and nine inches thick, dead. Decedent leaves a wife and three children.

February 13th, Sullivan County, Sunflower Mine.—Ray Leighman, day laborer, sixteen years of age, nationality American, was killed by an ascending cage. The accident occurred about 6:40

o'clock a. m. Decedent and the mine superintendent had taken the mules down into the mine preparatory to the day's work. The superintendent, wishing to go out of the mine, stepped on the cage and gave the signal to hoist. Leighman, who was standing back some distance from the shaft bottom at the time, ran and attempted to get on the cage just as the engineer started to hoist, and was caught between the side of the cage and the shaft curbing, which has a clearance of only about three inches. He was dragged in this position about seventy-five feet up the shaft before the cage could be stopped, killing him instantly.

February 16th, Greene County, Vandalia No. 8 Mine.—J. W. Masters, jerry, thirty-two years of age, American, single, was killed by falling slate. On the evening of the accident Masters and one other person were engaged cleaning up a fall of slate on one of the cross-entries. About 11:20 p. m. they were pushing a loaded dirt car into an idle room for the purpose of unloading it when a large piece of slate 4 feet 6 inches wide, 6 feet 6 inches in length, and 6 inches thick, suddenly gave way, falling on Masters, breaking his neck and killing him instantly.

February 21st, Sullivan County, Mildred Mine.—William Stevenson, timberman, fifty-six years of age, nationality Scotch, single, was fatally injured by falling slate. At the time of the accident decedent and a fellow-workman by the name of Kirkpatrick were making the necessary arrangements to set a crossbar under some loose slate on one of the cross-entries. At the point where the crossbar was needed, a thin ledge of slate eight inches thick extended from the side of the entry out over the roadway about three feet. In order to secure sufficient height under the crossbar it was found necessary to cut through this ledge the width of the bar, which was twelve inches wide. There was a slip in the roof which crossed the entry at about a forty-degree angle here, which together with cutting through the ledge still further loosened the then already dangerous slate, and at about 12:20 p. m., when decedent was finishing the above-mentioned cut, a large mass of the slate suddenly gave way, falling on him and injuring him so that he died at 11:30 a. m. the following day. A few props set temporarily under this loose slate for protection would have prevented the accident.

February 22d, Vigo County, Forrest Park Mine.—Richrd Roberts, driver, twenty-five years of age, American, single, was fatally injured by being caught and crushed between a moving mine car and a road prop. About 2:50 p. m. deceased had gone into a room with his mule after a loaded car. The mine track in this room was laid with wooden rails and a few feet outside the point where the loaded car was standing and over which it must pass the end of one of the rails was split. In order to prevent the wheels of the car from entering this split rail and cause the car to jump the track, the driver must of a necessity stand on one side of the track and push or guide the car until it had passed that point. This Roberts did, and after the defective rail had been crossed he made an attempt, while the car was moving, to get around to the front end of the car so that he could take his position on the end of the draw bar, the place where drivers usually ride. In making this attempt he was caught between the end of the moving car and a road prop which stood within about twelve inches of the track, crushing him through the hips and abdomen and so injuring him that he died on the 26th following.

February 25th, Sullivan County, Hudson Mine.—Louis Dublemont, miner, sixty-one years of age, French, who leaves a dependent wife, was killed by falling slate. About 8 p. m. deceased was at work mining off a loose shot, mining in the top of the coal seam, when a large piece of slate 11 feet in length, 5 feet wide and 2 feet thick, suddenly gave way, falling on him and killing him instantly.

February 25th, Knox County, Freeman Mine.—Frank Buddle, machine helper, single, was fatally injured by falling coal. At the time he met with his injuries Buddle and J. H. Hornbrook, machine runner, were engaged in undercutting with a mining machine the face of Room No. 4 on the second southeast cross-entry. The mining machine they were using was of the electric chain type and made an undercut, three feet wide, six and one-half feet deep. They had completed four undercuts and were working on the fifth one, the machine being about half way in, when a slab of coal 5 feet in width, 2 feet thick and the full height of the seam (7 feet), extending out over the fourth cut, just completed, suddenly gave way and fell on decedent, breaking and mangling his left leg so that amputation was necessary, also inflicting internal injuries from which he died at 9:15 p. m. following. The coal which fell on Buddle had evidently been loosened when shooting down the room the previous undercut, the powder from one of the shots probably flying ahead a few inches into the solid coal, and as soon as the bottom of the seam was removed back to and past this powder crack, the coal, having no support, gave way and fell, the noise of the machine when running preventing Buddle from hearing the breaking or crackling noise the coal usually makes before fall ing. From evidence brought forth at the investigations it is apparent that negligence on the part of three persons, that is the mine boss, machine runner and decedent himself, was partially if not wholly responsible for this accident. The mine boss in machine mines should either in person or by a competent representative examine all working places after they have been shot down and loaded out, and take down or make safe any loose coal that may have been left standing, such as described above. This the mine boss evidently did not do.

Hornbrook testified that he and decedent knew the coal was loose when they were making the fourth cut, and that he advised decedent to keep back from the face out of the way, as it was liable to fall. This being true, they should have spragged the coal before commencing the fifth cut, or Hornbrook, being the older and more experienced miner, should, by force, if necessary, have compelled decedent to conform to his advice.

March 4th, Parke County, Superior No. 2 Mine.—Charles Leachman, miner, thirty-eight years of age, American, was killed by falling coal. There were no eye-witnesses to this accident. The last seen of Leachman alive was at 9 a. m., when the driver, Charles Sills, gave him an empty car. About an hour later the driver, thinking he would have had time to load the car, went into the room after it and found him lying under a large block of coal dead. Deceased leaves a wife and three children.

March 5th, Pike County, Ayrshire No. 5 Mine.—Buxton Bradley, miner, sixty-five years of age, colored, single, was crushed to death between the top of a loaded mine car and the roof. About 8 a. m. Jesse Little, who was driving off the entry on which decedent met his death, met Bradley, who began chaffing him about being a better driver than he. In the conversation that followed Little jokingly proposed to Bradley that if he thought he was the better driver of the two that he (Little) would load a car for him while he made a trip. Bradley accepted the proposition. Taking the mule into an adjoining room he hitched it to a loaded car and started for the shaft bottom. This was the last seen of decedent alive. When found about thirty minutes later he was dead, lying on his back, crushed between the top of the loaded car and the roof in a space of about eight inches.

March 13th, Greene County, Vandalia No. 9 Mine.—John Koparic, driver, twenty-three years of age, Austrian, was killed instantly by falling slate. On the morning of the accident decedent was at his usual work, hauling coal out of the second cross-entry off the fourth west. About 9:30 he was coming out of the mine with a loaded car, riding with one foot on the tail-chain and the other on the drawbar of the car, when from some cause the car jumped the track, striking and knocking the timbers out from under a large mass of loose slate. When decedent saw the car jump the track, realizing his danger, he made an effort to reach a place of safety, but before he could do so the slate fell, catching him and crushing him into an almost unrecognizable mass. He leaves a wife.

March 16th, Greene County, Queen Mine.—William Fenwick, miner, thirty-seven years of age, English, single, was fatally injured by a blast. From evidence adduced at the investigation of this accident it was learned that decedent had prepared three shots in the face of his working place, ready to fire at firing time, 3:30 p. m. His working place, Room No. 2 off the main east entry, was driven in about forty feet and the three shots, each tamped on fuse, were located one on each rib and one in the center of the room. The shot firing, as was customary, commenced in the face of the main east entry, each room man firing in turn. It was also customary for a miner to light all the shots to be fired in a place, no matter how many, before leaving it. In lighting his shots Fenwick's light was in some way extinguished, presumably from the powder in the end of the fuse of the third shot lighted, and he called to a fellow-miner by the name of Thomas Machie for a light. Machie ran up into his room, meeting him about half way, or twenty feet from the entry, gave him a light and turned and ran for a place of safety, calling on Fenwick to follow him. The latter for some reason, however, returned to the face of his room, and when within about six feet of the face the shots began to explode, each of the three exploding, the pieces of flying coal striking him, crushing his skull and injuring him otherwise so that he died the following day. Owing to the fact that he never regained consciousness after being injured it was not learned why he returned to the face of his room instead of following Machie to a place of safety. It is presumed that he thought that he had failed to light one of his shots and was returning for that purpose. One more life chargeable to the long list due to the use of fuse in shot firing.

March 28th, Vermillion County, Maple Valley Mine.—George Howser, miner, fifty-four years of age, American, was killed by falling slate. At about ten a. m. decedent was at work in the face of his room mining off a loose shot when a piece of slate 5 feet in length, 2 feet 11 inches in width, and 19 inches in thickness, suddenly gave way, falling on him, crushing his head and inflicting internal injuries from which he died at 9:05 p. m. of the same date. He is survived by a wife and ten children.

April 11th, Vermillion County, Maple Valley Mine.—William Ryan, shot firer, thirty-five years of age, American, was killed in an explosion of carbon monoxide gas and coal dust combined. Decedent and Thomas Deal were employed regularly as shot firers at this mine. On the afternoon of above date they entered the mine and commenced firing the shots at 3 o'clock p. m. At 3:30 they had lighted all the shots in the mine except three, lighting about 175 shots in thirty minutes. A number of these shots were drilled past the cutting or loose end, and practically all of them were excessively overcharged. A conservative estimate as to the amount of powder burned would place it at not less than 875 pounds. There was some dust in the mine air brought into suspension from the mine floor by the concussion of heavy shots and from shots tamped with drill dust. In firing this amount of powder within the limited space of time above mentioned, with the other attending conditions, and one hundred or more shots any one of which would furnish a sufficient volume of flame to ignite the explosive gases generated by burning coal dust and powder burned in shots previously fired, only one result could obtain, that is, an explosion such as followed. Ryan is survived by a wife.

May 7th, Vigo County, Ray Mine.—Frank Jones, driver, thirty years of age, American, was fatally injured by being caught and crushed between a moving mine car and the entry rib. At the time of the accident, Jones was standing between the empty and loaded tracks on the main east double parting. The train driver was starting with a trip of two loaded cars for the shaft bottom and just as the cars began to move decedent jumped between them intending to cross over to a break-through on the opposite side, in doing so he in some way was caught between the moving cars and the entry rib and dragged or rolled along the entry side a distance of about six and one-half feet. The accident occurred at 9 a. m., May 7th, death resulting at 12:30 o'clock noon, June 21st. Decedent is survived by a wife and two children.

May 8th, Sullivan County, Consolidated Indiana No. 33 Mine.—Wm. McCoskey, electrician, twenty-three years of age, American, was fatally injured by a mine motor. At the time he met with his accident McCoskey, in company with Arthur Beckett, motorman, was riding on the rear end of the motor out of the twelfth southwest cross-entry with a trip of loaded cars. Just before they reached a double parting, McCoskey jumped off the motor intending to run ahead and see if the switches were set right, in passing the motor, his clothes were caught and his arm drawn into the gearing, the muscles of his arm were torn out and several arteries severed. He was taken to St. Anthony Hospital, Terre Haute, where he died three days later. He leaves a wife.

May 8th, Sullivan County, Consolidated Indiana No. 25 Mine.—Shelby Johnson, top laborer, thirty-five years of age, American, was killed by falling down the hoisting shaft. Decedent was employed to do general work around the top of the mine, among his other duties was that of sending props down into the mine. At about 2:30 p. m. of above date, wishing to send a car of props down the shaft, he called to A. B. Radcliff to open the west shaft gate for him, thinking the cage was at that landing. The engineer, however, had hoisted the cage up to the top landing just a few moments previous, and Johnson pushed the car into the shaft, involuntarily clutching the car, was jerked over into the shaft, falling with the car to the bottom, a distance of 225 feet, killing him instantly. He leaves a wife and two children.

May 9th, Sullivan County, Consolidated Indiana No. 25 Mine.—John Ewings, machine runner, thirty-eight years of age, American, was killed by falling slate. About 8:45 a. m. Ewings and his helper had finished cutting a room and had loaded their machine on the truck preparatory to leaving the room when a large piece of slate 13 feet in length, 5 feet and 6 inches thick, suddenly gave way, falling on decedent, injuring him so that he died four hours later. He leaves a wife.

June 4th, Pike County, Ayrshire Mine No. 3.—John Adams, miner, forty-five years of age, American, was fatally injured by a delayed shot. Decedent and a miner by the name of John Black were at work drawing pillars on the main east entry. Adams' working place was just inside that of Black. On the afternoon of above date they had prepared three shots ready to fire, each tamped on fuse. One of these shots belonged to Adams and two to Black. At firing time they lighted all of these shots and ran to a place of safety. Two of the shots exploded, and after waiting about ten minutes Black decided that he had failed to light one of his shots, and he and Adams went back into the place for the purpose of lighting it. They had reached the mouth of the drill hole, and just as Adams took hold of the fuse the shot exploded, the full force of the coal thrown out by the shot striking him, injuring him so that he died thirty minutes later. Decedent leaves a wife and five children.

June 6th, Vigo County, Minshall Mine.—Starl Biggs, miner, forty-nine years of age, American, was fatally injured by falling slate. At the time of his death decedent and his son were driving the main north entry. On entering his place the morning of the accident he noticed some very loose slate at the face of the entry and returned to the shaft bottom to notify the mine boss of the same. On his return he found his son at work under the loose slate loading a car of coal. He ordered his son back out of the way and took his place. He had thrown but a few shovels of coal when a large piece of the slate measuring 8 feet in length, 2½ feet in width, and 14 inches thick, gave way, falling on him, inflicting injuries from which he died at eight a. m. of the following day. He leaves a wife and five children.

June 8th, Vermillion County, Crown Hill No. 1 Mine.—Tony Bonami, miner, forty years of age, Italian, single, was killed by an ascending cage. About eight a. m. decedent, wishing to go out of the mine, came to the shaft bottom, and asked for a cage. About twenty minutes later he was given the cage and the cager gave the signal to hoist. When last seen alive Bonami was standing on the cage holding to one of the supports attached to the crosshead of the cage. When the cage was about eighty-five feet up the shaft he was heard to give an outcry and the next instant his body fell back into the sump. The space between the side of the cage and the buntings through which decedent was dragged was only eight inches and his death was evidently instantaneous. It is not known what caused him to fall, as the cage was well equipped with supports by which he could maintain his balance. It is supposed that his fall was due to dizziness produced by the motion of the cage or by heart failure induced from the same cause.

June 18th, Parke County, Parke No. 11 Mine.—Joseph Hookey. timberman, sixty-five years of age, American, was killed by falling slate. At the time he met his death, Hookey, in company with John Philips, also a timberman, was at work cutting hitch holes preparatory to setting some crossbars under a large body of loose slate over a double parting. While so engaged, at 2:40 p. m., a piece of the slate measuring 36 feet in length, 12 feet in width, and 12 inches in thickness, suddenly gave way, falling on both men, killing Hookey instantly and seriously injuring Philips. Decedent leaves a wife. A few temporary props set under this loose slate would have saved the life of one person and prevented serious injury to another.

June 25th, Clay County, Brazil Block No. 1 Mine.—George Inglehart, miner, fifty-one years of age, American, was killed instantly by falling slate. About 7:15 a. m. decedent was at work gathering up some loose coal along his roadway and loading it into a car. He had cleaned the roadway up to within fifteen feet of the face of his place when a large piece of slate, weighing out two tons, fell on him, crushing his head beyond recognition against one of the wooden track rails. He leaves a wife and three children.

July 18th, Sullivan County, Vandalia No. 10 Mine.—Orvil Gray, miner, sixteen years of age, American, was fatally injured by falling slate. On the morning of the accident, decedent was at work with his father in room No. 1 on the fifth northwest cross entry. About eight p. m. he had occasion to leave his room. Just as he was passing out of the mouth of the room into the entry a large mass of slate fell, crushing and injuring him so that he died on the 20th following.

August 4th, Dering No. 14 Mine.—James McLoney, driver, nineteen years of age, American, single, was kicked by a mule and fatally injured. McLoney was employed as a gathering driver and was hauling coal from the fifth and sixth southeast cross-entries to a double parting on the main east. About 8:30 a. m. the morning of his accident he came into the double parting with a loaded trip, and not being able to get out of the empty parting with his empty cars by reason of some loaded cars which stood in the way, was standing between the empty and loaded tracks waiting for the parting driver to pull the loaded cars up out of the way. The mule they were trying to move the cars with was known to be very fractious and addicted to kicking. The cars were very hard to move and after making one or two ineffectual attempts to start them, the mule commenced kicking and running backwards to where decedent stood, some ten feet distant, and before he could get out of reach the mule kicked him in the right side of the abdomen. He was not thought to be seriously injured at the time. Peritonitis set in in a short time, from which he died at 9 a. m. the day following.

August 6th, Sullivan County, Vandalia No. 10 Mine.—J. W. Wilson, loader, twenty-four years of age, English, single, was fatally burned in an explosion of fire damp. The fire boss had examined the face of Wilson's working place, the second northeast cross-entry, at five a. m., and found considerable fire damp. He placed a danger signal across the entry near the last break-through, in the shape of a piece of 2×4 inch railing marked in chalk, "Gas; brush out," it being customary where the gas was not in large quantity, for the loader to brush or fan it out with his coat. In addition to the danger signal, the fire boss met decedent on his way to work and notified him of the gas and warned him to be careful. Decedent continued to his working place, set his lamp in the break-through which was thirty-six feet from the face of the entry, and proceeded to fan the gas out of the entry face with his coat, directly toward his open light. The result was only what might have been expected: the gas ignited, causing an explosion in which he was so badly burned that he died at 6:10 p. m. following.

September 4th, Parke County, Superior No. 3 Mine.—Lewis Morgan, miner, twenty-nine years of age, American, was killed by falling slate. Little could be learned of this accident as there were no eye-witnesses. The mine boss visited decedent about 8 a. m. and found his place well timbered and, as he thought, safe. At the time the boss visited him, Morgan was working off a loose shot, mining in the top of the coal seam. About 11:30 a. m. the driver went into his room to pull his loaded car and found him lying close up to the face of the coal under a large piece of slate, dead. He is survived by a wife and one child.

September 28th, Sullivan County, Shirley Hill No. 1 Mine.—William Madison, miner, fifty-six years of age, English, was killed by a blast. The investigation of this accident brought forth but little information other than the fact that decedent was killed by a blast, either premature or delayed. The miners do their own shot firing in this mine, and at firing time, 3:30 p. m. the afternoon he met his death, all the shots adjacent to Madison's working place were fired and the miners had left the mine, leaving him to fire his shots alone. The miners traveled to and from the mine on a miners' train, and while waiting for the train it was noticed that decedent was not present. A searching party was immediately organized, and on returning into the mine they found him lying in his room, dead. Two shots had been fired and a third remaining one had not been lighted, considerable loose coal was scattered over the room and around the body, evidently thrown out by the exploded shots, and decedent's head was crushed and other cuts and bruises in evidence, indicating that he had been struck by flying coal. It is the general opinion that he was trying to light the three shots before leaving his room and that one of the shots first lighted exploded prematurely. He is survived by one child and an invalid wife.

September 29th, Vermillion County, Klondyke Mine.—Joe Karbastus, shot firer, forty-five years of age, Russian, single, was killed in an explosion caused by rapid shot firing and blown out shots. This accident was investigated by Assistant Inspectors Thomas and Irving. From evidence adduced at their investigations it was learned that decedent and one other person had been employed for some time as regular shot firers in this mine. On the afternoon of the explosion, they commenced firing the shots at 3:15 p. m., the explosion occurring one hour and thirty minutes later. There were seventy-eight miners employed in the mine who had prepared at least two shots each, or there were not less than 156 shots to be fired. Their shots were each charged with not less than five pounds of powder; some of them contained considerably more than five pounds and were excessively overcharged. A conservative estimate of the total quantity of powder burned in the shots would place it at not less than 780 pounds. All the shots in the mine had been fired when the explosion occurred, and two of the last ones fired were blown-out shots. Thus it will be seen that an average of nearly two shots were fired, and not less than ten pounds of powder burned each thirty seconds during the time of shot firing. In some instances probably a half-dozen or more shots exploded simultaneously. Thomas estimates that approximately 6,250 cubic feet of carbon monoxide gas was generated from the powder burned. This quantity of gas, brought to its highest explosive point, "is indicated by the explosion," would furnish an explosive mixture of about 62,500 cubic feet volume, which was evidently lighted by one of the blown out shots. Decedent was found in room No. 2, on the twelfth east cross-entry, dead, having been overcome by afterdamp.

October 2d, Vigo County, Wabash Mine.—James Swabrick, machine runner, twenty-seven years of age, American, was killed by an electric shock. At the time of the accident, 3 p. m., Swabrick and his helper, Charles Flynn, were unloading their mining machine at the face of the second southeast cross-entry, preparatory to undercutting the entry. The machine they were operating was of the Morgan-Gardner self-propelling type, and before commencing to unload they connected the electric cable to the machine, intending the propeller to assist in the unloading. Just as the machine was dropped off the track on the skids, the positive wire attached to the terminal block was in some way disconnected, thereby causing the machine frame, chain and other gearing to become highly charged with electricity. At this moment Swabrick, who was using one of the jackbars, a piece of hollow pipe, as a lever to push the machine forward on the skids, received the full voltage. Flynn heard him give an outcry. Surmising the trouble he ran back and disconnected the cable. When he returned to the face of the entry he found deceased lying face downward on the machine, dead. He leaves a wife and one child.

October 20th, Vigo County, Miami No. 1.—George Morris, miner, thirty-six years of age, English, and Thomas Boot, also a miner, twenty-eight years of age, and English, were both killed at the same time by a fall of rock. Morris and Boot had been employed for several months drawing pillars in the first southeast cross-entry and aircourse. At the time of the accident they were working on the pillar between the entry and aircourse. They were working the pillar loose and intending to retreat, taking all the coal, and had excavated a large area, the roof over which, being robbed of the support of the pillar, had begun to settle and break along the edges of the coal where they were working. This condition was noticed on the morning of the accident by Peter Spence, a fellow-miner, who warned them of the fact and advised them to set more props. The roof, however, was a very hard sandstone, the safety of which the two unfortunates evidently overestimated, and to this fact is due the accident which followed. Notwithstanding the warning of Spence, also that given by the roof settling and breaking, they continued their work after setting but five props, where they should have set not less than fifty. About 12 o'clock at noon, Boot was loading a car and Morris was mining off some loose coal when a large piece of rock, measuring 24 feet in length, 18 feet in width, 3½ feet thick, the estimated weight of which was ninety tons, suddenly gave way, falling on decedents, killing them both instantly. Eighty props were required to be set for safety of workmen and three hours' labor required before the bodies were recovered. Morris is survived by a wife and three children, and Boot by a wife.

October 21st, Parke County, Mecca No. 3 Mine.—John Graves, miner, nineteen years of age, American, single, was killed by falling slate. Graves and a fellow-miner, Samuel Sylvester, were working buddies in room No. 2 on second south cross-entry, the room was only partially turned, being driven in about fourteen feet from the entry and was about fourteen feet wide at the face. About 9 o'clock the morning of the accident, decedent was engaged loading a car and his buddie was drilling a hole in the face of the room.

While in the act of bending over the car to level down the coal he had been shoveling, a piece of slate 14 feet in length, 8 feet wide, and 12 inches thick, gave way, falling and catching him on the edge of the car, killing him instantly. The same fall caught his buddie and broke his leg, seriously injuring him otherwise. The slate which caused the accident was known by both Graves and Sylvester to be loose, and they were advised the day previous to the accident to timber it, by William Johnson, a neighbor miner. They also had abundance of props of proper length lying in their room neck with which they could have made themselves safe, yet they continued their work of mining and loading coal without setting any props whatever. The result which followed was all that could have been expected.

October 29th, Sullivan County, Jackson Hill No. 4 Mine.—George Gill, loader, twenty-six years of age, Polander, was killed by falling slate. At the time the accident occurred, Gill and his buddie, Lucus Protuske, also a Polander, were loading coal out of room No. seven on the sixth southeast cross-entry. The room, which had been undercut with an electric chain mining machine, was shot down by them the evening previous to the accident. The undercut was about 6½ feet deep, and when the coal was shot down a rock roll or slip was uncovered. The roll lay diagonally across the face of the room and the slip extended for some distance up into the roof. As a rule the roof adjacent to slips or rolls of this character is affected and becomes very dangerous and requires careful attention in the way of setting props, crossbars, etc., to prevent it from falling. The mine superintendent, in company with the mine boss, visited decedent's working place early on the morning of the accident and saw the roll, which had been uncovered, and knowing the dangerous conditions liable to result therefrom, gave orders to the loaders to timber the room securely before commencing to load coal. They, that is, the superintendent and boss, continued on their way through the mine, though without waiting to see if the order would be conformed to. Both of the loaders were non-English speaking, and probably only partially understood the order, and not fully realizing their danger proceeded to load coal without setting the necessary timbers to secure themselves, and about 10 a. m., while they were engaged loading a car, a large piece of the slate gave way, falling on decedent and inflicting injuries from which he died one hour later. The superintendent and boss were both negligent of their duty in this instance, by reason of the fact that they did not stay in the room until they knew that their order given with reference to timbering would be conformed to, or by instructing the driver to give the loaders no empty cars until the room had been securely timbered. The loaders also evidently knew to some extent, at least, the dangerous nature of the roof and contributed to the accident when they commenced to load coal without first having made some effort to secure themselves. Decedent is survived by a wife and one child.

November 13th, Greene County, Vandalia No. 8 Mine.—Louie Vonderschmitt, driver, sixteen years of age, German, was killed by a mine car. Decedent was employed hauling coal on the second northwest cross-entries. About 8:10 a. m. he was coming into the double parting on that entry with a trip of two loaded cars, riding in the position in which drivers usually ride—that is, standing with one foot on the drawbar of the car and the other on the tail-chain. When he came to the west end of the parting the mule, instead of following the loaded track as it should have done, turned into the empty switch, Vonderschmitt jumped down off the car for the purpose of turning the mule and to slew or guide the car over the switch points. While so doing he was in some way caught between the moving car and the entry rib, breaking his neck and killing him instantly.

December 15th, Sullivan County, Dering No. 4 Mine.—George Peyton, loader, fifty years of age, American, was killed by falling slate. There were no eye-witnesses to this accident. Decedent was last seen alive about 7 a. m. At that time he was pushing an empty car up his room. About 7:30 the driver, thinking he would have the car loaded, went into the room for the purpose of pulling it, and found him lying under about 3½ tons of slate, dead. The car was partially loaded, and from the position in which the body was found it is presumed he was loading the car when the slate fell on him. He leaves a wife and three children.

December 21st, Sullivan County, Hocking Mine.—Thomas Beasley, driver, twenty-five years of age, American, single, was run over and killed by a loaded mine car. There were no eye-witnesses to this accident and little information could be obtained at the investigation. Beasley was employed as a train driver between the double parting on the sixth west cross-entry and that on the main south. He was last seen alive about 10 o'clock a. m. At that time he was leaving the sixth west parting with a trip of two loaded cars, riding on the front end of the first car in the trip. About thirty minutes later he was found 442 feet from the main south parting, lying under the front car in his trip, dead. He leaves a dependent mother.

December 22d, Gibson County, Oswald Mine.—Anton Bonheim, shot firer, forty-two years of age, German, was killed by a delayed shot. Bonheim and Wm. Bush were employed as regular shot firers in the mine, and on the evening of the above date they were in the mine firing the shots in the usual manner. About 5:15 they tamped two shots on fuse in room 9 on the sixth southwest cross-entry. After lighting their two shots they moved on to room 10, where they tamped one shot, leaving Bonheim to fire it. Bush moved on down the entry, expecting Bonheim to follow him after lighting this shot. However, instead of following Bush, decedent turned and went back into room 9, where one of the shots previously lighted had not exploded. When within a short distance of the face of the room the shot exploded, the pieces of flying coal striking him, killing him instantly. It is not known why he returned to room 9, unless he thought he had failed to light one of the shots and was returning for that purpose. He leaves a wife and two children.

The following summary of fatal accidents exhibits the date on which each fatality occurred; the name, age, occupation and nationality of person killed; the dependents left at each death; the cause of the accident; the name of the mine wherein the accident occurred, and the county in which the mine is located:

TABLE.

Summary of Fatal Accidents.

Date.	NAME.	Occupation.	Age.	Cause of Accident.	Mine.	County.	Dependents. Wife.	Dependents. Children.	Dependents. Other Dependents.	Nationality.
Jan. 8	McClellan St. Clair	Shot-firer	36	Explosion of powder gases	Oswald	Gibson	1	4		American.
Jan. 8	Solomon Lawrence	Shot-firer	53	Explosion of powder gases	Oswald	Gibson	1			American.
Jan. 14	Alonzo Ragsdale	Mine boss	47	Falling slate	Gilmour	Greene	1	2		American.
Jan. 23	Enoch P. Venable	Miner	22	Falling coal and slate	P. & I.	Greene				American.
Jan. 24	Julien Maurice	Miner	25	Ascending cage	Black Creek	Greene				French.
Jan. 25	David Black	Driver	38	Premature blast	Minshall	Vigo	1	1		American.
Jan. 27	Asa Sargent	Timberman	27	Falling slate	Clover Leaf	Sullivan	1	1		American.
Jan. 29	James Philips	Miner	65	Delayed shot	P. & I.	Greene				American.
Feb. 12	Frank Bishluk	Loader	36	Falling slate	Jackson Hill No. 4	Sullivan	1	3		Polander.
Feb. 13	Ray Leighman	Day laborer	16	Ascending cage	Sunflower	Sullivan				American.
Feb. 16	J. W. Masters	Jerry	32	Falling slate	Vandalia No. 8	Greene				American.
Feb. 21	Wm. Stevenson	Timberman	56	Falling slate	Dering No. 13	Sullivan				Scotch.
Feb. 22	Richard Roberts	Driver	25	Mine cars	Forrest Parke	Vigo				American.
Feb. 25	Louis Dublemont	Miner	61	Falling slate	Hudson	Sullivan	1			French.
Feb. 25	Frank Buddle	Machine helper	20	Falling coal	Freeman	Knox				American.
Mar. 4	Charles Leachman	Miner	38	Falling coal	Superior No. 2	Parke	1	3		American.
Mar. 5	Buxton Bradley	Miner	65	Mine cars	Ayrshire No. 5	Pike				Colored.
Mar. 13	John Coparice	Driver	23	Falling slate	Vandalia No. 9	Greene	1			Austrian.
Mar. 16	Wm. Fenwick	Miner	37	Delayed shot	Queen	Greene				English.
Mar. 28	George Houser	Miner	54	Falling slate	Maple Valley	Vermillion	1	10		American.
April 11	William Ryan	Shot-firer	35	Explosion powder gases	Maple Valley	Vermillion	1			American.
May 7	Frank Jones	Driver	30	Mine cars	Ray	Vigo	1	2		American.
May 8	Wm. McKaskey	Electrician	23	Mine motor	Con. Ind. No. 33	Sullivan	1			American.
May 8	Shelby Johnson	Top laborer	35	Fell down shaft	Con. Ind. No. 25	Sullivan	1	2		American.
May 9	John Ewings	Machine runner	38	Falling slate	Con. Ind. No. 25	Sullivan	1			American.
June 4	John Adams	Miner	45	Delayed shot	Ayrshire No. 3	Pike	1	5		American.
June 6	Starl Biggs	Miner	49	Falling slate	Minshall Mine	Vigo	1	5		American.
June 8	Louie Bonami	Miner	40	Ascending cage	Crown Hill No. 1	Vermillion				Italian
June 18	Joseph Hookey	Timberman	65	Falling slate	Parke No. 11	Parke	1			American.
June 25	George Inglehart	Miner	51	Falling slate	Brazil Block No. 1	Clay	1	3		American.
July 18	Orvil Gray	Miner	16	Falling slate	Vandalia No. 10	Sullivan				American.

parting, lying under the front car in his trip, dead. He leaves a dependent mother.

December 22d, Gibson County, Oswald Mine.—Anton Bonheim, shot firer, forty-two years of age, German, was killed by a delayed shot. Bonheim and Wm. Bush were employed as regular shot firers in the mine, and on the evening of the above date they were in the mine firing the shots in the usual manner. About 5:15 they tamped two shots on fuse in room 9 on the sixth southwest cross-entry. After lighting their two shots they moved on to room 10, where they tamped one shot, leaving Bonheim to fire it. Bush moved on down the entry, expecting Bonheim to follow him after lighting this shot. However, instead of following Bush, decedent turned and went back into room 9, where one of the shots previously lighted had not exploded. When within a short distance of the face of the room the shot exploded, the pieces of flying coal striking him, killing him instantly. It is not known why he returned to room 9, unless he thought he had failed to light one of the shots and was returning for that purpose. He leaves a wife and two children.

The following summary of fatal accidents exhibits the date on which each fatality occurred; the name, age, occupation and nationality of person killed; the dependents left at each death; the cause of the accident; the name of the mine wherein the accident occurred, and the county in which the mine is located:

TABLE.

Summary of Fatal Accidents.

Date.	NAME.	Occupation.	Age.	Cause of Accident.	Mine.	County.	Dependents. Wife.	Dependents. Children.	Dependents. Other Dependents.	Nationality.
Jan. 8	McClellan St. Clair	Shot-firer	36	Explosion of powder gases	Oswald	Gibson	1	4	....	American.
Jan. 8	Solomon Lawrence	Shot-firer	53	Explosion of powder gases	Oswald	Gibson	1	....	....	American.
Jan. 14	Alonzo Ragsdale	Mine boss	47	Falling slate	Gilmour	Greene	1	2	....	American.
Jan. 23	Enoch P. Venable	Miner	22	Falling coal and slate	P. & I.	Greene	....	....	....	American.
Jan. 24	Julien Maurice	Miner	25	Ascending cage	Black Creek	Greene	....	....	....	French.
Jan. 25	David Black	Driver	38	Premature blast	Minshall	Vigo	1	1	....	American.
Jan. 27	Asa Sargent	Timberman	27	Falling slate	Clover Leaf	Sullivan	1	1	....	American.
Jan. 29	James Philips	Miner	65	Delayed shot	P. & I.	Greene	....	....	....	American.
Feb. 12	Frank Bishluk	Loader	36	Falling slate	Jackson Hill No. 4	Sullivan	1	3	....	Polander.
Feb. 13	Ray Leighman	Day laborer	16	Ascending cage	Sunflower	Sullivan	....	....	....	American.
Feb. 16	J. W. Masters	Jerry	32	Falling slate	Vandalia No. 8	Greene	....	....	....	American.
Feb. 21	Wm. Stevenson	Timberman	56	Falling slate	Dering No. 13	Sullivan	....	....	....	Scotch.
Feb. 22	Richard Roberts	Driver	25	Mine cars	Forrest Parke	Vigo	....	....	....	American.
Feb. 25	Louis Dublemont	Miner	61	Falling slate	Hudson	Sullivan	1	....	....	French.
Feb. 25	Frank Buddle	Machine helper	20	Falling coal	Freeman	Knox	....	....	....	American.
Mar. 4	Charles Leachman	Miner	38	Falling coal	Superior No. 2	Parke	1	3	....	American.
Mar. 5	Buxton Bradley	Miner	65	Mine cars	Ayrshire No. 5	Pike	....	....	....	Colored.
Mar. 13	John Coparice	Driver	23	Falling slate	Vandalia No. 9	Greene	1	....	....	Austrian.
Mar. 16	Wm. Fenwick	Miner	37	Delayed shot	Queen	Greene	....	....	....	English.
Mar. 28	George Houser	Miner	54	Falling slate	Maple Valley	Vermillion	1	10	....	American.
April 11	William Ryan	Shot-firer	35	Explosion powder gases	Maple Valley	Vermillion	1	....	....	American.
May 7	Frank Jones	Driver	30	Mine cars	Ray	Vigo	1	2	....	American.
May 8	Wm. McKaskey	Electrician	23	Mine motor	Con. Ind. No. 33	Sullivan	1	....	....	American.
May 8	Shelby Johnson	Top laborer	35	Fell down shaft	Con. Ind. No. 25	Sullivan	1	2	....	American.
May 9	John Ewings	Machine runner	38	Falling slate	Con. Ind. No. 25	Sullivan	1	....	....	American.
June 4	John Adams	Miner	45	Delayed shot	Ayrshire No. 3	Pike	1	5	....	American.
June 6	Starl Biggs	Miner	49	Falling slate	Minshall Mine	Vigo	1	5	....	American.
June 8	Louie Bonami	Miner	40	Ascending cage	Crown Hill No. 1	Vermillion	....	....	....	Italian
June 18	Joseph Hookey	Timberman	65	Falling slate	Parke No. 11	Parke	1	....	....	American.
June 25	George Inglehart	Miner	51	Falling slate	Brazil Block No. 1	Clay	1	3	....	American.
July 18	Orvil Gray	Miner	16	Falling slate	Vandalia No. 10	Sullivan	....	....	....	American.

Aug. 4	James McLoney	Driver	19	Kicked by mule	Dering No. 14	Sullivan	....	....	....	American.
Aug. 6	J. W. Willson	Loader	24	Explosion of fire damp	Vandalia No. 10	Sullivan	....	....	....	English.
Sept. 4	Louis Morgen	Miner	29	Falling slate	Superior No. 3	Parke	1	1	....	American.
Sept. 28	William Madison	Miner	56	Delayed shot	Shirley Hill No. 1	Sullivan	1	1	....	English.
Sept. 29	Joe. Swismiski	Shot-firer	45	Explosion of powder gases	Prince	Vermillion	....	....	....	Russian.
Oct. 2	James Swabrick	Macbine runner	27	Electric shock	Wabash	Vigo	1	1	....	American.
Oct. 20	George Morris	Miner	36	Falling rock	Miami No. 1	Vigo	1	3	....	English.
Oct. 20	Thomas Boot	Miner	28	Falling rock	Miami No. 1	Vigo	1	....	....	English.
Oct. 21	John Grraves	Miner	19	Falling slate	Mecca No. 3	Parke	....	....	....	American.
Oct. 29	George Gill	Loader	26	Falling slate	Jackson Hill No. 4	Sullivan	1	1	....	American.
Nov. 13	Louis Vonderschmitt	Driver	16	Mine car	Vandalia No. 8	Greene	....	....	....	German.
Dec. 15	George Peyton	Loader	55	Falling slate	Dering No. 14	Sullivan	1	3	....	American.
Dec. 21	Thomas Beasley	Driver	25	Mine car	Hocking	Sullivan	....	....	1	American.
Dec. 22	Anton Bonheim	Shot-firer	42	Delayed shot	Oswald	Gibson	1	2	....	German.

Aug. 4	James McLoney	Driver	19	Kicked by mule	Dering No. 14	Sullivan	....	....	....	American.
Aug. 6	J. W. Willson	Loader	24	Explosion of fire damp	Vandalia No. 10	Sullivan	....	....	....	English.
Sept. 4	Louis Morgen	Miner	29	Falling slate	Superior No. 3	Parke	1	1	....	American.
Sept. 28	William Madison	Miner	56	Delayed shot	Shirley Hill No. 1	Sullivan	1	1	....	English.
Sept. 29	Joe. Swismiski	Shot-firer	45	Explosion of powder gases	Prince	Vermillion	....	....	....	Russian.
Oct. 2	James Swabrick	Machine runner	27	Electric shock	Wabash	Vigo	1	1	....	American.
Oct. 20	George Morris	Miner	36	Falling rock	Miami No. 1	Vigo	1	3	....	English.
Oct. 20	Thomas Boot	Miner	28	Falling rock	Miami No. 1	Vigo	1	....	....	English.
Oct. 21	John Grraves	Miner	19	Falling slate	Meeca No. 3	Parke	....	....	....	American.
Oct. 29	George Gill	Loader	26	Falling slate	Jackson Hill No. 4	Sullivan	1	1	....	American.
Nov. 13	Louis Vonderschmitt	Driver	16	Mine car	Vandalia No. 8	Greene	....	....	....	German.
Dec. 15	George Peyton	Loader	55	Falling slate	Dering No. 14	Sullivan	1	3	....	American.
Dec. 21	Thomas Beasley	Driver	25	Mine car	Hocking	Sullivan	....	....	1	American.
Dec. 22	Anton Bonheim	Shot-firer	42	Delayed shot	Oswald	Gibson	1	2	....	German.

TABLE

Showing the Number of Tons of Coal Mined, the Number of Persons Employed, the Number of Fatalities and the Number of Tons of Coal Produced per Each Fatality Each Year from January 1, 1898, to January 1, 1909.

YEAR.	Tons Produced.	Employes.	Fatalities.	Tons per Fatality.
1898	5,146,920	No report.	22	233,950
1899	5,864,975	7,366	15	390,997
1900	6,283,063	8,858	18	349,059
1901	7,019,203	10,296	24	292,466
1902	8,763,197	13,139	24	365,133
1903	9,992,563	15,128	55	181,683
1904	9,872,404	17,838	34	290,304
1905	10,995,972	17,856	47	233,956
1906	11,422,027	19,562	31	368,450
1907	13,250,715	19,009	53	250,013
1908	11,997,304	19,092	45	266,606

TABLE OF PERMANENT ACCIDENTS.

The Following Table Exhibits the Date of Accident, the Name, Age, and Occupation of Each Person Injured, the Number of Persons Dependent on Each for Support, the Nature and Cause of Injury, and the Name of the Mine and the County Wherein the Accident Occurred.

Date.	NAME.	Age.	Occupation.	Dependents.			Days Lost.	Injury.	Cause of Accident.	Mine.	County.
				Wife.	Children.	Other Dependents.					
Mar. 31	James Gott	26	Miner	....	....	....	....	Back injured	Falling slate	Mecca No. 3	Parke.
Aug. 4	Wm. Hagg	29	Machine helper	1	3	....	....	Leg amputated	Mining machine	Dering No. 14	Sullivan.
Sept. 10	Jack Moreland	24	Machine runner	1	1	....	....	Dislocated spine	Falling slate	Vandalia No. 9	Greene.

TABLE

Exhibiting the Number of Serious Accidents Occurring in 1908, the Name, Age and Occupation of Persons Injured, the Number of Persons Dependent on them for Support, the Length of Time they were Idle by Reason of Injuries (where Same could be Learned), the Name of the County and the Mine Wherein the Accident Occurred.

Date.	NAME.	Age.	Occupation.	Dependents.			Days Lost.	Injury.	Cause of Accident.	Mine.	County.
				Wife.	Children.	Other Dependents.					
Jan. 11	Coon Littles	52	Timberman	1	1	....	....	Broken ribs	Falling slate	Lyford No. 1	Parke.
Jan. 30	Irvin Jones	23	Loader	....	....	....	....	Broken leg	Falling slate	Parke No. 11	Parke.
Jan. 6	Jonathan Winterbottom	58	Loader	1	2	....	....	Foot fractured	Falling slate	Ind. Con. No. 25	Sullivan.
Jan. 8	W. R. Richardson	32	Miner	1	2	....	....	Face and hands burned	Explosion of fire damp	Clover Leaf	Sullivan.
Jan. 8	Wm. Stephens	50	Timberman	....	....	....	....	Rib fractured	Falling timber	Dering No. 13	Sullivan.
Jan. 10	Frank Love	....	Machine runner	....	....	....	....	Leg cut	Mining machine	Dering No. 13	Sullivan.
Jan. 11	Ore Hatfield	19	Driver	....	....	....	....	Internally injured	Mine car and prop	Vandalia No. 10	Sullivan.
Jan. 18	Wm. Ralston	72	Loader	1	....	....	....	Broken leg	Falling slate	Freeman	Sullivan.
Jan. 19	Wm. Thompson	35	Miner	1	2	....	....	Face and hands burned	Explosion of fire damp	Clover Leaf	Sullivan.
Jan. 19	Wm. Winfield	35	Miner	1	2	....	....	Face and hands burned	Explosion of fire damp	Clover Leaf	Sullivan.
Jan. 22	Roy Norris	24	Driver	....	....	....	....	Back injured	Mine cars	Phoenix	Sullivan.
Jan. 23	Fred Mulen	34	Loader	....	....	....	....	Hips and legs	Falling slate	Ind. Con. No. 25	Sullivan.
Jan. 24	Pete Stevenson	26	Driver	....	....	....	....	Shoulders injured	Mine cars	Dering No. 13	Sullivan.
Jan. 28	Claude Ewing	19	Driver	....	....	....	....	Mashed fingers	Rail and tail chain	Jackson Hill No. 2	Sullivan.
Jan. 28	Asa Sargent	27	Jerry man	1	1	....	....	Crushed ankle	Falling slate	Clover Leaf	Sullivan.
Jan. 30	H. E. Bennett	39	Electrician	1	5	....	....	Back injured	Falling over piece of coal	Hocking	Sullivan.
Jan. 8	Joe Motrin	22	Miner	....	....	....	18	Back injured	Falling slate	Brazil Block No. 1	Clay.
Jan. 14	Leon Waugh	....	Timberman	....	....	....	....	Leg injured	Falling slate	Vandalia No. 65	Clay.
Jan. 2	Charles Burrts	35	Fire boss	1	4	....	....	Arm fractured	Falling slate	Letsinger	Greene.
Jan. 4	John Hains	44	Load dropper	1	....	....	17	Rib broken	R. R. car	Vandalia No. 3	Greene.
Jan. 11	Dave Keyhoe	....	Machine runner	....	....	....	43	Ankle bruised	Falling slate	Vandalia No. 9	Greene.
Jan. 13	Joseph Nicodemm	44	Miner	1	....	....	35	Face and hands burned	By blast	Vandalia No. 3	Greene.
Jan. 14	Sam Roberts	57	Miner	....	....	....	29	Ribs fractured	Falling coal	Vandalia No. 3	Greene.
Jan. 17	Thomas Dodds	28	Trip rider	1	4	....	....	Broken foot	Mine car	Lattas Creek	Greene.
Jan. 18	Jas. Losig	37	Miner	....	....	....	....	Ribs fractured	Falling down on track	Green Valley	Greene.
Jan. 20	Joe Jones	45	Miner	1	....	....	....	Leg broken	Falling on slate	Black Creek	Greene.
Jan. 23	Jas. Philips	64	Loader	....	....	....	....	Arm fractured	Coal from flying shot	P. & I	Greene.
Jan. 24	Pat Fowler	68	Miner	....	....	....	....	Back injured	Falling slate	Lattas Creek	Greene.

Jan. 30	Jas. South	45	Cager	1	1		27	Shoulder dislocated	Caught between mine car	Vandalia No. 21	Greene.
Jan. 30	George Waters	23	Driver	1	1			Arm dislocated	Caught between mine car mule	Lattas Creek	Greene.
Jan. 30	J. W. Hunter		Miner				27	Leg bruised	Struck by moving car	Vandalia No. 3	Greene.
Jan. 7	Paul Kirkman	23	Driver					Back injured	Mine car	Lyford No. 1	Parke.
Jan. 9	Nate Bryan		Driver	1	1			Ribs and forearm	Mine car and roof	Lyford No. 1	Parke.
Jan. 3	Benjamin Lape	24	Driver					Shoulder dislocated	Mine car	Buckeye	Vermillion.
Jan. 6	Nick Grase	45	Miner	1	3			Leg fractured	Mine car	Buckeye	Vermillion.
Jan. 20	Mack Luck	29	Driver					Hips injured	Mine ear	Dering No. 7	Vermillion.
Jan. 8	Andrew Winterbottom	21	Driver					Hips injured	Mine car	Fauvre No. 2	Vigo.
Jan. 28	Adam Lutz	24	Driver	1				Stomach	Kicked by a mule	Dawson	Warrick.
Feb. 7	Len Smith	26	Driver	1	3			Hips injured	Mine ears	Island Valley	Clay.
Feb. 8	James Rojert	43	Miner				2	Face and arms burned	Delayed shot	Progressive	Clay.
Feb. 3	Colonel Bonet	23	Miner					Foot mashed	Mine car	Oswald	Gibson.
Feb. 11	Comodore Lake	36	Miner	1	4			Back injured	Falling slate	Vandalia No. 5	Greene.
Feb. 11	Sid Edington	35	Miner	1	2			Broken jaw	Falling slate	Vandalia No. 3	Greene.
Feb. 11	Howard Taylor	20	Driver				109	Hips injured	Mine car	Vandalia No. 3	Greene.
Feb. 13	Devon Beck	47	Miner	1				Rib broken	Falling slate	Vandalia No. 3	Greene.
Feb. 13	Clay Tennis		Machine runner	1	1			Foot crushed	Mining machine	Gilmour	Greene.
Feb. 13	Eben Terril		Driver				24	Body bruises	Mine car	Vandalia No. 9	Greene.
Feb. 16	Andy Gogd		Jerry							Vandalia No. 8	Greene.
Feb. 16	John O'Herin	15	Trapper					Collar bone broken	Mine car	Summitt	Greene.
Feb. 24	Roy Buckner		Miner				30	Bruised head	Falling coal	Vandalia No. 9	Greene.
Feb. 6	Benjamin Goodwine	49	Miner	1				Dislocated hip	Falling coal	Freeman	Knox.
Feb. 27	Lawrence Malitts	56	Miner					Back injured	Falling slate	Superior No. 3	Parke.
Feb. 7	Jno. Courtney	36	Machine helper	1				Arm burned	Electric current	Phoenix No. 4	Sullivan.
Feb. 10	H. H. Shelton	20	Loader	1	1			Fingers mashed	Falling coal	Rainbow	Sullivan.
Feb. 12	Philip Hart	34	Machine helper	1	5			Ribs fractured	Falling slate	Ind. Con. No. 25	Sullivan.
Feb. 13	Vern Nicholson	25	Machine helper	1	1			Finger mashed	Mining machine	Jackson Hill No. 2	Sullivan.
Feb. 17	Frank Richardson		Cager				70	Leg bruised	Mine car	Phoenix	Sullivan.
Feb. 20	Thomas Morrison	19	Driver					Arm injured	Minc car	Clover Leaf	Sullivan.
Feb. 20	Eugene Fitchner	45	Timberman					Broken leg	Falling slate	Dering No. 13	Sullivan.
Feb. 20	Dolph Starks	54	Miner	1	1			Both legs broken	Falling slate	Hudson	Sullivan.
Feb. 27	John Bains	22	Loader					Broken toes	Falling coal	Ind. Con. No. 25	Sullivan.
Feb. 29	Levi Bardsley	35	Timberman	1				Fingers broken		Phoenix No. 4	Sullivan.
Feb. 4	Wm. Bridgewater	22	Miner					Broken leg	Falling slate	Lawton	Vigo.
Feb. 24	Andrew Howell	20	Bottom shooter					Legs and back sprained	Falling slate	Domestic Block	Vigo.
Feb. 25	Ralph Shelton	26	Shot firer					Face and hands burned	Shot through pillar	Lower Vein No. 1	Vigo.
Feb. 29	James Lambert	30	Trip rider	1	3			Hips injured	Mine car	Miami No. 2	Vigo.
Feb. 22	Jno. F. Pritchard	28	Driver					Shoulders fractured	Mine car	Castle Garden	Warrick.
Mar. 5	Charles Fowler	42	Miner	1	4			Shoulder and leg	Falling slate	Crawford No. 9	Clay.
Mar. 13	Ava Philippie	22	Driver					Jaw broken	Kicked by mule	Crawford No. 8	Clay.
Mar. 14	Dugger Canader	16	Loader					Injured foot	Nail in foot	Vivian No. 2	Clay.
Mar. 18	Sherman Johnson	31	Miner					Hands and face burned	Premature shot	Crawford No. 9	Clay.
Mar. 19	William Nelson	42	Miner	1				Broken fingers	Falling coal	Crawford No. 1	Clay.
Mar. 26	Fred Buckhanan	30	Machine runner					Skull fractured	Mining machine	Vivian No. 2	Clay.
Mar. 31	Ora Kastner	23	Driver	1	2			Hand crushed	Mine car	Rebstock	Clay.
Mar. 21	Henry Hill	20	Driver					Collar bone dislocated	Mine car	Oswald	Gibson.
Mar. 10	Mitt. Price	34	Driver					Shoulder blade fractured	Mine car	Gilmour	Greene.

TABLE EXHIBITING THE NUMBER OF SERIOUS ACCIDENTS OCCURRING IN 1908, ETC.—Continued.

Date.	NAME.	Age.	Occupation.	Dependents. Wife.	Dependents. Children.	Dependents. Other Dependents.	Days Lost.	Injury.	Cause of Accident.	Mine.	County.
Mar. 13	M. A. Tait	35	Loader	1				Broken leg	Falling slate	Vandalia No. 8	Greene.
Mar. 16	A. L. Beal	23	Driver					Ankle crushed	Mine car	Vandalia No. 5	Greene.
Mar. 4	Wm. Thompson	20	Driver					Hips injured	Mule fell on him	Knox	Knox.
Mar. 12	Claude VanMeeter	24	Driver					Two ribs broken	Kicked by mule	Tecumseh	Knox.
Mar. 23	Mattis Robey	18	Driver					Collar bone broken	Mine car	Knox	Knox.
Mar. 23	Charles Meyers	24	Driver					Hand mashed	Mine car	Freeman	Knox.
Mar. 25	Mat Towbridge	35	Driver					Foot fractured	Mine car	Freeman	Knox.
Mar. 17	Ott Yocom	21	Driver					Back injured	Mine car	Superior No. 5	Parke.
Mar. 20	John Buskenowsky	59	Miner	1	2			Hands and face burned	Powder explosion	Superior No. 2	Vigo.
Mar. 24	Wm. Cooper	35	Miner	1				Broken leg	Falling slate	Parke No. 10	Parke.
Mar. 3	Harry Brown	46	Miner	1	1			Leg fractured	Mine cars	Littles	Pike.
Mar. 6	Wm. Fetinger	35	Dumper	1	4			Dislocated arm	Falling	Ayrshire No. 4	Pike.
Mar. 7	John Black	23	Driver	1	2			Hips injured	Mine car	Ayrshire No. 5	Pike.
Mar. 3	Herman Engle	19	Spragger					Leg mashed	Mine car	Hocking	Sullivan.
Mar. 5	John Herr	22	Loader					Wrist broken	Mine car	Hocking	Sullivan
Mar. 7	George Carty	32	Electrician	1				Hand burned	Electric cable	Phoenix No. 8	Sullivan.
Mar. 9	A. C. McKee	36	Machine helper	1				Hand burned	Electric cable	Dering No. 13	Sullivan.
Mar. 10	Claude Norris	23	Machine runner	1	2			Fingers fractured	Mining machine	Shirley Hill No. 3	Sullivan.
Mar. 11	A. B. Yantz	47	Loader	1	2			Broken leg	Falling slate	Little Giant	Sullivan.
Mar. 16	Fred Worthington	26	Machine runner	1				Broken leg	Falling slate	Vandalia No. 10	Sullivan.
Mar. 20	Henry Puck	42	Driver	1	1			Breast injured	Mine car	Ind. Con. No. 30	Sullivan.
Mar. 26	Charles T. Watters	23	Driver	1	1			Foot mashed	Mine car	Rainbow	Sullivan.
Mar. 28	Fred Sims	23	Trip rider	1	1			Fractured foot	Mine car	Vandalia No. 10	Sullivan.
Mar. 27	Alf. Shoptew		Driver				16	Leg bruised	Mine car	Rainbow	Sullivan.
Mar. 3	Steve. Weise	45	Miner		1			Dislocated shoulder	Falling slate	Vandalia No. 69	Vigo.
Mar. 3	Mike Bandore	25	Cager					Fractured arm	Coal falling down shaft	Dering No. 6	Vigo.
Mar. 4	Frank Moore	40	Fireman				43	Legs scalded	Steam	Vandalia No. 69	Vigo
Mar. 4	Fred Scoltz		Driver				15	Arm bruised	Mine car	Vandalia No. 69	Vigo.
Mar. 10	Lewis Englehart	22	Miner					Hand mashed	Falling coal	Miami No. 3	Vigo.
Mar. 10	Charles Story		Greaser				30	Foot mashed	Mine car	Vandalia No. 69	Vigo.
Mar. 12	Edward Linsley	34	Machine runner	1	3			Leg broken	Falling slate	Domestic Block	Vigo.
Mar. 19	John Bonneta	18	Driver					Arm broken	Mine car	Dering No. 6	Vigo.
Mar. 20	Mike Mesae	45	Miner					Ear cut, back injured	Falling slate	Victor	Vigo.
Mar. 23	Clarence Norris	50	Miner	1			30	Back injured	Falling slate	Forrest	Vigo.

Mar. 23	Allen Lutz	21	Loader	1	3			Internal injuries	Mine car	Electric	Warrick.
Mar. 27	B. Taylor	50	Miner					Collar bone broken	Falling slate	Big Four	Warrick.
April 30	Willes Scaggs	26	Day man	1				Leg scalded	Steam	Vivian No. 2	Clay.
April 27	Walter Damall	27	Day man	1	2			Body burned	Explosion of fire damp	Oswald	Gibson.
April 27	Jeen Powell	21	Day man	1				Body burned	Explosion of fire damp	Oswald	Gibson.
April 22	Charles Myers	15	Driver					Ankle dislocated	Mine car	Twin No. 5	Greene.
April 9	Joe Stout	45	Driver	1	4			Leg crushed	Mine car	Gilmour	Greene.
April 10	Charles Gordon	36	Loader	1				Back injured	Falling slate	Calora	Greene.
April 24	H. Watson	19	Driver					Foot crushed	Mine car	Green Valley	Greene.
April 25	John Savio	50	Miner					Back injured	Falling rock	Brazil Block No. 9	Parke.
April 11	Harry Carshman	20	Driver					Hips injured	Mine car	Vandalia No. 10	Sullivan.
April 13	Robert Clemmins	18	Loader				78	Head cut	Falling slate	Hocking	Sullivan.
April 16	John Galleger	30	Loader	1	3			Face and hands burned	Explosion of fire damp	Hocking	Sullivan.
April 22	Pete Hardesty	23	Driver					Two broken ribs	Mine car	Viola	Sullivan.
April 27	Orvil Heck	17	Driver				12	Wrist dislocated	Mine car	Hocking	Sullivan.
April 27	John McCoskey	27	Machine helper				119	Back injured	Falling coal	Hocking	Sullivan.
April 20	B. Maddle	18	Miner					Leg injured	Mine car	Crescent	Vanderburgh.
April 19	Charles Sadler	21	Driver					Arm broken	Falling slate	Dering No. 8	Vermillion.
April 29	Arthur S. Hanover	15	Trapper					Ribs fractured	Kicked by mule	Buckeye	Vermillion.
April 18	John Seellock	62	Miner	1				Both legs broken	Falling slate	Vandalia No. 69	Vigo.
April 22	Joe Bainley	27	Driver					Leg injured	Mine car	Victor	Vigo.
April 23	Thomas McKenna	15	Miner					Back injured	Falling slate	Lawton	Vigo.
April 28	Edwin Sherrell	35	Top man				35	Back injured	R. R. car	Forrest	Vigo.
May 6	Ollie Huff	21	Miner					Fingers cut off	Electric drill	Vivian No. 2	Clay.
May 12	Fred Pierceton	40	Miner			1		Ribs fractured	Falling slate	Progressive	Clay.
May 13	Cliff Chatham		Top laborer	1				Head and ankle injured	Falling from scaffold	Clay Product Co.	Clay.
May 9	Ton. Dewerre	25	Miner	1	2			Toes broken	Falling coal	Oswald	Gibson.
May 5	Thomas Buckner	48	Loader			1		Back injured	Falling slate	Twin No. 4	Greene.
May 5	Louis Ford	22	Jerry					Back injured	Falling slate	Twin No. 4	Greene.
May 12	Cleve Goodman	22	Driver	1				Feet and hips injured	Falling slate	Vandalia No. 9	Greene.
May 11	Claude Ewing	19	Driver					Ankle injured	Mine car	Jackson Hill No. 2	Sullivan.
May 14	Orvil Renvard	19	Miner					Leg broken	Falling coal	Ind. Con. No. 33	Sullivan.
May 2	George Martin	39	Miner	1	4		103	Back injured	Falling coal	Vandalia No. 67	Vigo.
May 13	Charles Campten	40	Jerry	1	3			Fingers broken	Mining machine	Wabash	Vigo.
May 13	Wm. McDonald	45	Boss driver	1	1			Finger amputated	Mine car	Vandalia No. 67	Vigo.
May 20	Pat. Branon	24	Driver				10	Foot crushed	Mine car	Forrest	Vigo.
June 19	Alf. Connett	48	Miner	1				Ribs broken	Falling coal	Vandalia No. 65	Clay.
June 20	Andrew Craig	27	Miner					Back infured	Falling coal	Superior No. 3	Clay.
June 5	Gus. Miller	22	Driver			2		Ribs broken	Mine car	Oswald	Gibson.
June 9	Peter Campbell	28	Carpenter	1	1			Broken nose	Falling from scaffold	Island Valley No. 4	Clay.
June 10	Charles Bicknell	35	Driver	1			12	Ankle injured	Falling coal	Vandalia No. 5	Greene.
June 19	Oral Trump	23	Loader	1				Back injured	Falling slate	Calora	Greene.
June 25	Sam Bonham	47	Miner	1	7			Face injured	Delayed shot	Lattas Creek	Greene.
June 26	Robert Gibson	18	Jerry					Leg mashed	Caught by sinking bucket	Calora	Greene.
June 30	George Tucker	30	Miner	1			7	Back and hips injured	Falling slate	Vandalia No. 5	Greene.
June 18	John Philips	25	Jerry	1	2			Internally injured	Falling slate	Parke No. 11	Greene.
June 6	Curtus Bidwell	25	Motorman	1			48	Body bruises	Motor collided with mule	Vandalia No. 10	Sullivan.
June 10	Paul Congach	25	Loader					Back injured	Falling slate	Dering No. 13	Sullivan.

TABLE EXHIBITING THE NUMBER OF SERIOUS ACCIDENTS OCCURRING IN 1908, ETC.—Continued.

Date.	NAME.	Age.	Occupation.	Dependents: Wife.	Children.	Other Dependents.	Days Lost.	Injury.	Cause of Accident.	Mine.	County.
June 19	John Boss	21	Driver					Foot dislocated	Mine car	Shirley Hill No. 3	Sullivan.
June 20	Hebis Nileler	32	Track man	1				Foot injured	Stepped on nail	Rainbow	Sullivan.
June 25	Orville Watson	31	Machine runner	1	1			Leg broken	Mining machine	Phoenix No. 4	Sullivan.
June 29	Harry Tryon	60	Miner	1				Legs and two ribs broken	Falling slate	Little Giant	Sullivan.
June 29	Thomas Bidwell	32	Loader	1	3			Back and shoulder	Falling coal	Ind. Con. No. 33	Sullivan.
June 30	John N. Howard	46	Loader	1	6			Body bruised	Falling slate	Phoenix No. 4	Sullivan.
June 11	Bert Clark	22	Driver	1				Collar bone broken	Mine car	Oak Hill No. 5	Vermillion.
June 16	James Davy	18	Trip rider					Back injured	Mine car	Dering No. 5	Vermillion.
June 23	Charles Boelnar	47	Jerry	1	2			Back injured	Falling slate	Crown Hill No. 3	Vermillion.
June 9	Charles Cruthers	26	Driver					Leg injured	Mine car	Forrest	Vigo.
June 18	John Smith	22	Jerry				2	Injured foot	Stepping on nail	Wabash	Vigo.
June 23	Ed. Hains	38	Miner	1	2			Back injured	Falling slate	Vandalia No. 69	Vigo.
June 23	Amiel Caron		Loader	1	3			Body bruised	Falling slate	Plymouth No. 1	Vigo.
June 25	E. G. Lockwood	42	Miner	1				Rib fractured	Falling coal	Glen Ayr	Vigo.
June 25	John Walkins	31	Loader	1				Fingers amputated	Falling slate	Wabash	Vigo.
July 10	Tony Buse	34	Miner	1				Side injured	Prop fell on him	Vandalia No. 65	Clay.
July 23	Otis Harison	25	Driver					Broken arm	Mine car	Crawford No. 9	Clay.
July 15	Coc. Barnett		Driver					Arm fractured	Kicked by mule	Oswald	Gibson.
July 18	Elzie Malone		Load dropper					Finger broken	Mine car	Oswald	Gibson.
July 7	Del Plane	35	Miner	1				Ankle crushed	Falling coal	Black Creek	Greene.
July 10	Walter Cammons	38	Loader	1				Hips and leg crushed	Falling coal	Freeman	Knox.
July 8	Riley Muncy	23	Driver	1	1			Arm and wrist crushed	Mine car	Lyford No. 1	Parke.
July 16	Bert Short	23	Driver	1	3			Hips crushed	Mine car	Lyford No. 1	Parke.
July 25	Edwin Johnson	40	Track man			4	4	Hips crushed	Falling slate	Superior No. 4	Parke.
July 1	Otis Johnson	24	Driver					Ankle fractured	Falling slate	Ayrshire	Pike.
July 27	Jas. Church	22	Driver					Shoulder	Mine car	Blackburn No. 2	Pike.
July 2	Charles Hill	46	Timberman	1	3		55	Head and shoulder	Falling slate	Phoenix No. 4	Sullivan.
July 3	Comodore Parks	27	Track man				27	Back injured	Falling slate	Vandalia No. 10	Sullivan.
July 3	Vest Gill	47	Mine boss	1	3		75	Leg broke	Motor and mine door	Little Giant	Sullivan.
July 14	Otte Hale	20	Miner					Foot crushed	Falling coal	Little Giant	Sullivan.
July 14	John R. Murphy	50	Loader	1				Hip and abdomen injured	Falling slate	Hamilton	Sullivan.
July 11	H. W. White	23	Spragger	1	1			Foot crushed	Mine car	Oak Hill	Vermillion.
July 13	A. Attaiga	24	Driver	1				Ribs fractured	Mine car	Dering No. 5	Vermillion.
July 13	Jas. Shetton	32	Driver	1	1			Back injured	Mine car	Dering No. 7	Vermillion.

July	13	A. Evans	34	Driver					Ribs fractured	Mine car	Dering No. 7	Vermillion.
July	13	John Terrel	26	Driver	1				Hip dislocated	Mine car	Prince	Vermillion.
July	15	Joe Stupan	....	Miner					Foot crushed	Falling coal	Prince	Vermillion.
July	16	August Bonheimer	15	Trapper					Arm and back injured	Mine car	Crown Hill No. 1	Vermillion.
July	28	Frank Rodes	37	Jerry	1	6			Legs injured	Falling slate	Dering No. 8	Vermillion.
July	28	Evert Rodes	28	Jerry	1	1			Both legs broken	Falling slate	Dering No. 8	Vermillion.
July	6	Fred Stutts	33	Miner	1	1			Internal injuries	Falling slate	Lawton	Vigo.
July	7	Silas Montgomery	40	Machine runner	1	4		30	Toes broken	Mining machine	Forrest	Vigo.
July	10	Grover Hains	23	Miner	1	3			Toe broken	Falling coal	Lawton	Vigo.
July	10	Orie Morchead	28	Spragger					Head mashed	Mine car	Forrest	Vigo.
July	16	Otis Jackson	26	Driver					Fingers broken	Mine car	Vandalia No. 69	Vigo.
July	20	Ray Steppens	27	Driver					Hips crushed	Mine car	Vandalia No. 69	Vigo.
July	21	John F. Beid	39	Miner					Ankle and leg injured	Falling coal	Tower Hill	Vigo.
July	21	L. C. Wright	34	Miner	1	2			Back and leg injured	Falling coal	Vandalia No. 69	Vigo.
Aug.	8	George Church	54	Miner	1				Side and hips injured	Falling slate	Crawford No. 2	Clay.
Aug.	12	Raymond Wright	20	Driver					Nose fractured	Kicked by mule	Plymouth No. 2	Clay.
Aug.	18	Arthur Maxwell	18	Cager				50	Hand crushed	Ascending cage	Vandalia No. 65	Clay.
Aug.	20	Thomas Geddon	32	Cager				38	Foot crushed	Ascending cage	Vandalia No. 65	Clay.
Aug.	28	Earl Martin	18	Miner					Head mashed	Falling coal	Wizard	Clay.
Aug.	28	Isack Housel	34	Superintendent	1	1			Shoulder dislocated	Fell off box car	Superior No. 5	Clay.
Aug.	31	Ord. Rhodrick	30	Driver					Hips and legs injured	Mine car	Vivian No. 2	Clay.
Aug.	26	J. W. Smith	45	Miner	1	3			Foot fractured	Falling coal	Oswald	Gibson.
Aug.	5	John McCann	27	Miner	1				Leg and collar bone broken	Falling slate	Vandalia No. 8	Greene.
Aug.	13	Nathan Tipton	50	Miner	1	4			Shoulder injured	Falling slate	Vandalia No. 5	Greene.
Aug.	24	James Hale	22	Driver					Shoulder and right ear	Mine car	Vandalia No. 2	Greene.
Aug.	24	Joseph Penland	60	Miner	1	2			Leg and shoulder	Falling slate	Gilmour	Greene.
Aug.	31	Otis Cahall	26	Loader					Broken leg	Falling slate	Green Valley	Greene.
Aug.	1	Jno. Daughtery	23	Miner	1	2			Broken leg	Falling slate	Mecca No. 3	Parke.
Aug.	19	Irwin Young	40	Driver	1	4			Foot injured	Mine car	Mecca No. 3	Parke.
Aug.	28	Fred Guldenbach	31	Driver	1	4			Finger mashed	Mine car	Vandalia No. 316	Parke.
Aug.	28	Hugh Hirkland	60	Mine boss	1				Back injured	Falling slate	Superior No. 3	Parke.
Aug.	31	Keller	36	Driver					Back injured	Mine car	Vandalia No. 316	Parke.
Aug.	3	Emery West	30	Miner	1				Two fingers mashed	Falling slate	Peacock No. 2	Pike.
Aug.	4	Wm. Hagg	29	Machine runner	1	3			Leg broken	Mine car	Dering No. 14	Sullivan.
Aug.	6	James Ferguson	18	Driver					Foot mashed	Mine car	Vandalia No. 10	Sullivan.
Aug.	14	Burl Dubrie	45	Miner	1	2			Leg broken	Falling slate	Citizens	Sullivan.
Aug.	27	Pearl Miller	27	Driver					Two ribs broken	Mine car	Jackson Hill No. 4	Sullivan.
Aug.	27	Amos Chipman	26	Driver					Leg injured	Mine car	Jackson Hill No. 4	Sullivan.
Aug.	4	Harry Gall	24	Driver					Face injured	Kicked by mule	Crown Hill No. 3	Vermillion.
Aug.	5	Fred Nelson	28	Driver		1			Hips injured	Mine car	Crown Hill No. 3	Vermillion.
Aug.	25	David Davis	41	Jerry	1				Back injured	Falling slate	Dering No. 8	Vermillion.
Aug.	26	Chas. Kemskey	28	Shot firer					Face and hand burned	Delayed shot	Prince	Vermillion.
Aug.	27	John Pescolie	33	Machine runner					Foot mashed	Mining machine	Crown Hill No. 3	Vermillion.
Aug.	28	F. Dugger	20	Miner					Body bruised	Mine car	Buckeye	Vermillion.
Aug.	6	Evert Woods	22	Driver	1	2			Finger cut off	Mine car	Lawton	Vigo.
Aug.	10	Dora Ward	28	Shot firer	1	2			Back and hips injured	Coal from flying shot	Vandalia No. 69	Vigo.
Aug.	11	Frank Cunningham	24	Driver					Leg broken	Mine car	Glen Ayr	Vigo.
Aug.	12	Philip Erwin	21	Cager					Back injured	Mine car	Vandalia No. 67	Vigo.

TABLE EXHIBITING THE NUMBER OF SERIOUS ACCIDENTS OCCURRING IN 1908, ETC.—Continued.

Date.	NAME.	Age.	Occupation.	DEPENDENTS. Wife.	Children.	Other Dependents.	Days Lost.	Injury.	Cause of Accident.	Mine.	County.
Aug. 22	Dave Smider	40	Miner	1	2			Broken collar bone	Falling coal	Ray	Vigo.
Aug. 29	Wm. Dorman	28	Shot firer	1	1			Face and hands burned	Premature shot	Fauvre No. 2	Vigo.
Sept. 9	Frank Niekle	37	Miner					Leg broken	Falling coal	Plymouth No. 2	Clay.
Sept. 2	George Merdith	23	Driver	1	3			Broken fingers	Kicked by mule	Calora	Greene.
Sept. 5	John Sims	38	Track man				61	Back injured	Falling slate	Vandalia No. 8	Greene.
Sept. 11	Howard Taylor	21	Driver				41	Leg broken	Mine car	Vandalia No. 8	Greene.
Sept. 13	John Styles	28	Pumper	1	3			Back injured	Falling slate	Antioch	Greene.
Sept. 21	Henry Jett	21	Driver	1	1			Back injured	Mine car	Green Valley	Greene.
Sept. 26	H. Vigner	26	Cager					Arm broken	Coal falling down shaft	Summitt	Greene.
Sept. 4	Charles Jackman	34	Miner	1	3			Wrist broken	Falling down	Vandalia No. 316	Parke.
Sept. 9	Jessie Adams	....	Miner	1	1			Broken leg	Falling coal	Vandalia No. 316	Parke.
Sept. 24	Thomas West	28	Driver	1	2			Collar bone broken	Falling slate	Vandalia No. 316	Parke.
Sept. 30	Frank C. Meyers	28	Miner	1	1			Back injured	Falling slate	Ayrshire No. 4	Pike
Sept. 2	Andrew Craig	37	Loader	1	3			Lost an eye	Coal from flying shot	Dering No. 13	Sullivan.
Sept. 2	George Greek	20	Loader					Body bruised	Falling slate	Reliance	Sullivan.
Sept. 12	Charles Johnson	26	Driver					Hip injured	Mine car	Little Giant	Sullivan.
Sept. 14	Jessie Dix	23	Loader	1	3			Finger mashed	Falling rock	Con. Ind. No. 25	Sullivan.
Sept. 14	H. H. Shilton	70	Flagman	1	1			Ankle fractured	Mine car	Rainbow	Sullivan.
Sept. 16	Elmer Martin	28	Miner					Leg broken	Mine car	Con. Ind. No. 25	Sullivan.
Sept. 19	John Cazzill	22	Loader					Leg broken	Falling slate	Sun Flower	Sullivan.
Sept. 25	Ted. G. Lewis	26	Mine boss	1	4			Foot crushed	Mine car	Citizens	Sullivan.
Sept. 26	H. J. Hoover	25	Driver					Crushed body	Mine car	Dering No. 13	Sullivan.
Sept. 26	George Reighead	17	Driver					Legs crushed	Mine car	Vandalia No. 10	Sullivan.
Sept. 29	Elza Stewart	35	Loader	1	1			Foot crushed	Falling coal	Reliance	Sullivan.
Sept. 30	G. Francis	35	Miner	1				Back injured	Falling slate	Little Giant	Sullivan.
Sept. 29	Wm. Kelly	23	Cager	1	1			Rib broken	Falling down shaft	Dering No. 6	Vigo.
Sept. 16	Ed. Horten	31	Driver	1	6			Internally	Mine car	Fauvre No. 2	Vigo.
Sept. 16	Henry Mucker	35	Timberman	1	1			Neck and head	Falling slate	Forrest	Vigo.
Sept. 16	George Montgomery	19	Miner					Leg and back	Falling slate	Lawton	Vigo.
Sept. 21	John Biggs	48	Miner	1				Foot broken	Falling coal	Minshall	Vigo.
Sept. 25	Elmer Cruss	24	Miner					Hips and chest crushed	Falling coal	Vandalia No. 66	Vigo.
Sept. 21	Harvey Day	23	Driver					Hips crushed	Mine car	Crown Hill No. 3	Vermillion.
Sept. 1	E. Hammock	30	Fire boss	1				Face and hands burned	Explosion fire damp	Elberfeld	Warrick
Sept. 1	Hiram Punninger	25	Miner					Face and hands burned	Explosion fire damp	Elberfeld	Warrick.

Sept. 26	Frank Hargrove	24	Driver	1				Broken arm	Mine car	Dawson	Warrick.
Sept. 28	J. S. Austin	50	Miner	1	4			Face and hands burned	Powder explosion	Polk Patch	Warrick.
Oct. 10	Thomas Bennett	49	Miner	1	3			Broken arm	Premature shot	Brazil Block No. 4	Clay.
Oct. 23	Ben. Batchler	24	Miner	1	1			Ribs broken	Falling slate	Eureka No. 5	Clay.
Oct. 23	Roy Gribble	16	Trapper					Foot mashed	Mine car	Vandalia No. 65	Clay.
Oct. 27	Tongo Bare		Miner				16	Shoulder bruised	Falling slate	Vandalia No. 65	Clay.
Oct. 1	Patrick O'Hern	47	Miner	1	8			Broken thigh	Falling slate	Summitt	Greene.
Oct. 7	John Wilson	29	Miner			1		Leg broken	Falling slate	Queen	Greene.
Oct. 8	Walter Salceup	32	Driver					Shoulder	Falling slate	Calora	Greene.
Oct. 15	Westly Baldwin	19	Driver					Arm and leg cut	Kicked by mule	Vandalia No. 9	Greene.
Oct. 15	Ray Watson	19	Driver					Hips crushed	Mine car	Green Valley	Greene.
Oct. 17	Michael Moss	18	Driver					Arm broken	Kicked by mule	Summitt	Greene.
Oct. 24	Wm. Johnson	22	Driver					Arm dislocated	Mine car	Vandalia No. 21	Greene.
Oct. 29	John Cox	32	Track cager	1	3		57	Arm broken	Mine car	Vandalia No. 8	Greene.
Oct. 30	Jerry Coakly	55	Miner	1	4			Mashed through chest	Mine car	Vandalia No. 5	Greene.
Oct. 2	Joe Todd	23	Loader					Ankle fractured	Falling slate	Knox	Knox.
Oct. 12	George Hooker	28	Driver				26	Fingers cut off	Mine car	Mary	Parke.
Oct. 22	Samuel Sylvester	49	Miner	1	2			Broken leg	Falling coal	Mecca No. 3	Parke.
Oct. 26	John Galleger	24	Driver			2		Knee injured	Mine car	Mary	Parke.
Oct. 27	Corbett Martin	15	Miner					Thumb fractured	Falling coal	Brazil Block No. 9	Parke.
Oct. 27	George Curry	51	Miner	1	2			Back and hips injured	Falling slate	Mecca No. 3	Parke
Oct. 20	Ben. Clarke	20	Driver					Broken leg	Falling slate	Jackson Hill No. 4	Sullivan.
Oct. 20	Geo. M. Carke		Loader				16	Hips bruised	Falling coal	Rainbow	Sullivan.
Oct. 28	John Lewis	22	Driver					Two fingers broken	Mine car	Crown Hill No. 3	Vermillion.
Oct. 7	William Patrie	36	Machine runner	1	4			Broken arm	Falling slate	Domestic Block	Vigo.
Oct. 10	Edgar Gains	34	Miner					Broken foot	Falling rock	Miami No. 1	Vigo.
Oct. 19	John Scott	68	Timberman	1				Broken leg	Falling slate	Miami No. 4	Vigo.
Oct. 22	Leslie Ogden	20	Driver					Hip dislocated	Mine car	Vandalia No. 81	Vigo.
Oct. 24	Edward Burke	40	Miner					Back injured	Falling slate	Lawton	Vigo.
Oct. 24	Ernest Batterman	16	Miner					Ankle broken	Falling slate	Vandalia No. 66	Vigo.
Oct. 24	Dan. Gargess	40	Miner	1	4			Foot mashed	Falling coal	Victor	Vigo.
Oct. 28	John Graves	42	Driver	1			8	Injured thigh	Mine car	Vandalia No. 67	Vigo.
Nov. 13	Frank Careenskie	29	Miner					Body injured	Falling slate	Vandalia No. 66	Vigo.
Nov. 20	Arthur James	30	Miner	1	2			Broken toe	Falling coal	Crawford No. 9	Clay.
Nov. 24	Oddie Hill	19	Driver					Ribs broken	Mine car	Oswald	Gibson.
Nov. 6	S. E. Freely	25	Driver	1				Pelvic bone broken	Mine car	Queen	Greene.
Nov. 7	A. D. Osborn		Loader				21	Thumb mashed	Falling slate	Summitt	Greene.
Nov. 16	Joseph Mitchell	33	Boss driver	1	3			Thigh bruised	Mine car	Summitt	Greene.
Nov. 17	Chas. Bailey	32	Loader					Broken leg	Falling coal	Lattas Creek	Greene.
Nov. 19	Clarence Cross	26	Loader	1				Back wrenched	Falling slate	Lattas Creek	Greene.
Nov. 23	Paris Beach	42	Machine runner	1				Broken leg	Falling slate	Lattas Creek	Greene.
Nov. 23	Emmet Boden		Machine helper				16	Bruised head	Falling slate	Lattas Creek	Greene.
Nov. 28	Frank Baggh	26	Motorman	1	2			Mashed hand	Mine car	Lattas Creek	Greene.
Nov. 13	J. C. Smith	26	Driver	1				Finger mashed	Coal falling off car	Freeman	Knox.
Nov. 7	Frank McVay	24	Driver	1			14	Fractured ankle	Mine car	Mary	Parke.
Nov. 4	Tom Archer	23	Driver	1			21	Wrist dislocated	Mine car	Mary	Parke.
Nov. 12	Frank Thurley	40		1	4			Face scalded	Repairing boiler	Vandalia No. 316	Parke.
Nov. 5	Marion King	34	Miner	1	1			Back injured	Falling slate	Ayrshire No. 4	Pike.

TABLE EXHIBITING THE NUMBER OF SERIOUS ACCIDENTS OCCURRING IN 1908, ETC.—Continued.

Date.	NAME.	Age.	Occupation.	Dependents. Wife.	Dependents. Children.	Dependents. Other Dependents.	Days Lost.	Injury.	Cause of Accident.	Mine.	County.
Nov. 7	Wm. Loveless	29	Miner	1	3			Bruised arm	Falling coal	Littles	Pike.
Nov. 2	John Godfrig	60	Miner	1				Broken leg	Falling coal	Kettle Creek	Sullivan.
Nov. 3	James Powers	24	Jerry man	1				Broken arm	Falling slate	Jackson Hill No. 4	Sullivan.
Nov. 3	James Priest	27	Machine runner	1	1			Broken leg	Falling slate	Shirley Hill No. 3	Sullivan.
Nov. 6	Jas. Cockran	21	Driver					Body crushed	Mine car	Rainbow	Sullivan.
Nov. 7	Robert Harris	50	Machine helper	1				Broken arm	Falling slate	Ind. Con. No. 33	Sullivan.
Nov. 11	John Collins	48	Loader					Body bruises	Premature shot	Reliance	Sullivan.
Nov. 21	Joseph Keen	36	Miner					Body burned	Premature shot	Clover Leaf	Sullivan.
Nov. 23	Herbert Murrat	25	Loader					Foot crushed	Mine car	Ind. Con. No. 25	Sullivan.
Nov. 23	Kirk McCrosby	51	Jerry man	1	5			Ankle out of place	Falling slate	Phoenix No. 4	Sullivan.
Nov. 16	Jacob Rabus	20	Driver					Collar bone broken	Mine car	Dering No. 8	Vermillion.
Nov. 2	Chas. Riggs	32	Driver					Fractured finger	Mine car	Glen Ayr	Vigo.
Nov. 4	Joseph Hoffman	38	Loader	1	3			Foot broken	Falling slate	Grant No. 3	Vigo.
Nov. 6	Frank Hodges	26	Driver					Bruised back	With mule	Fauvre No. 2	Vigo.
Nov. 7	Wm. Pierce		Miner				17	Bursted finger	Water pipe	Forrest	Vigo.
Nov. 11	Thomas Waters	26	Miner	1				Bruised hip and leg	Falling coal	Lawton	Vigo.
Nov. 11	Joe Blinskie	30	Miner					Broken toes	Falling slate	Lawton	Vigo.
Nov. 16	P. Surretie	40	Miner					Head bruised, broken rib	Windy shot	Minshall	Vigo.
Nov. 16	Robert Adams	17	Miner					Body bruises	Windy shot	Minshall	Vigo.
Nov. 16	Chas. McQuillin	35	Miner	1	2			Broken leg, body bruises	Windy shot	Minshall	Vigo.
Nov. 20	Wm. Sims	32	Machine runner	1	1			Squeezed hips	Mining machine	Forrest	Vigo.
Nov. 28	John Anderson	60	Day man	1				Hip dislocated	Falling slate	Miami No. 1	Vigo.
Dec. 3	Elza Pell	36	Miner	1	3			Broken toe	Falling slate	Big Vein	Clay.
Dec. 4	Clarence Light	27	Miner	1				Broken leg	Falling slate	Big Vein	Clay.
Dec. 28	Chas. Cutts	40	Miner					Arm fractured	Mine car	Vivian No. 2	Clay.
Dec. 31	Alex Brown	45	Miner	1				Back bruised	Falling slate	Vandalia No. 65	Clay.
Dec. 24	C. E. Anderson	28	Driver	1	1			Collar bone broken	Mine car	Oswald	Gibson.
Dec. 1	William Hays	35	Track layer	1	1			Back bruised	Falling slate	Vandalia No. 8	Greene.
Dec. 1	Seral Battie	38	Machine runner	1	4			Broken leg	Mining machine	Vandalia No. 21	Greene.
Dec. 2	R. Conrad	23	Timberman	1	1			Foot injured	Stepping on nail	Summitt	Greene.
Dec. 3	Holmer Gott	22	Driver					Broken hand	Mine car	Summitt	Greene.
Dec. 6	Albert Abbott							Wrist and two ribs broken	Falling down shaft	Black Creek	Greene.
Dec. 14	Geo. Walters		Driver	1	2			Shoulders squeezed	Mine car	Lattas Creek	Greene.
Dec. 19	Jal Cox	15	Trapper					Broken ankle	By mule	Lattas Creek	Greene.

Dec. 29	Carl Gott	24	Driver	....	....	....	....	Foot broken	Foot caught in frog	Summitt	Greene.
Dec. 10	Hugh Wampler	19	Driver	....	....	....	....	Bruised leg	Mine car	Knox	Knox.
Dec. 29	William Onions	24	Miner	....	....	....	....	Ankle and leg bruised	Falling coal	Knox	Knox.
Dec. 31	Carl Norris	32	Loader	....	....	....	....	Hand lacerated	Falling coal	Freeman	Knox.
Dec. —	George Myers	17	Pick carrier	....	....	....	....	Shoulder and back bruised	Mine car	Tecumseh	Knox.
Dec. 1	John Sargent	25	Spragger	1	1	....	....	Body bruises	Mine car	Phoenix No. 4	Sullivan.
Dec. 9	Dave Edwards	24	Driver	....	....	....	9	Hips crushed	Water box	Hocking	Sullivan.
Dec. 16	John Bick Enerhart	22	Driver	....	....	....	....	Ear cut, bruised head	Mine car	Jackson Hill No. 2	Sullivan.
Dec. 18	Ham Tony	21	Driver	....	....	....	....	Foot mashed	Falling coal	Jackson Hill No. 2	Sullivan.
Dec. 26	Claude Carter	20	Driver	....	....	....	....	Broken foot	Mine car	Rainbow	Sullivan.
Dec. 26	Parke Rusher	68	Mule tender	....	....	....	....	Fractured rib	Squeezed by mule	Rainbow	Sullivan.
Dec. 10	Joseph M. McCormick	33	Shot firer	....	....	....	....	Face and arms burned	Windy shot	Plymouth No. 1	Vigo.
Dec. 12	John Wrimmer	50	Miner	1	....	....	....	Toes broken	Falling slate	Glen Ayr	Vigo.
Dec. 28	Clarence Mann	25	Miner	1	1	....	....	Broken toe	Falling slate	Lawton	Vigo.
Dec. 29	Alex Getuck	....	Miner	....	....	....	....	Bruised back	Falling duty band	Vandalia No. 67	Vigo.
Dec. 30	James Keith	53	Cager	1	5	....	....	Muscles torn from hip	Caught between cage & mine car	Wabash	Vigo.
Dec. 5	Harry Wright	54	Day man	1	....	....	....	Body injured	Falling slate	Dering No. 8	Vermillion.
Dec. 12	W. Shorter	17	Driver	....	....	....	....	Hips and head crushed	Falling slate	Dering No. 8	Vermillion.
Dec. 24	Wade Erwin	23	Driver	....	....	....	....	Thigh broken	Mine car	Buckeye	Vermillion.

TABLE

Showing the Total Number of Fatal, Permanent, Serious and Minor Accidents and the Different Occupations of Persons Injured.

Occupation.	Fatal.	Serious.	Per-manent.	Minor.	Total.
Drivers	7	114	....	187	308
Pick miners	18	113	1	89	321
Loaders	4	39	....	36	79
Machine men	3	22	2	32	59
Car greasers	....	1	....	1	2
Timbermen	3	9	....	14	26
Trappers	....	5	....	2	7
Pumpers	....	1	....	4	5
Cagers	....	9	....	16	25
Motor men	....	2	....	6	8
Electricians	1	2	....	4	7
Road men	....	6	....	8	14
Trip riders	....	4	....	3	7
Car couplers	....	....	....	3	3
Boss drivers	....	2	....	1	3
Top men	1	6	....	11	18
Mine superintendent	....	1	....	....	1
Mine bosses	1	3	....	4	8
Fire bosses	....	2	....	2	4
Shot firers	5	5	....	4	14
Spragers	....	4	....	2	6
Jerry men	2	18	....	22	42
Flag man	....	1	....	....	1
Dumper	....	1	....	....	1
Firemen	....	1	....	....	1
Load dropper	....	2	....	....	2
Carpenter	....	1	....	....	1
Total	45	375	3	452	875

TABLE

Showing the Nationality of Persons Killed and Persons Permanently or Seriously Injured.

Nationality.	Fatal.	Per-manent.	Serious.	Total.
American	29	3	319	351
English	5	....	2	7
Scotch	1	....	8	9
Welsh	....	....	4	4
Irish	....	....	9	9
German	3	....	8	11
French	2	....	3	5
Polish	1	....	1	2
Finlander	....	....	2	2
Russian	1	....	1	2
Roumanian	....	....	1	1
Austrian	1	....	1	2
Slav	....	....	2	2
Italian	1	....	10	11
Colored	1	....	3	4
Greek	....	....	1	1
Total	45	3	375	423

LEGISLATION AND ITS EFFECT ON MINE ACCIDENTS.

In order that this subject may be treated properly, it is necessary that we discuss, at length, the conditions and practices that obtain in Indiana Coal Mines at the present time and note the many dangerous factors in connection with mining that have become prominent of late years, some of which may be partially if not wholly removed through legislation.

Also to note the several mining laws recently enacted and the effect such laws have had in the past, or may have on mine accidents in the future.

EXPLOSIVES.

Next to fire-damp, the most dangerous elements that enter the daily life of persons engaged in mining, those that have directly or indirectly been responsible for the greatest number of accidents to mine employes arise from the use or handling of explosives. Under this head we class these dangerous factors, arranged in the order of their importance, as follows:

The use of fuse in shot firing, drill bitts of too large diameter, shots tamped with coal slack or drill dust, shots drilled past the cutting or loose end, misplaced shots, overcharged shots, charging shots a second time, a number of shots fired in rapid succession, kegs of powder placed within range of the flame from shots and kegs of powder opened with coal picks.

No matter what care we exercise the element of danger is always present, at every stage, when explosives are being used or handled. Add to this, the recklessness and utter disregard for all laws of safety, either of a statutory nature or of good judgment, exhibited daily by miners when handling or using explosives and the increased dangers cannot be calculated.

The practice of firing shots with fuse we consider one of the most dangerous in connection with mining. This method of firing shots came into practice in the Clinton field somewhere about the year 1899, and at the present time practically all the shot firing in the State is done by this method.

The origin of the practice was first due to the excessive use of blasting powder, where miners had charged one or more shots so heavily they were afraid to remain in the near vicinity when the shots were exploded. Later other fields adopted the method as a matter of convenience, because of the fact that where a miner had a number of shots to fire he could light all of them before leaving his working place. In this lies the chief danger in firing shots with fuse. The greater number of accidents from this source occur in hand mines where the coal is blasted off the solid. At present shot firers are employed in nearly all of this class of mines, and in many instances miners take advantage of this fact and misplace or overcharge their shots in a manner they would not think of were they to be fired by themselves. A shot tamped on fuse leaves the shot firer no means whatever of determining the distance the shot may be drilled past the cutting or loose end nor the direction in which the hole is drilled, and as a result he may light an extremely dangerous shot which to all outward appearance is safe. Perhaps the greatest danger from this practice lies in the fact that there may be anywhere from fifty to two hundred shots ready to fire in a mine; the charges in these shots range from three to ten or more pounds of powder. At firing time they are lighted one after another in rapid succession as long as there are any shots to light, and as the fuse on which the shots are tamped is cut at as many different lengths as there are shots, the result is there may be from five to twenty-five shots exploded at the same time. Perhaps one or more of this number may be windy or blown out shots, in which event an explosion is sure to follow.

Each year records a number of deaths and serious accidents due to miners going back on delayed shots tamped on fuse. The most criminal negligence, however, is noted in the following accident.

On November 21st a miner by the name of Joseph Keen was seriously burned and otherwise injured by a blast in the Clover Leaf Mine, Sullivan County. On investigation it was learned that at firing time Keen had lighted the fuse in a charge of powder, after which he placed the charge in the drill hole and proceeded to tamp it, the shot exploding sooner than expected, nearly costing him his life.

This is probably the most suicidal practice that has yet come to our notice, and on inquiry we find it has become quite prevalent in this particular mine.

Drill Bitts and Material for Tamping.

Two factors closely related to each other that should receive the most serious consideration.

When holes drilled for the purpose of blasting are made of too large diameter there is an opportunity to place an overcharge of powder which the miner seldom fails to take advantage of. This feature, however, is of secondary importance to other dangerous conditions that follow. The chief danger lies in the fact that the charge is usually tamped so loosely that the gases generated by the powder at the moment of explosioin may, instead of breaking down the coal, slip the tamping and be thrown into the mine air and cause an explosion. For illustration we cite the Clinton field, where nine-tenths of the smoke explosions in the State occur. In this field considerable of the tamping is done with a cartridge pin or with the button on the end of a scraper instead of a tamping bar such as miners should use. The tamping formerly used (also used to a considerable extent at the present time) was composed of fine drill dust or dry coal slack made up into cartridges ranging from six to twelve inches in length, called dummies. These cartridges are pushed back against the charge loosely; in fact, it would be impossible to tamp them solid even with a heavy tamping bar, much less a cartridge pin or scraper, hence they can have but little if any, effect in confining the charge.

Inasmuch as powder will always follow the point of least resistance and the fact that the drill hole (especially if of large diameter), when tamped as above described, would afford the point of least resistance, it is only natural that even with holes of medium diameter at least a portion, frequently all, of the charge is spent in the mine air, and the dry coal slack or drill dust loosely packed in the hole, lying directly in the path the flame from the blast must travel, is distilled into carbon monoxide gas and thrown into the air, combining with that of the powder burned, forming an explosive mixture ready to be lighted by the flame from a succeeding shot of like character. If this condition results with holes of medium diameter, what may we expect of those of large diameter.

Shots drilled past the cutting or loose end and misplaced shots are each extremely dangerous factors that have been responsible for many mine accidents. The dangers arising from each of this class of shots lies in the fact that the point of the shot where the charge is located is of such thickness or strength the coal cannot be thrown out and the force of the charge finds vent only through the drill hole or by seaming, i. e., by breaking a flat or vertical crack in the coal seam, through which the force of the charge is spent in the mine air, causing a windy or blown out shot.

The dangers arising from a number of shots being fired in rapid succession and that of overcharging shots are very closely related. It is safe to say that ninety-five per cent of the shots fired in hand mines are excessively overcharged and that at least fifty per cent of the exploded powder remains in the mine air in the form of carbon monoxide gas. When the fact is considered that powder at the moment of explosion expands 1,700 times its original volume, it can easily be seen that a small amount of powder will generate a large volume of gas which, if mixed in proper proportions with air, at a high temperature, becomes dangerously explosive.

When a number of shots are fired in rapid succession two results follow, viz., large volumes of the above gas are generated from the exploded powder, and the temperature of the mine air rises rapidly. When this condition obtains and a sufficient time has not elapsed between the exploding shots for the air to cool, or the gases to become diluted beyond the exploding point, an explosion may be easily induced by the flame from a blown out shot projected into the mixture. Ordinarily there is a greater or less quantity of coal dust burned which adds to the volume of carbon monoxide, or there may be present a small per cent of marsh gas, either of which greatly increases the danger of an explosion. An explosion may be brought about, however, under the above-named conditions in the absence of one or both of these agents.

The danger arising from recharging a shot that has once been fired and that of placing kegs of powder within range of the flame from shots are fully demonstrated in the explosion that occurred January the 8th in the Oswald Mine, Gibson County. This explosion was the direct result of a recharged shot, the flame from which exploded a number of kegs of powder. This shot was drilled eight feet deep, prepared on the 7th by Harry Whitman, a practical miner of several years' experience, and was fired on the evening of the same date by the shot firers. The blast failed to bring down the coal, and on the following day Whitman recharged the shot, filling up six feet of the drill hole with powder, on which he placed twelve inches of tamping.

The same shot firers who fired the shot on the first occasion fired it again on the evening of the 8th, and the excessively large volume of flame, the only possible result that could be expected from a shot of this character, exploded a number of kegs of powder in a break-through near by; these in turn fired other kegs farther up the entry. The gases generated from the exploding kegs of powder and those from a number of shots previously fired, all combined to bring about an explosion of unusual violence, in which both shot firers were killed.

Fire Damp.

This dangerous element is present in all coal mines, though not always in sufficient quantity to enable its detection with a light nor to affect persons breathing it. The latter feature, however, does not preclude the fact that fire damp is an extremely dangerous factor even in so-called non-gaseous mines.

There are instances of record where inbursts from either roof or floor have completely filled mines with gas in which none had previously been detected. An instance of this kind occurred during the past year in the Buckeye mine, Vermillion County. This is practically a non-gaseous mine, only a small per cent of gas being found at times in the advanced workings. The pump man, on going down into the mine early one morning to look after the pumps, found a quantity of gas on one of the main entries, and on investigating it was found that the workings of the mine were almost completely filled with gas, the inflow coming from a gas-bearing strata located some distance above the coal seam, which had been uncovered by a caved-in working place.

Had this body of gas not been discovered some hours before the regular time of starting the mine, an explosion and a terrible loss of life in all probability would have resulted. There are a number of mines in Indiana where the component gases that form a fire damp mixture are constantly given off from the coal seam or contiguous strata in considerable quantity, which requires the utmost care to prevent accidents. There are also many mines where the per cent is so small as to become dangerous only at times. Perhaps a greater number of accidents occur in the latter class of mines than in the former, due to the fact that because the danger is not always present men become negligent and, notwithstanding the fact that competent fire bosses are employed to examine mines for fire damp before workmen are permitted to enter them, also other laws relating to safety of employes are generally observed, each year records one or more fatalities and a number of serious or minor accidents from fire damp. An example of carelessness may be had in the fatal accident occurring August 6th in the Vandalia No. 10 mine. The fire boss, in making his rounds of the mine in the morning, found a considerable body of firedamp in one of the working places. He marked the place, "Gas. Brush out," and proceeded with the remainder of his examination. Some two hours later the miner to whom the place belonged entered the place, set his lamp in the break-through near the face and proceeded to fan the gas out with his coat directly toward the open light, with the result that the gas ignited, burning him so badly he died some ten hours later.

Another striking example of negligence occurred at the DeForrest Mine, Warrick County, when a mine boss, Patrick Bartley, ordered a number of miners into the mine before it had been examined by the fire boss and discharged one of them for refusing to obey the order. The miners who obeyed the order were liable to punishment by fine; it became a question, however, of losing a position or paying the fine, and a number of them chose the latter. The mine boss was also liable to punishment, after he had compelled the miners to conform to his order, only to the extent of a nominal fine.

Accidents from falling slate, falling coal, mine cars and the other numerous causes incident to mining have been commented on ''generally'' in our description of fatal accidents, and no further comments are necessary at the present time.

An investigating committee, composed of Senators Goodwine, Cavins and Moss and Representatives Slimp, Johnson, Garrard and Pierson, was appointed during the Legislature of 1907 for the purpose of investigating mine explosions and other dangerous conditions existing in coal mines, with a view to recommending legislation through which the number of mine accidents occurring might be reduced.

This committee met and organized January 25th by electing Senator Cavins chairman and Representative Garrard secretary. There were present representatives of the coal operators of the State collectively, the U. M. W. of A. and the state inspector of mines. It was decided by the committee, which decision was concurred in by the several interests present, that the investigation should first take up the question of mine explosions in general without regard to any particular explosion, which investigation should include examination of expert mining engineers, chemists of acknowledged standing in their profession and the current standard literature on this subject. Proceeding under this determination, the committee called as witnesses: The State Inspector of Mines of Indiana; Professor Harry E. Barnard, Chemist of the State Board of Health; W. S. Taylor, Mine Inspector for the Third District of the State of Illinois. Also, with the assistance of Reference Librarian Clarence V. Lester, of the State Library, all the standard works on mine engineering available at the State Library and the library of the city of Indianapolis were examined, and the scientific and technical information relating to mine explosions were laid before the committee.

There was a difference of opinion concerning the causes of mine explosions held by the witnesses examined, and similar differences were found in the standard works which were accessible to the committee. There was unanimity of opinion, however, that marsh gas stands first as a source of explosions in coal mines, and that excessive use of blasting powder, smoke arising from exploding powder, coal dust, heat, rapid shot firing with fuse, drill bitts of too large diameter, drill dust or coal slack used for tamping shots, kegs of powder opened with coal picks, etc., where each dangerous factors prominent in explosions or other mine accidents.

The investigating committee recommended and were instrumental in the enactment of several much-needed new mining laws and the amendment of several laws then on the statute books. We make mention of all these new laws and amendments in our report for 1907, but must of necessity again refer to some of the more important ones enacted, to some of which we shall recommend amendments. Among the most important was the law prohibiting drilling past the cutting or loose end; prohibiting the use of more than six pounds of powder in any one shot; making the maximum size of drill bitts two and one-half inches in diameter; prohibiting the use of inflammable material for tamping; regulating the dimensions of shots; regulating the manner of lighting or firing shots; prohibiting the opening of kegs of powder with coal picks and establishing *prima facie* evidence.

The committee in its report to the Legislature makes the following statements, viz: "Your committee is of opinion that under the restriction which we have recommended be placed against the charges of powder, the diameter of the drill hole and the lighting of shots, the elements of danger from the use of shot firers are practically eliminated, and the advantages claimed for the system can be secured without imperiling either the life of the miner or the properties of the operators." A portion of another paragraph reads: "Forty per centum of the fatal accidents incident to coal mining in our State are the results of the use of powder in shooting coal. No precaution, therefore, should be omitted which will tend to reduce the sacrifice of life from this cause." It will be noticed that there are three dangerous factors mentioned in the above, viz: charges of powder, diameter of the drill hole and the lighting of shots. The closing paragraph of the committee's report, which bears a relation to the laws enacted and to "subsequent events," reads as follows:

"Your committee presents no recommendation which was not accepted by the unanimous vote, including representatives of both the miners and operators and the members of the joint committee."

The new laws took effect April 11, 1907, but cannot be said to have become operative until the latter part of May in that year, and since that time, where the laws have been observed, not a single accident has occurred from windy or blown-out shots or smoke explosion.

In every instance where a fatality or an accident of any kind has occurred from this source, flagrant violations of the law and negligence of the grossest kind have been in evidence. Added to this, our report for 1907 shows that more coal per keg of powder was mined and greater average wages earned by miners during that year than ever before in the history of the State. Notwithstanding these facts and the unanimous acceptance of the recommendations, referred to above, the miners, through W. D. Van Horn and other members of U. M. W. of A., came before the Legislature convening in extra session September 18, 1908, and asked that the law prohibiting drill bitts being made larger than two and one-half inches in diameter be repealed and that the size of the bitt be permitted to be increased to three and one-half inches. We regret to say the law was repealed by a unanimous vote of both the Senate and House of Representatives and a law enacted which permits drill bitts to be made three and one-fourth inches in diameter, thus making the area of the drill hole practically double what the committee had previously recommended as being within the bounds of safety. This change was made over the protest of this department and only at the solicitation of the members of the U. M. W. of A., who represented to the Legislature that ninety-five per centum of the miners in the State wished the change, which statement was true only in cerain localities, conspicuous among which was the Clinton field, and in that field there is not one per centum of the miners who face any of the danger of shot fire. The shot firers in this and other dangerous fields in the State are the only ones who face that danger. The operators, with few exceptions, refused to permit the drill bitts used in their mines to be made larger than two and one-half inches in diameter, and up to the present time the changes have not been sufficient to determine what effect the larger bitt may have in the increase of accidents.

PROSECUTIONS.

Notwithstanding the fact that this department made 253 prosecutions for different violations of the mining laws during the year 1907, we were compelled to make 98 prosecutions in 1908 for practically the same violations. We give herewith the occupation of the persons prosecuted, the violation for which the prosecution was made and the number prosecuted under each violation:

Mine bosses, for failure to provide break-throughs required by law....	11
Mine bosses, for failure to report accidents	1
Mine bosses, for failure to conform to inspectors of mines' orders given for repairs	3
Companies, for failure to report tonnage, etc..........................	2
Mine bosses, for failure to provide splits in air currents as required by law	3
Companies, for failure to employ fire bosses...........................	2
Mine bosses, for failure to provide places of refuge on haulage roads....	1
Top boss, for failure to keep mine gates closed........................	1
Mine bosses, for failure to provide space along haulage roads..........	11
Mine superintendent, for failure to keep approach to manway in proper condition	1
Coal companies, for failure to provide a second outlet.................	1
Miners, for drilling past the cutting or loose end.....................	50
Miners, for tamping with drill dust....................................	2
Miners, for preparing shots more than the maximum thickness provided by law	1
Miners, for opening kegs of powder with picks..........................	6
Miners, for burning machine oil in the mine............................	2
Total	98

NOTE.—One of the prosecutions made for failure to provide space on haulage roads was against the management of the Vandalia No. 10 mine, Sullivan County. We met a reverse decision in this case. The plaintiff claimed that inasmuch as the block coal field was exempt from the provisions of the statute relating to the space to be left along haulage roads the law was class legislation and unconstitutional. This contention was sustained in the lower court and the case was appealed to the Supreme Court, whose opinion has not yet been rendered.

RECOMMENDED LEGISLATION.

There are a number of mining laws that are practically impossible of enforcement that should be so amended as to produce the desired results. Prominent among this class of laws is the law relating to the number of pounds of powder that may be placed in any one charge and the law relating to the manner in which shots may be lighted.

The former law is violated daily in almost every hand mine in the State, and the latter is scarcely observed at all in mines where shot firers are employed. The present statute provides that no more than six pounds of powder may be placed in any one charge. Violations of this law cannot be prevented because of the fact that when shots are charged and tamped there is no one present except the person who does the charging and tamping, and the only evidence possible to secure where an excessive amount of powder has been used is the effect produced when the charge has been exploded. This evidence is not sufficient to convict the violator.

The statute relating to the manner in which shots may be lighted is not operative in mines where shot firers are employed because of the fact that it only applies where more than one person is engaged in firing shots on the same entry.

Accidents resulting from violations of each of these laws may be prevented, or at least reduced in number, by the enactment of a statute making it the duty of the shot firers to charge, tamp and fire all shots in coal mines where coal is shot off the solid. The benefits of a law of this character would be manifest in the fact that the temptation, if not the opportunity, to fire a large number of shots at the same time is removed. The shot firer may also measure the length of the drill hole, note the direction in which the hole is pointed and determine whether the shot has been misplaced or drilled past the cutting or loose end, thus reducing the possibility of windy or blown-out shots and smoke explosions, and inasmuch as the shot firer would be the sole judge as to the amount of powder contained in each charge, the miner will in a majority of cases be more careful in the preparation of his shots. It will also be of mutual advantage that none but experienced miners are employed as shot firers. We heartily recommend the enactment of this law.

The evils attending shot firing with fuse have been fully explained in this and in former reports, and we recommend a statute prohibiting the use of fuse in connection with blasting coal.

We recommend a statute making it unlawful to recharge a drill hole that has once been charged and fired.

Drill bitts of large diameter, as previously explained, are conducive to mine accidents, and we recommend a statute prohibiting bitts being made more than two and one-half inches in diameter. We also recommend a statute prohibiting miners from clearing out a working place of gas by the method known as brushing.

There are two means by which more complete conformance to the mining laws may be had. One is by removing the temptation to commit a violation by removing the opportunity to commit the act. In every case where it is possible this method should be adopted, but where the temptation and opportunity cannot be removed the penalty attached should be made so severe that persons inclined to commit violations cannot afford to run the risk of conviction. At present the punishment attached for violation of any of the mining laws is practically the same, and usually consists of a nominal fine, to which the court may add imprisonment. Thus, a driver who burns a lamp of machine oil is punished as severely as the mine boss who imperils the lives of employes, or the miner who, by overcharging or misplacing a shot, may cause a loss of life or lives.

There are two cases of record in the past year where justice demanded that the violators be punished by imprisonment. One of these was the case of Bartley, the mine superintendent who compelled a number of miners to go down into the mine before it had been examined by the fire boss; the other was the case of Whitman, who, over the protest of his fellow-employes and against the dictates of good judgment, placed a shot which caused the loss of two lives.

The statute should be so constructed that when certain violations occur and extreme criminal negligence is in evidence, resulting in the loss of life, the charge should be manslaughter and the violator punished accordingly.

The mines of Indiana are being sunk to coal beds lying at greater depths each year, thus increasing the avenues of danger which are attendant to deep mining, and while we may invoke the aid of science, deriving some benefits therefrom, without discipline the daily and yearly increase in the number of mine accidents can never be checked.

ACCIDENTS TO MINE PROPERTY.

The flooding of the Charles F. Keeler Coal Company's Atherton Mine, located at Atherton, Vigo County, probably represents the greatest financial loss of any one accident to mine property during the year. On the night of January 16th a large volume of water broke into this mine, coming down through a slip or fault in the roof. This slip, it is presumed, extended up to a gravel bar or sand bed lying some sixty to one hundred feet above the level of the coal seam. The fact that the mine is only one and one-half miles distant from the Wabash River, and the excessive quantity of water coming into the mine, furnishes good grounds for the supposition that the gravel or sand bar is fed from that source. All of the workings in the mine were not flooded by the first inbreak of water, and the company entertained hopes of being able to handle it with pumps and continue to operate at least the unaffected workings of the mine. The water, however, continued to gain so rapidly, despite the fact that a number of large pumps were kept running constantly day and night, that they were compelled to suspend operation early in February. An effort was then made by the company to dam off the water permanently with bulk-heads constructed of brick and cement. Eleven bulk-heads in all were required to effectually seal off the water, ten of whose respective widths ranged from seven to eleven feet and one fifty feet, built along a very thin pillar. In constructing these bulkheads evidently but little consideration was given the height of water head and the extremely heavy pressure incident thereto. The bulkheads in the narrow places were of sufficient thickness, viz., six feet of solid brick and cement, but they were built with a square face to the water pressure, having an anchorage of only twelve to twenty-four inches in a soft fire clay floor, while at the side some of the bulk-heads had no anchorage whatever and none of them more than eighteen inches, and no anchorage whatever in the roof. The fifty-foot bulkhead was fifteen inches at the roof, four and one-half feet at the bottom, with an anchorage of about two feet in the floor and none in the roof. A short time after their completion the bulkheads were inspected by Assistant O'Connor, and all of them found leaking badly, indicating a very heavy pressure, and at this time the full pressure was partially relieved by a ten-inch wooden pipe laid in one of the bulk-heads which was running full. Mr. O'Connor condemned the bulkheads and notice was served on the company that the mine would not be permitted to operate until the bulkheads had been properly constructed. Accompanying this notice we furnished specifications under which bulkheads could be constructed that in our judgment would insure the safety of employes from a mine flood.

In July the Atherton Splint Coal Co. assumed control of the property, and through the able management of their superintendent, John Shirkie, the bulkheads were reconstructed and pronounced, in our judgment, safe. The mine was cleaned up and made ready to hoist coal the latter part of December. This is a valuable mine property, and under the present management bids fair to become one of the largest producers in the county. The total estimated cost to both companies for pumping water, constructing bulkheads, cleaning up and timbering the mine is given at about fifty thousand dollars. A blue-print plan giving specifications of each of the bulkheals was filed with this department by the company.

Fauvre No. 1 Mine.—This mine suffered a small mine fire during the month of January. The fire occurred at the face of the Main North Entry, and was lighted by a shot. About one hundred ($100) dollars was expended before the fire was extinguished.

Vandalia No. 66 Mine.—The Vandalia Coal Co. expended several hundred dollars constructing dams and pumping to prevent this mine from being flooded with water from the old abandoned Hector Mine.

Massie Mine was flooded in February through a cave-in to the surface, and after the water had been pumped out the pillars were found to have started to squeeze and the general conditions of the mine were such that it was abandoned.

Ayrshire No. 3 Mine was flooded in February and was idle as a result during the months of March, April and May. Cost of removing water not learned.

Vandalia No. 65 Mine suffered a small mine fire in the interior of the mine in February, which resulted in laying idle a portion of the mine one week. The cost of extinguishing the fire was probable five hundred dollars ($500).

Brazil Block No. 1 Mine was idle twenty-three days in May by reason of water flooding the mine. Financial loss not known.

Parke No. 10 Mine.—The entire surface plant at the mine, consisting of tipple, engine and boiler-room, also dynamo and compressor-rooms, was burned the morning of May 10th. Cause of fire is unknown. Total estimated loss is twenty-seven thousand dollars ($27,000). Insurance is twenty-two thousand dollars ($22,000). The mine was so near worked out the company decided to abandon it.

Consolidated Indiana No. 33 Mine.—The coal around the bottom of the manway at this mine caught fire in June, and before it could be extinguished had made such progress that it was found necessary to brattice off the approach to the manway. Notwithstanding the fact that this left the mine with but one means of escape, viz., the main hoisting shaft, the company continued to operate while they were making a very dilatory effort to remove the water that lay between this mine and No. 32, their purpose being to use the latter as an escape or second outlet for No. 33. An investigation of the matter was made June 29 by Assistants O'Connnor and Irving, at which time the mine was closed down until the second outlet should have been provided and the mine superintendent and the mine boss prosecuted.

Consolidated Indiana No. 25 Mine.—The coal at the face of one of the working places caught fire from a shot on the evening of August 21st; little damage was done and a very small expense entailed in extinguishing the fire.

Fauvre No. 2 Mine.—The coal at the face of the Main South entry caught fire the evening of September 18th, igniting from an explosion of gas and powder smoke; a part of the mine was idle for three weeks and an expense of about three hundred dollars ($300) incurred before the fire was extinguished.

Viola Mine.—Fire broke out at the face of the first southeast cross-entry the evening of October 2d, igniting from a shot. The fire was not discovered until the following morning, by which time it had gained such headway it could be extinguished only by sealing up the top of the hoisting shaft, manway and fan shaft. The mine was reopened in eight days, and fire was found still burning but was so reduced that it could be bratticed off in the bottom, and a portion of the mine resumed work. The cost of fighting the fire was five hundred dollars ($500).

MINE DIRECTORY.

CLAY COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Brazil Block Coal Co	Brazil	Brazil No. 1.
Brazil Block Coal Co	Brazil	Brazil No. 4.
Superior Block Coal Co	Brazil	Rebstock.
Zellar-McClellan Co	Brazil	Superior No. 4.
Crawford Coal Co	Brazil	Crawford No. 2.
Crawford Coal Co	Brazil	Crawford No. 6.
Crawford Coal Co	Brazil	Crawford No. 8.
Crawford Coal Co	Brazil	Crawford No. 9.
Crawford Coal Co	Brazil	Crawford No. 10.
Indiana Block Coal Co	Saline City	No. 1.
Coal Bluff Mining Co	Terre Haute	Plymouth No. 2.
American Clay Manufacturing Co	Brazil	Monarch.
Eureka Block Coal Co	Terre Haute	Eureka No. 5.
Treager Bros	Brazil	Treager.
Harrison Coal & Mining Co	Clay City	Harrison No. 4.
Schefferman Coal Co	Brazil	Schefferman.
Hall & Zimmerman	Brazil	Wizard.
Sam Pyrah	Brazil	Pyrah.
Progressive Coal & Mining Co	Brazil	Progressive.
Big Vein Mining Co	Terre Haute	Lewis.
Vivian Colliers Co	Chicago, Ill	Vivian No. 1.
Vivian Colliers Co	Chicago, Ill	Vivian No. 2.
United Fourth Vein Coal Co	Linton	Island Valley No. 4.
O. S. Richardson Coal Co	Brazil	Gifford No. 2.
Vandalia Coal Co	Indianapolis	Vandalia No. 65.

MINE DIRECTORY—Continued.

DAVIESS COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Horney & Winterbottom	Washington	No. 3.
Mutual Mining Co	Cannelburg	Mutual.
Mandabach Bros	Washington	Mandabach
Winklepeck & Overton	Raglesville	Winklepeck.

FOUNTAIN COUNTY.

Rush Coal Co	Toledo, Ohio	Indio.

GREENE COUNTY.

United Fourth Vein Coal Co	Linton	Black Creek.
United Fourth Vein Coal Co	Linton	Dickason.
United Fourth Vein Coal Co	Linton	Sponsler.
United Fourth Vein Coal Co	Linton	Antioch.
United Fourth Vein Coal Co	Linton	North Linton.
Vandalia Coal Co	Indianapolis	Vandalia No. 2.
Vandalia Coal Co	Indianapolis	Vandalia No. 3.
Vandalia Coal Co	Indianapolis	Vandalia No. 4.
Vandalia Coal Co	Indianapolis	Vandalia No. 5.
Vandalia Coal Co	Indianapolis	Vandalia No. 6.
Vandalia Coal Co	Indianapolis	Vandalia No. 8.
Vandalia Coal Co	Indianapolis	Vandalia No. 9.
Vandalia Coal Co	Indianapolis	Vandalia No. 20.
Vandalia Coal Co	Indianapolis	Vandalia No. 21.
Indiana So. Coal Co	Chicago, Ill	Gilmour.
Summit Coal & Mining Co	Bloomfield	Summit No. 2.
Green Valley Coal Co	Jasonville	Green Valley.
Southern Indiana Coal Co	Chicago, Ill	Lattas Creek.
Queen Coal & Mining Co	Jasonville	Queen.
Calora Coal Co	Indianapolis	North West.
Coal Bluff Mining Co	Terre Haute	Twin No. 4.
Coal Bluff Mining Co	Terre Haute	Twin No. 5.
Cherry Hill Coal Co	Linton	Cherry Hill.
Letsinger Coal Co	Bloomfield	Letsinger.
Morehead Coal Co	Midland	P. & I.
Enterprise Coal Co	Linton	Lyons.

GIBSON COUNTY.

Princeton Coal & Mining Co	Princeton	Oswald.
Fort Branch Coal & Mining Co	Fort Branch	Fort Branch.
Wyoming Coal Co	Francisco	Francisco.

KNOX COUNTY.

Knox Coal Co	Bicknell	Knox.
Lynn Coal Co	Bicknell	Lynn.
Freeman Coal Co	Bicknell	Freeman.
Home Coal Co	Bicknell	Bicknell.
Washington-Wheatland Coal Co	Wheatland	Wheatland.
Tecumseh Coal & Mining Co	Bicknell	Tecumseh.

MINE DIRECTORY—Continued.

PARKE COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Brazil Block Coal Co	Brazil	Brazil No. 9.
Brazil Block Coal Co	Brazil	Brazil No. 12.
Zellar-McClellan & Co	Brazil	Superior No. 2.
Zellar-McClellan & Co	Brazil	Superior No. 3.
Zellar-McClellan & Co	Brazil	Superior No. 5.
Fairview Coal Co	Mecca	Fairview.
Otter Creek Coal Co	Chicago, Ill.	Mary No. 1.
United Coal & Mining Co	Mecca	Mecca No. 3.
Parke County Coal Co	Rosedale	Parke No. 2.
Vivian Colliers	Chicago, Ill	Lyford No. 1.
Vandalia Coal Co	Indianapolis	No. 316.
James Moore	Kingman	Moore.
W. P. Harrison	Kingman	Harrison.

PIKE COUNTY.

Ayrshire Coal Co	Oakland City	Ayrshire No. 3.
Ayrshire Coal Co	Oakland City	Ayrshire No. 4.
Ayrshire Coal Co	Oakland City	Ayrshire No. 5.
Central Indiana Coal & Mining Co	St. Louis, Mo	Muren.
S. W. Little Coal Co	Evansville	Blackburn No. 1.
S. W. Little Coal Co	Evansville	Blackburn No. 2.
S. W. Little Coal Co	Evansville	Littles.
Muncie Coal & Mining Co	Muncie	Petersburg.
Winslow Gas Coal Co	Winslow	Winslow No. 4.
Winslow Gas Coal Co	Winslow	Winslow No. 5.
J. W. Welsh	New York, N. Y	Hartwell No. 1.
J. W. Welsh	New York, N. Y	Hartwell No. 2.
J. W. Welsh	New York, N. Y	Hartwell No. 3.
Peacock Coal & Mining Co	Indianapolis	Peacock No. 2.

SULLIVAN COUNTY.

Indiana So. Coal Co	Chicago, Ill	Rainbow.
Indiana So. Coal Co	Chicago, Ill	Phoenix No. 4.
Indiana So. Coal Co	Chicago, Ill	Hocking.
Indiana So. Coal Co	Chicago, Ill	Citizens.
Sunflower Coal Co	Dugger	Sunflower.
Consolidated Indiana Coal Co	Chicago, Ill	Consolidated No. 25
Consolidated Indiana Coal Co	Chicago, Ill	Consolidated No. 26
Consolidated Indiana Coal Co	Chicago, Ill	Consolidated No. 28
Consolidated Indiana Coal Co	Chicago, Ill	Consolidated No. 30
Consolidated Indiana Coal Co	Chicago, Ill	Consolidated No 32
Consolidated Indiana Coal Co	Chicago, Ill	Consolidated No. 33
Vandalia Coal Co	Indianapolis	Vandalia No. 10.
Jackson Hill Coal & Coke Co	Terre Haute	Jackson Hill No. 2.
Jackson Hill Coal & Coke Co	Terre Haute	Jackson Hill No. 4
Gregory Coal & Mining Co	Shelburn	Keystone.
Dering Coal Co	Chicago, Ill	Dering No. 13.
Dering Coal Co	Chicago, Ill	Dering No. 14.
Southern Indiana Coal Co	Chicago, Ill	Mammoth Vein
Shirley Hill Coal Co	Indianapolis	Shirley Hill No. 1.
Shirley Hill Coal Co	Indianapolis	Shirley Hill No. 3.
Shirley Hill Coal Co	Indianapolis	Little Giant.
Shirley Hill Coal Co	Indianapolis	Clover Leaf.
Kettle Creek Coal Co	Terre Haute	Pearl.
Peabody-Alwart Coal & Mining Co	Chicago, Ill	Reliance.
Hamilton Coal Co	Linton	Hamilton.
United Fourth Vein Coal Co	Linton	Black Hawk.
Carlisle Coal & Clay Co	Carlisle	Viola.
Sullivan County Coal Co	Terre Haute	Freeman.
Hudson Coal & Mining Co	Farmersburg	Hudson.
Bellevue Coal Co	Carlisle	Bellevue.
Larsh Coal Co	Farmersburg	Larsh.

MINE DIRECTORY—Continued.

VANDERBURGH COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Diamond Coal Co	Evansville	Diamond.
D. Ingle Coal Co	Evansville	Ingleside.
Sunnyside Coal Co	Evansville	Sunnyside.
Crescent Coal Co	Evansville	Unity.
Banner Coal Co	Evansville	First Avenue.

VERMILLION COUNTY.

Dering Coal Co	Chicago, Ill	Dernig No. 5.
Dering Coal Co	Chicago, Ill	Dering No. 7.
Dering Coal Co	Chicago, Ill	Dering No. 8.
Cayuga Brick & Coal Co	Cayuga	Eureka.
Clinton Coal Co	Clinton	Crown Hill No. 1
Clinton Coal Co	Clinton	Crown Hill No. 2.
Clinton Coal Co	Clinton	Crown Hill No. 3.
Oak Hill Coal Co	Clinton	Oak Hill.
Oak Hill Coal Co	Clinton	Maple Valley.
Oak Hill Coal Co	Clinton	Buckeye No. 2.
Oak Hill Coal Co	Clinton	Klondike.

VIGO COUNTY.

Vandalia Coal Co	Indianapolis	Vandalia No. 66.
Vandalia Coal Co	Indianapolis	Vandalia No. 67.
Vandalia Coal Co	Indianapolis	Vandalia No. 69.
Vandalia Coal Co	Indianapolis	Vandalia No. 81.
Indiana Southern Coal Co	Chicago, Ill	Forrest.
Atherton Splint Coal Co	Atherton	Atherton.
Coal Bluff Mining Co	Terre Haute	Lawton.
Otter Creek Coal Co	Chicago, Ill	Mary.
Coal Bluff Mining Co	Terre Haute	Plymouth No. 1.
Coal Bluff Mining Co	Terre Haute	Victor.
Coal Bluff Mining Co	Terre Haute	Wabash.
Coal Bluff Mining Co	Terre Haute	Minshall.
Lower Vein Coal Co	Terre Haute	Lower Vein No. 1.
Miami Coal Co	Brazil	Miami No 1.
Miami Coal Co	Brazil	Miami No. 2.
Miami Coal Co	Brazil	Miami No. 3.
Miami Coal Co	Brazil	Miami No. 4.
Fauvre Coal Co	Indianapolis	Fauvre No. 1.
Fauvre Coal Co	Indianapolis	Fauvre No. 2.
Deep Vein Coal Co	Terre Haute	Deep Vein.
Vigo County Coal Co	Seeleyville	Ray No. 2.
M. D. West Coal Co	Cloverland	Chicago No. 6.
Grant Coal & Mining Co	Burnett	Grant No. 3.
Sugar Valley Coal Co	W. Terre Haute	Sugar Valley.
Dering Coal Co	Chicago, Ill	Dering No. 6.
Domestic Block Coal Co	Kokomo	Domestic Block No. 1
National Coal & Fuel Co	W. Terre Haute	National.
Glen Ayr Coal Co	Terre Haute	Glen Ayr.

WARRICK COUNTY.

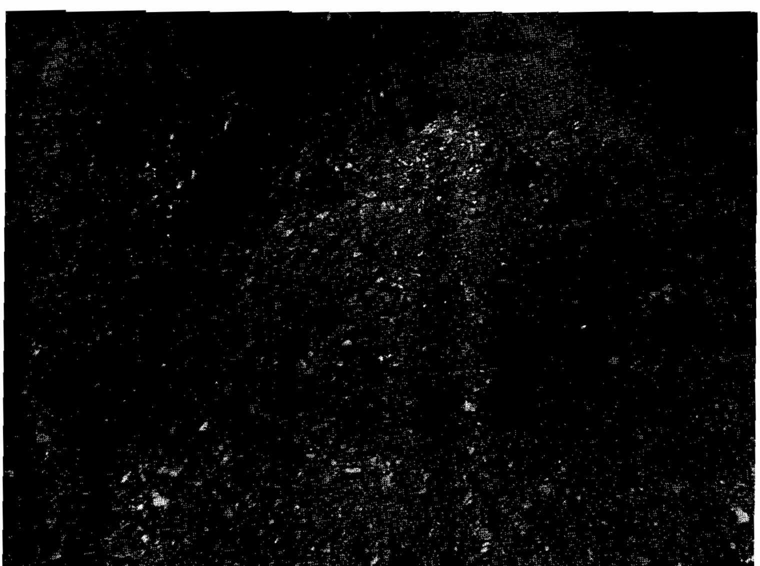
Big Four Coal Co	Boonville	Big Four.
Chandler Coal Co	Evansville	Chandler.
C. Menden Coal Co	Evansville	De Forrest.
T. D. Scales Coal Co	Boonville	Electric.
Caladonia Mining Co	Boonville	Dawson.
Erie Canal Coal Co	Boonville	Erie Canal.
Red Shaft Coal Co	Newburg	Red Shaft.
J. Woolley Coal Co	Boonville	Castle Garden
Worsham-Newburg Coal Co	Newburg	Brizius.
J. Woolley Coal Co	Boonville	Polk No. 5.
Elberfeld Oil, Gas & Mining Co	Elberfeld	Elberfeld.
Epworth Coal Co	Newburg	Epworth.

A SOIL SURVEY OF FOUR COUNTIES OF SOUTHERN INDIANA.

BY

CHAS. W. SHANNON,
L. C. SNIDER.

Showing topography and improvements in Upper Coal Measures near where the Patoka crosses the line between Dubois and Pike Counties.



Weathering and disintegration in shales and shaly sandstones of Upper Coal Measures near Duff, Dubois County.

Soil Survey of Dubois, Perry and Crawford Counties, Indiana.

By C. W. Shannon.

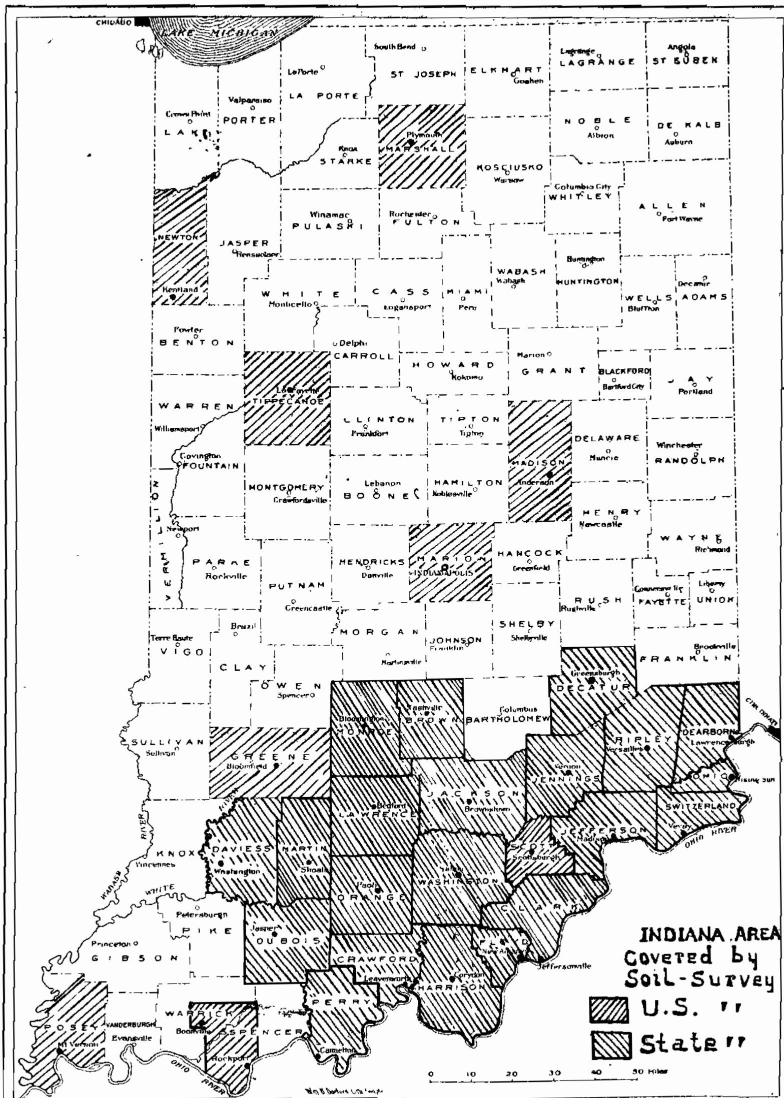
The three counties embraced in this report occupy an area in central-southern Indiana of about 1,015 square miles. These counties lie just to the west and south of the area of the former survey made by the State, and to the north and east of Warrick and Spencer Counties a part of which have been included in a soil survey made by the United States Bureau.

Taken as a unit the transportation facilities of the area are poor. Parts of the area are in good connection by rail with Louisville, Evansville and St. Louis. The southern part of Crawford and Perry have the advantage of a packet line on the Ohio, from Louisville to Evansville.

PHYSIOGRAPHY AND GEOLOGY.

The counties included in this survey lie in the driftless part of the State, with the exception of the northwestern part of Dubois, the topography and soils of which have been greatly influenced by glaciation. With one or two exceptions the same geological formations are found in each of the counties. The variety and distribution of the soils depend upon the geological formations. These formations have been described in detail in former reports, hence the descriptions embodied in this report will deal with little as to the structure and value of the formation. Some discussion, however, of the geological history, and the effects of weathering, erosion and other agencies must be given in order to understand the soil conditions. The soils have chiefly been derived from the underlying rock; and the soils of the same formation show little variation from one part of the area to another. The soil type will receive the fullest description under the county where it is best developed and occurs most extensively.

Area of Mitchell Limestone.—This formation is confined to the eastern part of Crawford County. The stone here is a fine grained, compact, hard limestone, varying in color from blue to almost white. In places it becomes somewhat coarser and contains considerable chert and other impurities, such as calcite, shaly material and a



staining of iron oxide. In the quarry at Milltown a vertical face of 100 feet is exposed. In the quarry at Marengo over 75 feet are exposed and is fairly uniform in character. In the bluffs along

Blue River are numerous outcrops which show well the texture of the stone. The sink topography is well developed. These sink-holes are basin-like or funnel shaped depressions from a few feet in depth, to more than 50 feet in depth, and ranging in diameter from a few feet to several hundred feet, with an opening at the bottom which leads to underground channels, which form the true drainage lines of the area. Where the underground channels have been abandoned by the streams they may be explored great distances, as in Wyandotte, Marengo and many smaller caves. Long narrow valley-like areas have been formed by the falling in of the roof of subterranean cavities. The topography in the main has been developed by the solution and erosion of the underground waters.

The chief values of the limestone, other than the residual soils are, for the manufacture of lime, railroad ballast, and road metal, and as the limestone ingredient in the manufacture of Portland cement.

The residual soil is primarily a stiff red clay, which soon becomes bleached to a light yellow, by exposure at the surface. Throughout the soil and especially in the subsoil, are found many fragments of chert and fossils. It is lacking in the general fertility and agricultural advantages of the limestone soils farther to the east. Great care must be taken with these soils to keep them up to the standard. Large applications of stable manure render the soil more fertile, and this is due probably to two things, by adding a large amount of humus to the soil, and by rendering available larger amounts of the potash and phosphates contained in the cherty soils. Commercial fertilizers are also used. Sugar, beech, elm, oak, walnut, chestnut, sassafras and cedar make up the principal timber growth. See Crawford County for further description of this type.

Huron Formation.—The members of the Huron Group form the surface rock over large areas in Crawford and Perry Counties, but a very limited area in Dubois, along the streams in the northeast corner and along Anderson creek in the southeast corner. A series of limestones, sandstones and shales make up the formation. In the typical formation three limestones and two sandstones are found, and the total thickness of the formation is about 100 feet. The sandstones of the formation are of fine texture and usually of a gray color except when they become red from the large amount of ferric oxide.

The limestones are very valuable as road metal. The lower limestone resembles very closely the Mitchell. Near Wickliffe in Crawford County, is an outcrop of the limestone of a dark grayish color, medium grained, and having a fair degree of hardness. Also in the vicinity of English, and along Little Blue River are outcrops of limestone of a rather impure quality. These outcrops are in regions where the roads are entirely unimproved and excellent use could be made of the material. In Perry County the stone outcrops are numerous, but at the present time no use has been made of the stone for road metal. The limestone of the Huron have also been used for burning of lime, and for bridge abutments and foundation stone. The sandstones are also used in bridge construction and for foundations, but otherwise have very little economic value.

The topography of the Huron is very rugged, and becomes more broken as the Mansfield area is approached. The drainage is both surface and underground. Springs are numerous along the outcrop, the water coming out between the stone and shales. The differences in elevation between the hills and valleys is from 100 to 250 feet. The line between the Mitchell and the Huron is somewhat sharply marked by a change in vegetation. The varied forest of the limestone soil gives place to those which are chiefly red, black and scrub oak. The uncultivated fields grow up quickly in wild daisies and sassafras. Persimmon trees are very plentiful in this area, although seldom found over the limestone.

Owing to the varied nature of the rocks from which it is derived the soil is not very uniform. Usually the surface soil is a yellowish sandy loam, underlain by a stiff white to yellow subsoil more clayey than the surface, but contains considerable sand. In many places the sandy soils are of a reddish color and are not very productive since they consist of little but quartz and ferric hydrate. The soil is only fairly productive, easily exhausted and washes badly, and most careful cultivation is required on the slopes to prevent destruction.

The Mansfield Sandstone.—The Mansfield Sandstone covers large areas in the three counties included in this report. This formation is also known as the Millstone grit and Conglomerate Sandstone and Division I of the Coal-measures. The formation varies in thickness from 50 to 150 feet. It varies in texture from a fine grained stone to a coarse pebbly conglomerate. The color is commonly yellow or brown, but is frequently found approaching a white color. In some places the massive sandstone comprises the total thickness, while in others, there are shales, coal and iron ores, at or near the base. The topography of the Mansfield is very rugged. It is a thoroughly dissected plateau. The region is characterized by having but little level land. The drainage lines are well developed. Steep hills, abrupt cliffs, and long, narrow, winding valleys are common. The streams run in deep ravines, from 100 to 300 feet in depth; the banks generally too steep for cultivation, except near the tops or bottoms, where they round out to the summit of the ridge or round outward to meet the bottom lands. As far as possible the roads follow the tops of the ridges, or run along in the valleys, and as shown on the maps are an index to the broken topography of the area. The materials of the formation have little economic value.

The soils of the Mansfield are of a light yellow color, and vary from fine sandy loams to sandy clay loams. The subsoil is of a reddish yellow color, mottled with white, and is more tenacious than the surface. The red color is due to large amounts of iron contained in the original formation. Large areas of these soils are uncultivated, being grown up with second growth timber and underbrush. Much rough stony land, unfit for cultivation is also found. The principal tree growth consists of oaks, beech, maple, walnut and mulberry.

Coal Measures.—In Crawford and to a much greater extent in Perry the coal-measures occupy the tops of the highest elevations and run in tortuous ridges a few rods in width to a mile or more across. In Dubois, however, the formation is better developed, and forms the surface rock over an area comprising about 250 square miles. The formation consists of a series of sandstone, shales, fire clays, iron ores, and thin-bedded limestones. Of these the shales predominate, and the result is that the topography is much more even than in the former area. The surface is of a rolling character, the ridges having been reduced by erosion until they are fairly low, with gentle slopes running to the streams, and are generally suited for farming. The ridges will generally vary from 50 to 100 feet above the streams, and the streams have considerable fall, hence the drainage is good.

The depth of the surface material formed by the disintegration of the underlying material is greater than in the sandstone areas to the east, and rock exposures are generally small. In the eastern part of the area where the coal measures occur as remnants of the high ridges, the ridges are flat topped and afford some good farm land.

The area here included takes in Divisions II, III and IV of the Coal Measures.

Alluvial Soils.—The alluvial soils of this area are chiefly those of the Ohio, White and Patoka rivers, and small areas along Anderson and Blue rivers. The characteristics of the alluvial soils are largely dependent upon the nature of the formations and soils found within the drainage area of the stream, and the relative proportion of the various components is dependent upon the steepness of the slope and the velocity of the current. This is true especially of all alluvial soils of this area found along the smaller streams. The Patoka Valley has been affected somewhat by glacial waters and deposition, but the surface soil is now principally washed from the uplands. The soils of the Ohio Valley have been derived from various sources, and carried considerable distance before being deposited. This has also become greatly modified by the material brought down by smaller streams and the continual wash and creep from the hills.

The Ohio, as it flows along the southern boundary of Crawford and Perry counties, has a meandering course through a rather deep and narrow valley. In fact, this is the chief characteristic of even all the smallest streams of this section of the State. The influence of the geological strata in directing the course of running is well presented by the stream. The general direction of the Ohio as it flows to its outlet is south of west, crossing the outcrop of the geological formation at nearly right angles to the line of strike. Wherever the stream has encountered a stratum of more than ordinary resistance the course of the stream is turned from the general direction and takes a northerly or southerly direction, following about the line of strike until a less resistant part is reached, or until it has acquired sufficient force to break through the rock barrier.

On reaching Perry County the river turns in a southerly direction and flows along the outcropping edges of the lower Carboniferous limestone, and with but little change until near Tobinsport it crosses the edge of the strata and makes it way in the opposite direction across the Mansfield sandstone, until near the mouth of the Deer Creek it swings again to the west and south and is hemmed on its northern side by high perpendicular walls; then, again, before Cannelton is reached, it turns to the northwest and continues in an almost straight line to Troy, where it has reached a level of about 100 feet above the Mansfield formation. Anderson Creek, Deer Creek and Blue River cross the formation in a similar way;

very few of the streams have flood plains at all commensurate with the size of the stream. The streams occupy practically the entire bottoms with the exception of meander curves, which are best developed in the Tobinsport bend.

Glacial Soils.—The glacial soils of the area are confined to the northwestern part of Dubois County and are discussed under that county.

CLIMATE.

The area of survey is not subject to severe winters or to excessive heat in the summer. The winters are mild and short. The growing season comprises about six months of the year, during which time crops are safe from damage from frost. The last killing frost in the spring usually occurs about April 10, and the first in the autumn during the last week of October. The annual normal rainfall is more than 40 inches, an amount equal for all crops if properly distributed; but usually during the early part of the spring excessive rains occur, causing the planting of crops to be very late, and then drought sets in, causing the late-maturing crop to be greatly injured, as was especially true in 1908. Such excessive variations are, however, not common, and the rainfall proves very adequate for the growing crops.

During the excessive spring rains in this region and that farther to the northeast the Ohio is made to overflow and causes large areas to be flooded, and crops are often late, but it has been found in such cases that corn planted late in June usually has time and moisture enough to mature before frost. The weather stations within the area, where accurate records are kept, are few, those of Rome and Marengo having the only available records. For comparison, the results of observation and record of other points with the southern part of the State are also given:

TEMPERATURE AND PRECIPITATION.

MONTH.	Evansville.		Marengo.		Louisville.	
	Temperature, °F.	Precipitation, Inches.	Temperature, °F.	Precipitation, Inches.	Temperature, °F.	Precipitation, Inches.
January	35.4	3.31	33	4.9	35	3.9
February	32.3	2.98	35	6.5	37	3.9
March	44.6	4.84	44	5.3	45	4.3
April	57.0	3.55	56	5.4	56	4.0
May	67.0	4.38	65	5.2	67	3.8
June	76.3	4.67	74	5.4	75	4.3
July	79.6	3.54	77	4.0	79	3.8
August	78.4	2.00	75	4.2	27	3.5
September	71.9	2.48	69	4.0	70	2.7
October	59.2	2.87	57	3.1	59	2.6
November	45.0	3.67	45	5.4	46	4.0
December	35.8	3.02	36	4.2	38	3.7
Year	56.9	41.40	56	57.6	57	44.5

Lowest temperature Marengo for period of 21 years	—28°
Lowest temperature Louisville for period of 21 years	—20°
Highest temperature Marengo for period of 21 years	106°
Highest temperature Louisville for period of 21 years	107°
Average number of rainy days for period at Marengo	97 days.
Average number of rainy days for period at Louisville	128 days.
Average depth of snow for period at Marengo	20.0 inches.
Average depth of snow for period at Louisville	14.4 inches.

The average temperature for Salem, which is farther north than any of the area of this survey, is 53.5°; amount of precipitation, 40.43.

The snows of this area are of short duration, and the ground is seldom frozen so hard but that muddy roads are found throughout the winter. The relatively high humidity of the atmosphere renders the summer heat more oppressive and the sensible temperature of the winter more severe than would the same temperature in less humid regions. The velocity of the wind is more noticeable now than formerly, and spring floods and summer droughts more marked, because of the disappearance of the forests.

DUBOIS COUNTY.

History of Settlement and Agricultural Development.

Dubois County was named in honor of Toussaint Dubois, a Frenchman of Vincennes, Indiana. He was a soldier under General Harrison and had charge of the guides and spies in the Tippecanoe campaign.

When Indiana was first organized as a Territory the land now comprising Dubois County was a part of Knox. Then in 1813, when Gibson County was organized, most of the area was included in that county. In December, 1816, by the formation of Pike County out of Gibson, Knox and Perry counties it was included in Pike and remained as a part of the county until December 20, 1817, when it was organized as a separate county. In 1818 another act affecting the county was passed and a part of it was again annexed to Perry County; and in 1820 Martin County was organized out of Daviess and Dubois counties, this reducing Dubois to about its present bounds.

It is generally believed that the county was settled in 1801, along a route that passed through the county, leading from Vincennes to Jeffersonville, and known as the "Mud hole trace," on account of the mud holes which rendered it almost impassable. It passed south of Portersville and almost parallel with the base line. Near Crystal a few years ago part of the old logs cut and used by General Harrison's men in making the road passable were dug out of the ground so that it might be cultivated.

At the first division of the county into civil townships, five were formed. The present townships are Boone, Harbison, Columbia, Hall, Marion, Bainbridge, Madison, Patoka, Cass, Jackson, Ferdinand and Jefferson. The county seat was located at Portersville, on the northern boundary of the county, on the east fork of White River. The seat of justice was not destined to long remain at this location. During the years from 1820-1830 all the towns along the streams in southern Indiana suffered much from sickness caused from the sluggish and overflow waters. Some of the towns were almost depopulated and Portersville was no exception. This unhealthy condition, together with the unfavorable situation for the central and southern part of the county, led to a change in 1829-30 in the location of the county seat, and the present site of Jasper was selected. So far as the healthy conditions were concerned they were very little improved by the change for some time.

because of the sluggish and malarial influence of the Patoka River. But other considerations were of value: the land was donated and the population was rapidly increasing in that part of the county, so that the new location proved to become a thriving center for trades and business enterprises.

Railway Facilities.—In 1869 several proposals were on foot for the construction of various railroads through the county. "The New Albany and St. Louis Air Line" made the best proposition. Elections were held over the county to determine the question of rating a tax for the new road, the company providing that the road should run within a half mile of Jasper, which proposition was approved almost unanimously by the southern part of the county. After various elections and much trouble the road was finally constructed across the southern part of the county in 1882, with Huntingburg the chief business point within the county.

In the meantime the Cincinnati, Rockport & Southwestern had been agitating the railway question, and after Bainbridge Township had granted aid amounting to more than $20,000 and a number of persons took stock amounting to $17,800, the road was built under discouraging conditions, and the first train came to Jasper on the evening of February 14, 1879.

The east and west line through the county is now known as the St. Louis Division of the Southern Railway and the north and south line as the Indianapolis & Evansville Division, a new road having been completed from Jasper to French Lick in 1907, this giving direct connection with the Monon to Indianapolis. This extension will prove a great benefit to Jasper and the surrounding parts of the county. A number of new developments have already been begun in the northeastern part of the county, and land there has advanced considerably in price.

In the early days flatboats of various dimensions were floated down the Patoka and White rivers during the spring high waters, carrying staves, hooppoles, bacon, beer, corn, flour, dried fruits and other products.

Agricultural Societies.—The first fair association in the county was organized early in the sixties, and one or two exhibitions were held, but the organization was soon disbanded because of the unsettled conditions arising from the war. An association known as the "Dubois County Agricultural Society" was organized and a fair was held in the autumn of each year for several years, but the society was finally disbanded.

The Dubois County fair grounds are southeast of Huntingburg. The fair was established in 1887, and a week's fair is held each year and is of some importance to the agricultural public.

Jasper, the county seat, has a population of 2,500. It is situated near the center of the county and owes its origin to the necessity for a more central location for the county seat than that afforded at Portersville. The ground was donated and the first court house and jail were erected by citizens free of cost to the county. In 1866 the town had a population of 507, and was incorporated in the beginning of that year. The town has several manufacturing establishments, among which are lumber yards, furniture factory, novelty works, veneer works, hub factory, ice plant, machine works, wagon works, creamery, canning factory, and two cigar factories. In the city are many fine residences, one of the largest stone churches within the State, municipal water works and electric light plant, and a parochial school known as Jasper College. There are now six passenger trains daily. The water supply is from the Patoka River.

Ferdinand is situated in the southern part of the county and has a population of 900.

The history of the town bears a close connection with the general settlement in the county, and in addition it owes an interesting part o fits history to its founder, Rev. Joseph Kindeck, who conceived the idea of establishing a town and trading center between Jasper and Troy in Perry County. The town is in the center of a good farming section, and in the early days a large amount of tobacco was raised in that section and it is yet the live tobacco market in the county. It has a foundry and machine shops, manufacturing threshing machines and engines, that gives employment to many men; brick yards, lumber yards and creamery. St. Joseph's Home for the Poor and Benedictine Sisters' Academy are situated here.

Holland, a town in the southwest part of the county, has a population of 200. It is located in a fairly fertile region and affords a good trading center.

Ireland is a site of some of the earliest settlements within the county. It was first called American city. It has a population of 320. It is situated in a very fertile area and should become the center of some industrial enterprises if transportation facilities could be secured.

Birdseye owes its origin as a trading place to the early days of the county. But its later growth is due to the construction of the Air Line. It is a good shipping place for cross-ties, hooppoles, staves and timber. It has a population of 550.

Schnellville was founded as a school location. It has a flour mill, saw mill, tobacco warehouse, furniture shops, church, school and other evidences of prosperity.

Bretzville, originally known as the "town of New Town," situated on the St. Louis Division of the Southern, is chiefly a trading center and shipping point for that section of the county.

Haysville is a little village east of Portersville and about one and a half miles south of the river.

Hillham is a little country village situated in the northeastern corner of the county.

Portersville, situated on the east fork of the White River, as above stated has the distinction of being the first county seat of Dubois County. At the foot of one of its streets, barges, flatboats and small steamers carried away the products of the surrounding country in the early days.

Crystal has a population of 50. It affords a trading place for the surrounding country, and now has a station on the new line of the Southern Railroad.

Dubois, frequently called Knox, is also situated on the new line of the Southern, and considerable improvements are being made. The old town of Dubois is about a half mile to the east.

Kyana owes its origin to the construction of the east and west line of the Southern Railroad. It was founded by the Louisville mining and manufacturing company, and bears the name of its home State and the termination of the State in which it is located. It has some new improvements, including a new church and a new school building.

Celestine, Ellsworth, St. Anthony, Maltersville, Millersport and Duff are other little villages and stores scattered over the county.

The county was originally covered with a dense growth of walnut, oak, poplar, beech, ash, gum, hickory and other hardwood trees.

The part of the county lying west of the line drawn west of Haysville running about a mile and a half west of Jasper to the Patoka is called the "garden spot" of the county.

Dubois County now has a population of about 25,000, and an estimated wealth of $10,000,000. The rapid growth is shown by noting that the population in 1830 was 1,774 and in 1875 about 5,600.

The county produces annually, according to the statistics of 1907 and 1908, 700,000 bushels of corn, an acreage of about 30 bushels per acre; wheat, 400,000 bushels, averaging from 10 to 15 bushels, and ranks tenth in the State for acreage of wheat; oats, 150,000 bushels, about 12 bushels per acre. A large acreage of timothy is raised and yields 1½ tons per acre. Clover yields about 1¼ tons of hay per acre; about 5,000 bushels of clover seed are produced. In the past two or three years a very little alfalfa has been grown with fair success. About 600 acres are annually planted in potatoes, yielding about 40 bushels per acre. In 1907 about 240 acres were planted in tomatoes, producing 26,800 bushels; in 1908 about 650 acres were planted, yielding about 68,000 bushels. In 1907 25 acres were planted in peas; in 1908 72 acres were planted. A few watermelons and cantaloupes are grown each year. In last year about 10,800 bushels of apples were raised. There are about 80,000 fruit-bearing trees in the county. The county ranks about 10th in the growing of tobacco, about 90,000 pounds being produced.

The number of live stock raised is not large, but there has been a decided increase in the number and quality in the past few years. Dairying is growing to be a leading business. There are now in the county four creameries, located at Jasper, Huntingburg, Ferdinand and Holland; another located at Otwell just across the line in Pike receives much milk from the northwestern part of Dubois County. These creameries produced during the past year about 240,000 pounds of butter, representing a business of over $70,000.

The rapid growth and developments in the county in the past few years has placed the county high among the leading counties of the State. Most of the land is owned by those who live upon it, and most of the citizens are considered well-to-do. A very large percentage of the population are Germans and represents a hard-working, progressive people. The thrift, good management and saving is shown in the economy of the farm land, the permanent improvements and general rural advantages.

There are in the county 700 miles of public roads, with about 40 miles improved. The first roads were improved in 1903. The improvement has been made with crushed stone at a cost of about $3,000 per mile. Dubois is one of the poorest counties in the State for good road material. There is no gravel, and limestone occurs only in the northeast and southeast corner, and in the bluffs of the Patoka seven miles southwest of Jasper. The earth roads through the better parts of the county are kept in good condition.

Physiography and Geology.

Three geological formations are found in Dubois County—Huron, Mansfield and Coal Measures. The rocks of the Huron formation occur only in small isolated areas along Patoka River and its tributaries in the northeast part of the county and along Anderson Creek in the southeast part. The Mansfield covers the greater part of the eastern third, and the Coal Measures about twice the area in the western part.

The topography is very broken, especially in the eastern part, where the hills rise 75 to 200 feet above the valleys, and in the southwest part also; especially in Cass Township the hills rise to considerable height but have more gentle slopes. The northwestern part of the county is comparatively level with the exception of a few hills of the preglacial formation which rise above the general level. The level area is included in Boone Township and is, as above stated, known as the "garden spot" of the county. The area is covered with alluvial and glacial material, and is discussed under the soil types of that area. The highest part of the county occurs in the vicinity of Birdseye and Ferdinand.

The principal drainage of the county is by White River along the northern part of the county, and the Patoka, crossing the county in a very meandering course from northeast to southwest, with its tributaries of Hunley and Straight Creeks from the southern part of the county. Pigeon Creek drains the southwestern corner, and the southeast corner below Birdseye is drained by Anderson River and its tributaries.

In general, the drainage conditions are fairly developed and the topography varies from high hills, narrow, winding ridges, steep bluffs with rock exposures in the east and south to level plains and rolling uplands in the northwest.

SOILS.

Dubois has a greater variety of soils than either of the other counties of this survey. There are five general types, each with various subdivisions. Three of the general types are due directly to the weathering and disintegration of the underlying formation. The alluvial types are those of the Patoka and White River bottoms. The glacial material belongs chiefly to the part of the old glacial lake in the northwest part of the county, and to the till found on the higher elevation between the White River bottom and the Patoka Lake plain. The following table shows the extent of each of the general types:

Huron	3 square miles
Mansfield	106 square miles
Coal measures	230 square miles
Alluvial	32 square miles
Glacial	54 square miles

1. Huron.

The Huron formation within the county is very limited. It consists chiefly of stone outcrops, steep bluffs and slopes leading down to the stream. It has very little value so far as the soils are concerned, but it affords the only limestone supply in the county. The places of occurrence are given under the general description of the Huron formation.

2. Mansfield Sandstone.

The soils of the Mansfield sandstone comprise the second largest area within the county. It makes up practically all the northeast corner, and extends in a strip about two miles wide entirely along the eastern side of the county. It also occurs rather extensively along the streams of the east central part of the county. In general, the topography is very rough, and the agricultural conditions are not the best.

The surface is a yellow, sandy loam from 6 to 18 inches in depth. The subsoil is of a similar color and with depth becomes more clayey and mottled with white and rusty brown.

The soils are not very productive. The improvements grade from poor to fair. Because of the shallowness of the soil corn is often injured by the dry weather, but on the average produces about 25 bushels per acre. Fertilizers are not very extensively used. Much of the land has become worn out by continued cropping. The soils wash badly on the slopes, and much land has been practically destroyed from improper cultivation. Much of the area has a dense second growth of timber, but it is being rapidly removed.

Some noted improvements are being made in the northeast part of the county since the coming of new railroads, and the soil will no doubt be looked upon with more favor than in the past. Land now sells at $5 to $25 per acre. Very little fruit is grown, but the soils are well adapted to this industry and such would prove paying since transportation facilities are provided. There are three or four little stations along the railroad in this area.

The soil conditions are more fully described under Crawford County. The following table shows the result of mechanical analysis of the soil:

MECHANICAL ANALYSIS OF MANSFIELD SANDSTONE, RESIDUAL SOILS.

Number.	LOCALITY.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
24	Near Crystal	Surface	.0	.3	.5	1.5	10.5	88—
		Subsoil	1.5	.2	.5	2.0	6.4	89.5
24a	Near county line east of Jasper	Surface	3.5	1.5	1.0	2.0	7.0	85.0
		Subsoil	6.4	1.0	1.4	2.5	5.0	84+

No. 24 is the same as that from which the chemical analysis is made, and is a typical sample for most of the area.

CHEMICAL ANALYSIS OF MANSFIELD SANDSTONE SOIL.

Laboratory No	24
Reaction to Litmus	acid
Moisture at 105°C	1.77
Total soil nitrogen	.089

ANALYSIS OF FINE EARTH DRIED AT 105°C.

Volatile and organic matter	3 563
Insoluble in (1.115 sp. gr.) HCl	88.011
Soluble silica	.033
Ferric oxide (FE_2O_2)	4.072
Alumina (AI_2O_3)	2.859
Phosphoric acid anhydride (P_2O_5)	.146
Calcium oxide (CaO)	.573
Magnesium oxide (MgO)	.517
Sulphuric acid, anhyride (SO_3)	.155
Potassium oxide (K_2O)	.327
Sodium oxide (Na_2O)	.340
Total	100.496

3. COAL MEASURES.

The Coal Measures occupy the largest area within the county. The area here is the best developed and largest of any over which the survey has been extended. In the east part the topography is very rugged, the hills rising to great height above the stream levels; in the part south of the Patoka River and west of Huntingburg the hills are not so high and have gentle slopes and soils have greater depth. This part of the area has evidently been influenced by glacial material. "As the ice melted and the glaciers began to recede, it is believed that a part of the material which later formed the soils of the area was released and carried still farther south and deposited on broad flats by streams, then issuing from the glacial front. It was later picked up by the winds and generally redeposited in the form of loam over the surface of the uplands, covering all older geological formations." The underlying formation has, however, much to do with the character of the

In the Patoka Valley near the town of Dubois.

Topography in Coal Measures, between Straight and Hunley Creeks. Large areas of this soil are devoted to wheat growing. To prevent washing is of importance.

soils. There is no great difference in the soils of this region and those derived from the Coal Measures outside of glacial influence. This particular region in the southwest corner of the county is fairly fertile, and, becoming of more even topography, demands higher prices than that of the eastern part. The farms sell at prices ranging from $35 to $60 per acre. The crop productions are good and the facilities for reaching the market are fair.

In general the soil is a light sandy clay loam averaging from 8 to 10 inches in depth and varying in color from a light gray to brownish yellow. The new soils are usually high in organic matter.

The improvements are fair throughout the area. Great care is necessary to keep the soils in highly productive state, and a rotation of crops is very essential in order to secure the best results. The soils wash very badly and large areas of the subsoil are exposed along the slopes.

The soils are adapted to all the ordinary farm products. Wheat, oats, and rye give good yields and large areas are planted. Clover and timothy yield about one and one-fourth tons per acre. Fruit is successfully grown, but so far but little attention has been given to the industry. Tobacco is also grown and produces well. Very little truck farming has been attempted, but there is opportunity for good developments along this line.

The following table shows the results of mechanical analysis of the soils:

Number.	LOCALITY.	Description	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
19	Southwest Huntingburg....	Surface...........	.2	.2	.4	1.5	5.0	93+
19a	Southwest Huntingburg....	Subsoil...........	.0	.4	.2	.5	6.5	94.2
23	Near Calumet.............	Surface...........	.0	.5	.0	5.5	8.0	86.0
23a	Near Calumet.............	Subsoil...........	.5	.4	1.2	3.0	5.0	89+

CHEMICAL ANALYSIS OF SURFACE COAL MEASURE.

Laboratory No.	23
Reaction to Litmus	acid
Moisture at 105° C.	1.39
Total soil nitrogen	.096

ANALYSIS OF FINE EARTH DRIED AT 105°C.

Volatile and organic matter	3.366
Insoluble in HCl (1.115 sp. gr.)	90.048
Soluble silica	.043
Ferric oxide (FE_2O_3)	2.490
Alumina (AL_2O_3)	2.877
Phosphoric acid anhydride (P_2O_5)	.120
Calcium oxide (CaO)	.418
Magnesium oxide (MgO)	.576
Sulphuric acid anhydride (SO_3)	.035
Potassium oxide (K_2O)	.219
Sodium oxide (Na_2O)	.311
Total	100.503

GLACIAL SOILS.

The glacial soils of Dubois County are those of the northwestern part and may be divided into four types—those of the Patoka Lake plain, the loess-covered areas lying just above the lake basin, the area of till in the northwest corner, and the sand areas, best developed in the region of Portersville.

Patoka Lake Plain.—When the ice sheets moved southward or southeastward, they pushed across the lower courses of many of the streams, damming them, and the ice remained at about the same point until the bodies of water thus made were silted up full. In many cases the streams thus dammed were of considerable size, as the Patoka River above Jasper, and the body of water thus formed was of great size, including many square miles. In many places the higher portion of the preglacial topography project above the level deposits. Examples of such are the uplands just north and west of Jasper and Cooper Hill in the northwest, an irregular ridge rising 60 feet or more above the surrounding levels. Many other small examples occur.

"The line making the eastern and southern limits of this level area, which will be called the Patoka Lake plain, with two embayments of Upper Patoka plain on the east and Middle Patoka or Straight and Hunley Creek plain on the southeast, leaves the present valley of White River in Sec. 27, T. 1 N., R. 5 W., and passes south through Sec. 35, T. 1 N., R. 5 W.; thence south through Secs. 2, 12 and the northeast corner of Sec. 13, T. 1 S., R. 5 W.; thence south across Sec. 18 and into Sec. 19 to the present bottom of the Patoka River. From this point the Patoka River marks the boundary as far south as Frog Island, where the line turns northwest through Sec. 25, crossing the southwest corner of Sec. 24, thence north across Sec. 23 and crossing the southwest corner of Sec. 14, leaving this section at the center of the west side, here turning west and south across Secs. 13, 21 and 28, and thence south and east through Secs. 34 and 35, T. 1 S., R. 5 W., to Patoka River at Jasper. From this point the Patoka River becomes the boundary as far west as Sec. 10, T. 2 S., R. 5 W., where the line turns north and west across the section and Sec. 4, thence west, south of the northern boundary of Secs. 5 and 6, T. 2 S., R. 5 W., where it again strikes the Patoka River, following it to the mouth of Flat Creek, where it turns north along this stream to the Pike County line.

"Upper Patoka plain includes Secs. 11 to 14, inclusive, T. 1 S.,

R. 5 W., and part of Secs. 24 and 25, T. 1 S., R. 5 W., and the southwest corner of Sec. 18 and the northwest part of Sec. 19, T. 1 S., R. 4 W. Straight and Hunley Creek plain includes Secs. 32 and 33 and part of 24, T. 1 S., R. 5 W., and Sec. 3 and part of Secs. 2, 11, 10, 4 and 5, T. 2 S., R. 4 W. The rest of Patoka Lake plain in this county comprises the east half of T. 1 S., R. 6 W., and part of T. 1 S., R. 5 W., T. 1 N., R. 5 W., and T. 1 N., R. 6 W. See accompanying map.

"The names Upper and Middle Patoka are suggested by Mr. Frank Leverett as designating the preglacial drainage of the Patoka. It is evident that in preglacial times the part of the drainage basin above the gorge near Jasper drained northwest across Upper Patoka plain to White River. The name Upper Patoka River is given to the stream draining the area at that time. West of this basin, and between the gorges near Jasper and near Velpen, Pike County, was another drainage basin known as the basin of the Middle Patoka River of preglacial times. Straight and Hunley creeks are part of the Middle Patoka River drainage. According to Mr. Leverett, the main stream flowed northwest to White River, passing close to Otwell. Most of the Patoka basin in Pike County belongs to what Mr. Leverett calls the Lower Patoka basin, which drained northwest into White River in western Pike or eastern Gibson County. The outlet of the Patoka Lake during glacial times appears to have been the low ground near Francisco, in Gibson County, where the old Wabash and Erie Canal crossed the divide between the Ohio and Patoka rivers.

"The drift and alluvial deposits of these plains vary in thickness from a few feet to 26 feet plus, it being impossible to get the maximum thickness, as the wells of this territory are all driven, going down to only the water-bearing strata which lies above the country rock.

"As stated above, it is quite probable that during the preglacial times the Patoka River turned northwest above Frog Island and flowed through what is now known as Buffalo Pond to the headwaters of Mill Creek, and followed down the present valley of Mill Creek and discharged near the present mouth of that stream, and that Hunley Creek and Straight Creek followed northwest along what has been described as Straight and Hunley creek plain, and then probably turned west and northwest across Patoka Lake basin, past Otwell, to the present valley of Beech Creek. This change in the location of these streams was doubtless brought about by the advancement of the ice sheet during the latter (?) part of the glacial period, when the ice probably pushed as far south as Portersville and the uplands of Secs. 25, 26, 35 and 36, T. 1 N., R. 6 W., damming the streams and forming Patoka Lake. During this period, and previous to the recession of the ice sheet, the drift and alluvial sands and clay were deposited over this part of the country.

"Also during this period, and probably when Patoka Lake reached its greatest extension, the Patoka River broke across the narrow divide one mile north of Jasper, flowing southwest and entering Straight Creek valley south of town. The preglacial gorge through this divide is very narrow, with rather steep and abrupt banks."*

The present soils consist of a modified so-called "loess," containing large percentage of silt, sand and rarely fine gravel. The soil to a depth of 8 to 12 inches is a light brown, loose, loamy soil, but becomes a lighter color and is more tenacious with depth. The subsoil is often mottled with a brown stain of iron oxide.

The soils were formerly very wet, but much tile drainage has been done and practically the whole area is under cultivation. The area is one of great agricultural value. The greater part is considered good for general farming purposes. Farms sell at $75 to $100 per acre. Some very large farms are found within this area. The improvements are all first class and all the most modern methods of farming are used. The soils are well kept up by crop rotation, manuring and the extensive use of commercial fertilizer.

Usually wheat is more extensively grown than any other crop. It produces an excellent growth and yields from 10 to 30 bushels per acre. Corn grows well and produces 30 to 75 bushels per acre. Oats grow but do not give abundant yields. Rye, clover, timothy make good growth and large acreages are raised. Fruit growing is carried on in a very limited way. A number of good stock is raised. Dairying is engaged in and the milk supply sold to creameries in Jasper and Otwell.

The area stands out in sharp contrast to that of the east and promises to hold high rank in crop production and farm improvements in southern Indiana.

The uplands just above the basin level are covered with a soil very similar except that it is of rich brown color, due to the unbleached condition. The mechanical analysis shows practically the same result, and chemical analyses are not greatly different. Its topographic position and productiveness give it great value. The area is rather limited compared with the former.

*J. A. Price, 23d Annual Report of State Geologist, pp. 1099–1102.

MECHANICAL ANALYSIS OF PATOKA LAKE PLAIN SOILS.

Number.	LOCALITY.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
26	Two miles northwest Ireland	White soil........	.0	1.0	.0	3.0	15.0	81.0
25	One-half mile.............	Brown soil........	.0	1.5	.1	2.5	12.0	83+

CHEMICAL ANALYSIS OF BROWN SOIL, PATOKA LAKE PLAIN.

Laboratory No.	25
Reaction to Litmus	acid
Moisture at 105°C	1.51
Total soil nitrogen	.103

ANALYSIS OF FINE EARTH DRIED AT 105°C.

Volatile and organic matter	3.451
Insoluble in (1.115 sp. gr.) HCl	89.299
Soluble silica	.013
Ferric oxide (FE_2O_3)	2.691
Alumina (AL_2O_3)	3.111
Phosphoric acid anhydride (P_2O_5)	.178
Calcium oxide (CaO)	.358
Magnesium oxide (MgO)	.525
Sulphuric acid anhydride (SO_3)	.045
Potassium oxide (K_2O)	.331
Sodium oxide (Na_2O)	.409
Total	100.411

CHEMICAL ANALYSIS OF WHITE SOIL, PATOKA LAKE PLAIN.

Laboratory No.	26
Reaction to Litmus	acid
Moisture at 105°C	1.33
Total soil nitrogen	.089

ANALYSIS OF FINE EARTH DRIED AT 105°C.

Volatile and organic matter	2.819
Insoluble in (1.115 sp. gr.) HCl	91.961
Soluble silica	.083
Ferric oxide (FE_2O_3)	1.415
Alumina (AL_2O_3)	2.447
Phosphoric acid anhydride (P_2O_5)	.093
Calcium oxide (CaO)	.508
Magnesium oxide (MgO)	.440
Sulphuric acid anhydride (SO_3)	.052
Potassium oxide (K_2O)	.213
Sodium oxide (Na_2O)	.305
Total	100.336

Till.—In the extreme northwest corner of the county, lying between the White River valley and the margin of Patoka Lake Plain basin, is an area of several square miles in which the soil is of great thickness, and shows in its contents the result of glaciation. This is glacial till from the Illinoian ice sheet. It is composed of more or less sandy clay, in which are imbedded rock fragments foreign to the region. The soft sandstone and shale underlying the till probably furnish the larger part of the material although but few fragments occur throughout the area of the soil. The texture of the finer portions of the till varies greatly, probably depending upon the nature of the rock from which it is chiefly derived. When shales appear to have furnished the layer portion of the material the clay contents are high and of a bluish-gray color. Where sandstones have predominated the soil is sandy and varies from buff to red in color. The soil seems to have been but little influenced by limestones. The actual thickness of the till is uncertain, but it may be said to vary from a few feet to 50 feet or more. As the eastern edge of the sheet is reached the till thins out very rapidly and the native rocks begin to outcreep and the till diminishes to a relatively thin sheet covering the local material. It is difficult to ascertain when the till leaves off and the residual soils begin. In the broader areas of the till great fertility is maintained and some well-improved farms occur. In the thin areas there is no marked difference in the productions between the till and residual soils.

Sand Areas.—At Portersville and extending toward Haysville are areas of sand which were very probably deposited with the tills along the ice margin. The sand area is not of sufficient extent to be of agricultural value. Hauling is very difficult throughout the area because of the loose, sandy condition of the roads.

Corn, wheat, tobacco and vegetables are the principal things grown on the till and sand areas. The tree growth includes sugar, walnut, wild cherry, oaks, pawpaw, etc.

5. Alluvial Soils.

The alluvial soils of the Dubois County are those along White River valley and Patoka, with very limited areas along some of the smaller streams.

The soils of White River valley comprise an area from 6 to 8 square miles. It is a sandy loam, containing varying amounts of clay. It grades from a light yellow to dark color. The organic content is usually high. The drainage is good although the area is very level. The land is affected by high waters only during the most excessive flood period. All crops are successfully grown but mot attention is given to corn, clover and timothy. Wheat yields well when the winter and spring rains are most excessive. The grasses make very heavy yields. There are very few buildings located in the bottom, but are mostly on the edge of the uplands. Most of the farms consist partly of bottom and partly of uplands. A considerable number of cattle and hogs are raised.

Along the Patoka the soils are known as the "flats." In some places the area becomes of great width while in others, as in the western side of the county, the streams flow in a very narrow channel. The soils are whitish in color, and are cold, being saturated with water in the winter and spring months and parched by drought in the summer.

Although portions of the soils have been under cultivation for many years, large areas still remain forested, the most common timber being elm, red maple, gum and water beech, but where the sand content is high, beech, sugar maple, oaks and tulip poplars are found. Within the past few years extensive areas have been reclaimed by drainage. Corn grows fairly well; some wheat is grown in the upper part of the valley in the northeast part of the county. In some places the bottoms are chiefly sloughs and bayous, grown up with cattails, water-lilies, willows and brush. The construction of the new line of the Southern Railroad has ponded large areas north of Jasper.

Drainage and cultivation to restore the organic matter to the soil would make these soils fairly productive. Drainage would be somewhat difficult, because of the low-lying condition of the soils. The Patoka is a very sluggish stream. The slight fall and meandering course produces much ponding in the wet season. The land can be bought at a low price and there is considerable salable timber on large tracts. It makes good pasture land when cleared, some cattle and sheep being raised. Cultivation is chiefly by old methods because of the wet soil and the newly cleared areas being practically covered with stumps.

PERRY COUNTY.

Perry County was organized in 1814 and named in honor of Commodore O. H. Perry. The county contains 383 square miles. The civil townships are Troy, Deer Creek, Anderson, Clark, Tobin, Union, Oil and Leopold. The population in 1830 was 3,378; in 1840, 4,655; in 1850 about 8,000 and at the present time about 18,800.

The principal towns are Cannelton, Tell City, Troy, Derby, Oriole, Dexter, Leopold, Rome and Rono.

Cannelton, the county seat, is located in the southern part of the county on the Ohio River. The town was laid out by the Cannel Coal Company about 1840. The principal part of the town lies above the ordinary high water mark, and extends back to the hill line. The town grew quite rapidly and the improvements were of a substantial nature.

The town has a population of 2,500. A branch of the St. Louis Division of the Southern Railway is extended to this part from Lincoln City; there are six passenger trains daily. The principal industries which give employment are the cotton mills, flouring mills, foundry and machine shops, pottery, bottling works, hub factory and lumber yards. About 400 people are employed, about half of whom are women, principally in the cotton mills. While the recent growth has been slow, the location offers inducements for many business enterprises.

Tell City is located on the Ohio two miles north of Cannelton. It has a population of 4,200. The site was purchased in 1858 by the Swiss Colonization Society, a colony of generous men who were attracted to the locality on account of coal, for cheap fuel, and the forests of good salable timber found in the region. Good improvements were made from the first and many manufacturing establishments have been established. Some of them are: four furniture factories, washing machine, hub, spoke, heading, hame, canning and chair factories; flour, woolen and planing mills, foundry and machine works, brick plant, two distilleries and a brewery. There are various establishments, giving employment to about 1,000 persons, about 100 of whom are women. The pay roll amounts to about $9,000 a week. The city is supplied with good electric light and water plants with about nine miles of mains. Driven wells are source of supply. There is a good sewer system emptying into the Ohio River. School facilities are good.

About four miles down the Ohio River is located the town of Troy with a population of 1,850. The town was settled by a company of English capitalists for the purpose of building extensive potteries, supposing that the clay found with the coal of this region would make the ordinary white queensware, but after extensive preparations were made it was found that such ware could not be made of the clay and the pottery was finally abandoned. Subsequent potteries have done a fair business by making "yellow" or "Troy" ware. The present industries include timber yards and planing mills, tobacco and chair factories.

Rome is located in Tobin Township, on the eastern side, with a population of 250, having decreased rapidly since the removal of the county seat to Cannelton.

The location of the county seat has been changed twice since the organization of the county. It was first located at Troy, and was afterwards removed to Rome and finally to Cannelton, where it no doubt will remain.

Rono and Derby are other small towns on the Ohio below Rome. Oriole, Dexter, Leopold and Siberia are other small country villages.

Perry County was somewhat backward in its early development, but since the extension of the Southern Railway to the towns along the river rapid progress has been made. The Ohio also affords the means of transportation and the L. & St. L. Railroad skirts the river on the Kentucky side, affording direct connection with Louisville. With the exception of the Ohio valley, the greater portion of Perry County is very broken and rather uninviting for agricultural purposes. The rural communities were tilled principally by an industrious class of Germans and French, who, by careful tillage, obtained fair productions of the various crops. Some large orchards were planted early and produced well, and the trees have shown that the soil is of such nature that a long period of fruitfulness may be maintained. Grapes were also grown somewhat extensively and yield well on the slopes.

In the valley of Tobin Township considerable truck farming was carried on at so early a period as the settlement of the county. Statistics show that in 1875 so high as 250 bushels of potatoes were grown to the acre near Rome. A large acreage of cabbage was also grown, and the crop sent to the market by way of the Ohio. Tobacco culture also received some attention both in the bottoms and uplands, but the production of this crop afterwards declined.

The farm area of the county is about 217,316 acres, of which

108,359 acres are improved. Some workable coals of value also occur.

The county now produces about 460,000 bushels of corn, an average of about 25 bushels per acre; 260,000 bushels of wheat, an average of 10 bushels per acre; oats about 20,000 bushels, averaging less than 10 bushels per acre. About 4,000 acres of timothy are grown, yielding about one and a half tons per acre; alfalfa is receiving some attention and 157 tons were grown in 1908. From three to four thousand acres of clover are grown, yielding about one and a half tons per acre, and producing about 1,000 bushels of seed. From 200 to 300 acres of potatoes are planted, with an average yield of about 50 bushels per acre; about 20 acres are devoted to tomatoes, yielding from 60 to 180 bushels per acre. About 300 acres of peas are grown annually, and ten acres of melons. There are in the county approximately 75,000 bearing fruit trees. The raising of live stock has not been a leading industry, but more attention is now being given to this, and especially in the valley farms some good breeds of stock are being produced. The farm lands and improvements are valued at more than $1,400,000. Land sells from $10 to $75 per acre.

There are in the county 800 miles of public road, and the county is well supplied with road material, both stone and gravel, but improvements have just begun. The earth roads are, however, well graded and drained and some excellent roads are found through the better parts of the county.

The extensive forests which formerly covered the county—only a small part of which now remains—consisted of walnut, oak, ash, poplar, wild cherry, sycamore, hickory, elm, hackberry, sassafras, persimmon and buckeye.

Physiography and Geology.

In general the surface of Perry County is very broken, and the hills rising from 250 to 400 feet above the valleys and bluffs of great height and with perpendicular sides are numerous. The only level country is found in the extreme bottom. In places, as in the Tobinsport bend of the Ohio River, the bottom is broad and becomes so extensive as to cover almost the entire bend, and affords some of the best farming land in the State.

The rocks of three geological formations form the surface rock—the Coal Measures, the Mansfield sandstone and the Huron formation. The rocks of the latter cover the eastern half of the county and outcrop in a number of places along the stream in the western part. The Coal Measure and Mansfield comprise about equal areas in the western half.

The Ohio River forms the boundary of the county for a distance of about 50 miles. Anderson River forms the boundary of much of the western side; its main tributaries are Hurricane, Middle Fork and Brushy creeks. In the central eastern part of the county are Windy, Deer and Little creeks flowing to the south; Poison, Little Poison and Oil creeks flow in an eastern direction. Little Blue River just touches the northeastern corner.

Some of the most picturesque and rugged scenery within the State occurs in Perry County. Perpendicular rock walls, solution cavities, rock houses, deep wooded ravines and the beautiful Ohio and its dotted valley, viewed from the uplands, speaks for the scenery of the county.

SOILS.

The soils of the area are divided naturally into two general groups—upland and bottom land. The two classes are also chiefly divisions as to the origin. Four general types are found with various subtypes. Three of these owe their origin directly to the underlying formations—Huron, Mansfield and Coal Measures—and the fourth, the Alluvial, is of glacial, transported and local origin, thus producing a marked variation in different parts.

The following table shows the extent of each of the general types:

Huron	185 square miles
Mansfield	85 square miles
Coal measure	90 square miles
Alluvial	23 square miles

1. Huron.

The residual soils of the Huron formation are the most extensive of any type within the county, covering about half the area. The greater part of the area is very rough, but the flat tops of the ridges afford some good tillable land and the slopes are well adapted to grasses and fruits. In general, the soil is a sandy clay loam, grading from light yellow to dark brown color. In some places the soil becomes high in silt and contains very little sand, even of the fine grades. In texture the soil grades from the "yellow clay," as it is called, to that of a more loamy texture. The yellow color disappears somewhat from alluvial surfaces and becomes a light gray. The deeper yellow color usually occurs on the slopes when the surface is frequently washed away.

The addition of organic matter causes a darker color, and the most fertile tracts are readily selected by the soil coloration. The subsoil usually contains more clay than the surface, except when the soil has been derived from the sandstone alone, in which case the subsoil contains a large percentage of sand and numerous fragments of broken sandstone. A mottled appearance is very common, due to the mixture of material of the various members of the Huron group; the brownish color is due to the presence of iron, and often at considerable depth the subsoil becomes a dark reddish yellow from the high iron content. In the areas of the limestone members, also, the soil becomes a stiff dark red. The many differences in depth of soil. texture and color are due chiefly to topographic conditions. Along the small streams where the soils are composed of wash from the uplands they contain a large amount of broken rock fragments and are designated as "rough, stony land," and in many places scarcely admit of cultivation. Aside from these stony areas some good, rich, loamy soils of small area occur along the streams.

There is a marked deficiency of organic matter in the virgin soils. Corn, wheat, oats, clover and timothy are the leading crops grown. Corn produces on the average from 25 to 40 bushels; wheat, 10 to 12 bushels; oats are short and yield but little; clover and timothy grow very well and yield about one and a half tons per acre.

Rotation of crops and green manuring are beginning to receive much attention. A large amount of commercial fertilizers is also used. Tobacco is grown to some extent and makes a good growth. Potatoes are also grown with good yields. Sugarcane is grown in very small patches and produces a good stalk growth. Some fruit is grown for home use, but present transportation facilities are not favorable for the development of the fruit growing industry.

The rougher parts of the area are better adapted to fruit growing and dairying than to general farming. There is a great deal of land once cultivated now abandoned and a dense growth of shrubbery finds a place. On the steep slopes cultivated soils wash badly, and such places can never be restored to their natural fertility. Great care should be manifested in the care of the virgin soils in order to prevent washing and depletion.

The following table shows the result of mechanical analysis of these soils:

Number.	LOCALITY.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
17	Northeast corner county....	Surface..........	.3	1.5	1.0	2.5	3.5	91.2
		Subsoil..........	.5	.5	.9	1.5	2.5	94.0
18	Near Rome...............	Surface..........	.5	2.0	1.5	2.0	3.5	86.0
		Subsoil..........	2.0	2.5	1.5	2.5	1.5	90.0

2. Mansfield.

The soils of the Mansfield comprise an area of long, narrow, winding ridges and steep slopes, the largest area occurring near the central part of the northern edge of the county. The surface is quite rugged, the hills running from 150 to 300 feet above the surrounding country. High sandstone outcrops are numerous, and in many places the abrupt cliffs have broken up into "rock houses," adding to the picturesque scenery. Along Deer Creek and to the east the sandstone is full of quartz pebbles. At other places throughout the county the sandstone is uniform, massive, medium-grained, and of great thickness. In the central and western part this area is known as "German Ridge." It is occupied by a class of Germans who, having acquired the land at a very low cost, have been able by their energy and thrift to derive good returns from the land. From the general appearance of the topography the area is not inviting to the farmer, and it is true that the soils are not very productive.

The surface soil is chiefly a yellow sand and clay loam from one to two feet in depth. The subsoil is in places very tenacious. Most of the large timber has been removed, but there is an extensive second growth consisting chiefly of oaks. The natural drainage is fair, and little of the land suffers from being too wet, but corn when late is often injured by the dry weather. Corn averages about 25 bushels per acre. Large amounts of fertilizers are used, and it has been found that the fertilizer suited best for the area is not the best for the Huron area below. Some fruits are grown. There are no large farms, but the land cleared for cultivation is well cared for and the fertility maintained. The improvements are fair. Most of the farms are owned by the persons living upon them.

The region is well adapted to fruit growing; the rough parts of the area along the slopes and streams might be used for pasture with good profits. Very few stock are raised except for the farm use.

Tobacco field on Upper Huron soil, north of Millston Creek, Tobin Township, Perry County. "German Ridge" of the Mansfield soil shown in background.

Tobacco field on Huron soil, just above the river bottoms, Section 34, northeast of Tobinsport.

The fertilizer most commonly used contains from 2 to 4 per cent of potash and about 8 per cent phosphoric acid. About 150 pounds per acre are applied for the general crops. The use of commercial fertilizers is rapidly increasing. Very little attention has been given to crop rotation.

The following table shows the result of mechanical analysis:

MECHANICAL ANALYSIS OF MANSFIELD SOIL.

Number.	LOCALITY.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
15	Near Siberia	Surface	.0	.5	.0	.8	1.5	97.2
		Subsoil	.4	.5	.3	1.5	.5	96.8
16	Three miles northeast Troy	Surface	.5	1.5	.2	1.0	5.8	91.0
		Subsoil	2.2	1.6	.5	2.0	2.5	91—

3. Coal Measures.

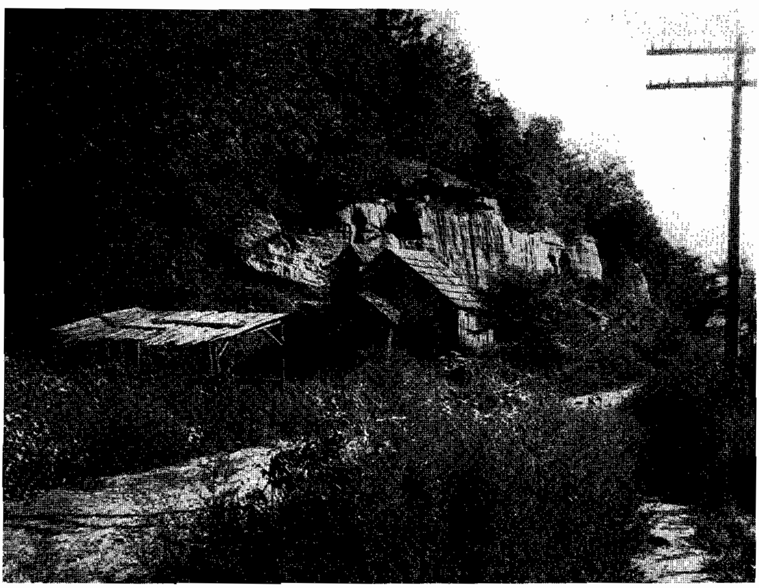
In Perry County the principal part of the Coal Measure formation consists of rather massive sandstone, with the bedded shales and limestone. A large part of the area consists of isolated patches and ridges of the higher elevation. In the region east of Troy and Tell City the soils become better developed and of much more even topography. Here considerable areas of fairly level land are found, but the descent to the lower formations and river valley is rather steep. Some workable coal veins are found, chiefly along the drainage levels and the coal is mined by drifting. The beds are thin and in many places have been exhausted; in other places the veins reach a thickness of five feet.

The surface soil is a sandy clay loam and fairly productive. Iron ore concretions are numerous throughout the soil. Land can be bought at prices from $5 to $50 per acre. See description under Dubois County for further description, and crops production.

4. Alluvial Soil.

The alluvial soils of Perry County are confined almost exclusively to those of the Ohio; the smaller streams having but very limited areas of bottom land. The bottom soils of the Ohio are also of small area considering the distance for which the river forms the boundary. Along the eastern side of the county the high bluffs come down almost to the present channel of the river, with the exception of two or three slight bends in which some bottom is

Weathering in the perpendicular, exposed faces of the Mansfield sandstone along the Ohio, east of Cannelton.



Showing massive structure, and weathering in Mansfield sandstone, east of above view.

formed. The chief areas occur in the Tobinsport and Cannelton bends.

The alluvial soils consist of three chief divisions, which are best and most extensively developed along the western and south side of the Tobinsport area. The area known as the river flats is most extensive and occurs along the entire border of the county, varying in width from a few rods to a mile or more. These soils are flooded annually. The soil consists of a light brown sandy clay loam. The percentage of clay and silt is large, with usually a high percentage of fine sand. With depth the soil becomes more tenacious, grading into a stiff mottled claying subsoil, containing inert concretion of iron, lime, etc., which have been leached from the surface soil by stagnant waters. The area is comparatively level with the exception of small swampy area with the ridges intervening and in some places a low terrace is found very near the present channel of the stream; the soil has become very sandy. In most places the drainage is very good and soils are of good agricultural value. The upper layer of the surface soil is continually being renewed by the overflow of the Ohio. This frequent addition to the soil maintains the production, and excellent crops are grown, except in seasons of excessive rainfall. The area is planted almost exclusively in corn, averaging about 40 bushels per acre; and in better drained areas from 60 to 75 bushels are produced.

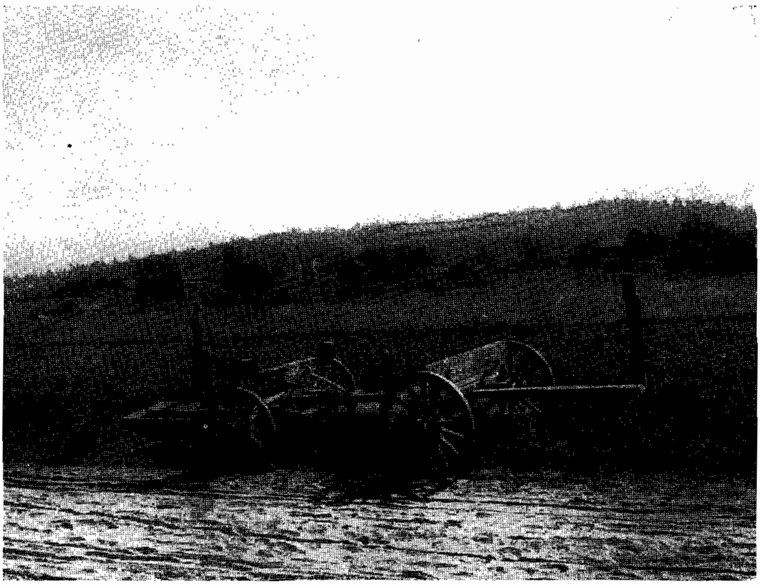
Wheat when not reached by flood waters yields from 10 to 15 bushels per acre. The soil is mostly too wet for oats, but they are grown in a limited way. Grasses grow well and give heavy yields, but are often coarse. In wet seasons meadows and pastures are badly grown over with swamp grasses, whitetop and ragweed. Some tobacco is grown.

The following table shows the result of mechanical analysis of these soils:

MECHANICAL ANALYSIS OF SANDY CLAY LOAM OF RIVER FLATS.

Number.	LOCALITY.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
13	Tobinsport	Surface	.3	1.5	1.0	1.5	8.0	87.6
13a	Tobinsport	Subsoil	.5	1.0	1.5	2.0	34.0	91.0
14	East of Cannelton	Surface	.5	2.0	1.5	2.5	10.0	83.5
14a	East of Cannelton	Subsoil	1.5	1.5	2.5	2.0	6.0	87+

The second division of the alluvial soil is a fine sand loam, consisting chiefly of a narrow rounded top ridge extending along the



Five miles southeast of Cannelton. Well improved farms through the sandy loam areas. In the background the narrow ridge of Mansfield and Huron extending into the Tobinsport bend.

View in Ohio River bottoms, near mouth of Deer Creek. Narrow, unfenced roadway winding through large areas of growing corn.

river, in some places approaching very near the present river bed, but in the widest part of the valley extends back a mile or more from the river. No sharp line of demarcation can be made between this soil and the type above discussed. The summit of the ridge rises several feet above the bottom areas. Its elevation and the sandy texture gives good drainage. The slope next the river is more abrupt than that next the lowland on the opposite side.

The soil to a depth of 12 to 18 inches is a light brown, fine, sandy loam, and becomes heavier with depth. The size of the sand particles and the amount of clay found is varying, because of the assorting power of the water at time of deposition at various levels.

In average seasons the crop productions are good. Oats, corn, wheat, potatoes, melons, beans, cowpeas, clover and alfalfa.

The area while rather limited would be well adapted to truck farming and growing of small fruits.

The improvements throughout the area are excellent. Good farm houses, barns, roads well graded, and the live stock are kept in good condition.

The following table shows the result of mechanical analysis of this type:

MECHANICAL ANALYSIS OF FINE SANDY LOAM.

Number.	LOCALITY.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay
11	Four miles northwest of Tobinsport	Surface	.2	.5	.5	20.0	18.0	59+
12	Four miles northwest of Tobinsport	Subsoil	.3	.5	.8	18.0	10.5	70+

The third type of alluvial soils lies between the sand ridges and the uplands. It is a white clay, becoming very loamy in places. As the depth increases it becomes more tenacious, and is almost impervious to water, hence the drainage conditions are bad. During the floods the area is overflooded, and when the waters have gone down, the land becomes baked and cracked, so that when plowed it is very difficult to pulverize. The soil is derived chiefly from the upland wash, and the small amount of deposition which takes place from the river floods. The organic matter content is very low, and the soils show the leaching effect of ponded, stagnant waters. Many small concretions of various elements are found in the subsoil and the surface soil is greatly lacking in the necessary plant foods. Much "crawfishy" land occurs throughout the area.

View in the alluvial soils of the Ohio, in the Tobinsport bend. Taken from the top of the Huron formation shown in frontispiece.

Just west of the above view. The ridge is on the Kentucky side of the river.

The area is not very extensive, and the yield of the various crops cultivated on the soil depends to a great extent on the thoroughness of the drainage and the care taken in cultivation. Corn produces from 15 to 30 bushels, wheat from 8 to 12 bushels per acre. Some clover and timothy is grown, but good stands are difficult to obtain. The grass growth is coarse and fibrous. Redtop grows well. The larger part of the area is considered a poor soil for general farming conditions. Some areas are used for pasture in connection with the uplands. The uplands rise somewhat abruptly and with extensive stone outcrops.

The following table shows the result of mechanical analysis of this type:

Number.	LOCALITY.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
9	Northwest of Tobinsport...	Surface..........	.2	1.5	.5	2.5	2.0	93.3
9a	Northwest of Tobinsport...	Subsoil..........	2.5	1.5	.3	1.4	1.5	92.8

The alluvial types above described are of much value among the soils of the county. They represent various stages in the work of the river and much accurate history in the development of the Ohio valley could be worked out from the study of the origin of these soils.

SUMMARY.

Perry County was chosen at an early date as the home of a very energetic and thrifty class of people, so that for a long time it has ranked as one of the important manufacturing counties.

Corn, wheat, oats, clover, timothy, tobacco and potatoes are the chief crops. Stock raising receives comparatively little attention. Since few animals are raised on the farms, most of the produce is sold from the land. The upland soils are very deficient in organic matter, and the same is true in a large part of the alluvial soils. Some of the alluvial soils which carry a high percentage of humus are remarkably fertile.

The river valley is practically all under cultivation, but most of the residences and other buildings are on the higher sand ridges, or on the edge of the uplands.

At least 75 per cent. of the farmers own and cultivate their own land. Some farms are rented for cash at about $4 per acre, but the most of them are grain rent, the landowner receiving from one-third to one-half of the crop production.

The alluvial soils are planted chiefly in corn on account of the spring floods. The corn makes an enormous stalk growth, and yields fairly well. In 1908 the wet spring prohibited early planting and much bottom corn was caught by the early frost. Very few of the farms are fenced along the public highways. The farm improvements as a rule are very good. The farms average from 20 to 160 acres.

Tobacco is grown chiefly on the upland soils, about 200 acres being grown in 1908 and yielding about 170,000 pounds.

In the sandy bottoms many pastures are badly overrun with trumpet creepers, steelweed and ragweed. Wells are easily secured throughout the valley, at depths ranging from 10 to 35 feet. Some driven wells are as much as 75 feet in depth.

Alfalfa has been successfully grown on the various soils. Sorghum is also raised with profit. Large acreage of cowpeas is also grown in the bottoms. Timothy makes a heavy growth in some of the poorly drained areas of the lowlands.

Much profit could be derived from the cheap land in devoting them to special crops, such as tomatoes, pumpkins, sweet corn, etc., for canning factories; vegetable raising and fruit growing could be successfully carried on, should transportation facilities be increased.

A good cropping system such as is being developed in the bottoms would greatly enrich the uplands. As much as possible of the crops produced should be returned to the soil. The soil responds well to large applications of stable manure.

The commercial clubs of Troy, Tell City and Cannelton are endeavoring to have the new line of the E. & E. Traction Company, from Evansville to Rockport, extended on to Perry County towns. These men desire to see the road built and promise a rich, fruitful country greatly in need of traction facilities.

CRAWFORD COUNTY.

History of Settlement and Agricultural Development.

Crawford County was organized in 1818, and was named after the unfortunate Col. William Crawford, the land agent of General Washington in the West, who was taken prisoner by the Indians and burned at Sandusky in 1782. The county was formed from parts of Harrison, Orange and Perry Counties. The only town in the county was Mt. Sterling, and it was named as the county seat. In 1821 the seat of justice was moved to Leavenworth, on the Ohio river, where it remained until a few years ago, when the town of English was decided upon as a more suitable location for the county seat.

The county is very irregular in shape and contains 350 square miles. The county is divided into eight townships, viz.: Jennings, Patoka, Johnson, Union, Sterling, Liberty, Whiskey Run and Ohio. The latter now including the former township of Boone. The population in 1830 was 3,184; in 1840, 5,282; in 1850, about 6,200, and at the present time about 14,000.

The principal towns of the county are English, Marengo, Milltown, Eckerty, Wyandotte, Leavenworth, Alton, Riddle, Grantsburg, and Taswell. Several other little villages and country stores are scattered over the county.

English, the county seat, is situated in the north central part of the county on the St. Louis division of the Southern Railway, and has a population of 750. There are six passenger trains daily, and the general improvements are good. A stave factory is the principal manufacturing concern. The town offers a number of inducements to various enterprises. Limestone and timber are available, and the surrounding country has a fertile soil.

Marengo, with a population of about 800, is situated six miles east of English. It is a thriving town, and with the available supply of limestone near, there is opportunity for great development. A stone-crusher, lime-kiln and canning factory are the principal industries.

Milltown, with a population of 500, is about 2 miles east of Marengo. The stone industry has caused a rapid growth in recent years, and plans are being made for further development. The location is most favorable for growth.

Eckerty, a little village west of English, affords a trading place for the vicinity. Its only industry is a mill for flour, meal and feed.

Alton, with a population of 350, is located on the Ohio River, 12 miles southwest of Leavenworth. Its only shipping facilities are by boat. A canning factory, wagon factory and lumber yards are the principal industries.

Leavenworth, located on the Ohio in the southeastern part of the county, has a population of 700. Its only transportation facilities are afforded by the Ohio River, the nearest railroad station being Marengo, 13 miles distant. The industries are lumber yards, flour and feed mills, pearl-button factory, machine-shop products and skiffs. Should better transportation facilities be found the location, the surrounding agricultural advantages and the stone suited for road metal and cement, all offer inducements for investment.

General Improvements.—There are in the county 229 miles of public roads, with less than ten miles improved. The first improved roads were built in 1892. The improvement is chiefly with crushed stone, and the original cost per mile has been about $1,700. The county contains an abundant supply of the best road material within the southern part of the State, and no doubt a large amount of improvement will be made in some section of the county in a few years.

The only railroad in the county is the St. Louis division of the Southern, which crosses the northern third of the county from east to west. The Ohio River, on the southern boundary, provides an outlet for the southeastern part of the county. A few rural routes lead out to parts of the county, and others are promised when improved road conditions are brought about.

Agricultural conditions have not reached the highest standard. The surface of the county in general is very broken. It is possible that the ruggedness of the county kept immigrants from seeking homes there at as early a date as in other places. Both the hillsides and valleys were heavily timbered with a great variety of trees, but of chief importance were the oaks and poplars. For the hardy pioneer there were many attractions, but the toil and privations he had to undergo before he could have a farm in readiness for cultivated crops were discouraging; yet he had few needs and these were supplied from nature. The forest and the streams were attractive, and the whole was a paradise for the hunter. The cleared land produced abundantly, but careful cultivation of the soil did not receive much attention at first. The virgin soil was naturally very productive, and as it declined in value, new areas were cleared and made ready for growing crops. The careless methods of cultivation finally caused depletion of the soil. The fertility was lost, hillsides were badly washed, and now the present generation of farmers must exercise continual care to secure profitable yields.

The past few years have shown that the soils are adapted to a great diversity of crops, and considerable interest has been aroused as to the agricultural possibilities of the county. Very little experiment work has been done in these soils, and the State would be well repaid by giving some time here to soil conditions. The staple crops may be successfully grown, and the region is well adapted to the growing of fruit.

The county now produces, according to the latest statistics, about 480,000 bushels of corn, an average yield of 25 to 35 bushels to the acre; wheat, 200,000 bushels, averaging from 10 to 20 bushels per acre; oats, about 10,000 bushels, yielding from 18 to 30 bushels per acre; timothy and clover both do well, yielding from 10 to 20 bushels per acre; some clover seed is produced, but the yield is usually less than 1 bushel per acre; alfalfa grows fairly well, and about 200 acres are now sown; about 400 acres of potatoes are grown, yielding from 40 to 75 bushels per acre. Tomatoes and peas are now being raised for canning factories, and the yields are very satisfactory. Watermelons and cantaloupes usually have an acreage of 25 acres or more. A few acres are found in tobacco each year. There are about 40,000 bearing fruit trees. The hills are well adapted to the growing of fruit, and the county promises to be one of the great fruit-growing sections of the State.

Physiography and Geology.

In Crawford County four geological formations make up the surface rock. The Mitchell limestone is found in the eastern part. Its topography is described under the description of the corresponding soil. The principal formations of the county are the Huron and Mansfield; the latter being confined to the western third. The Coal Measures also occur on the higher elevations along the line of the Southern railway in the vicinity of Taswell and Eckerty, and becomes better developed to the southwest. The topography of the surface varies from level flood plains and flat-topped ridges, remnants of the old table-lands, to undulating areas with irregular depressions in the region of sinks, to high, steep, winding ridges, and narrow, deep valleys in the central and western part. The greatest range in elevation is from 250 to 480 feet above the valleys of the Ohio and Blue Rivers.

The limestone outcrops of the eastern half, in the Mitchell and Huron, afford the best road material in southern Indiana. Quarries and crushing plants at Marengo and Milltown are making some good developments in the use of this limestone.

The natural drainage of the county is fairly well developed. The eastern part by Blue River and its tributaries, many of which are subterranean passages from the region of the Mitchell. Wyandotte, Marengo and many smaller caves with their numerous winding arms, and the large number of sinks on the surface show the underground system of drainage well developed.

"The sink holes vary much in size, sometimes being but a rod or two across, and again embracing several acres in extent. They are for the most part, inverted cones or funnel-shaped cavities, and where small, have the sides covered with a matted growth of vines and shrubs. Where larger, trees varying in size are often found growing from the scanty soil on the sides, or from the bottoms of the sinks. If one will examine closely the lowest part of the sink hole he will usually find a crevice or fissure through the limestone, or sometimes a large opening which, if it be possible to enter, will be found to lead to an underground cavity—a cave.

"Both sink holes and caves not only owe their origin, but usually their entire formation to the slow, unceasing action of rain or carbonated water upon the limestone strata in which they occur.

"The action of the rain water upon the limestone is usually hastened by humic acid, with which the former has combined in passing through decaying vegetable matter before reaching the limestone."*

Blue River is a meandering stream with a deep narrow valley. The alluvial soils occupy very small areas within the bends of the stream. The stream was formerly much used for water power. Little Blue River is similar to Blue River except that the valley is not so deep. It receives the surface water from the extreme northern edge of the county. The drainage area is much greater than would be expected from first sight of the stream. Practically all the drainage of the county, with exception of the two northwestern townships, which are drained by tributaries of the Patoka River, is brought through the mouth of these two streams into the Ohio. A very few short streams find their way

*W. S. Blatchley Report 1896, p. 121.

directly into the Ohio. The winding streams with the diversified character of the valley sides, through the different formations present some of the most picturesque scenery. Springs break out in a number of places and afford good water for domestic purposes. In a few places the water contains considerable mineral substances. A number of small lost streams occur in the eastern part.

SOILS.

There are in Crawford County five general types of soil, four of which have been derived directly from the geological formation. The fifth type, alluvial, comprises a rather small area considering the large mileage of river boundary and the materials of which it is composed, are for the most part not far removed from the point of original formation. Showing chiefly the same constituents as the residual types, intermingled to some extent with glacial material brought down from above. There are some local variations in the general types, but the prevailing characteristics are those found in all areas where the same geological formation occurs.

The following table shows the proportion of each general type:

Mitchell	40 square miles
Huron	190 square miles
Mansfield	52 square miles
Coal measure	12 square miles
Alluvial	10 square miles

1. Mitchell Area.

The residual soils of the Mitchell limestone cover about 40 square miles in the eastern part of the county. The topography of the surface is very broken. The underlying limestone with its peculiar characteristics weathering has produced, has a very uneven surface. There are no great variations in elevation over the area, the chief differences being from the general level of the tableland to the bottom of the sinks. The depth of the soil varies from one to several feet.

The surface soil is from 6 to 18 inches in depth and consists of clay loam, grading from a gray or yellow color to red. The difference in color is often very noticeable in the same field giving it a very mottled appearance when freshly plowed. The subsoil is a heavy clay loam varying from a brownish yellow to a dark red as the solid rock is approached, and it usually contains a large

Old mill on Blue River, Crawford County. The high ridge in the background shows the typical wall and narrow valley of Blue River.

View of the Ohio River and valley at Leavenworth, Crawford County.

amount of chert, in some places of sufficient quantity to be termed gravelly. The surface soil with cultivation becomes rather loose and is easily washed away on the slopes, so that in many places the surface has been entirely worn away and the stiff red clay exposed. This subsoil presents a higher fertility than would be judged from its appearance. The soils become more shallow and the amount of chert and other impurities increase as the drainage line of sinkholes is reached. The sides of the sinks are often covered with a matted growth of vines and shrubs, and trees often grow from the scanty soil of the sides or from the bottom. Places where the soils are worn out and washed and become practically covered with sassafras and blackberry briars are known as "the barrens" and cannot be made of much agricultural value.

The drainage is almost entirely by the underground passages and sinks. Generally the soils are well drained and crops sometimes suffer from drought. In other places the soil is of a very compact nature and some artificial drainage is necessary. There are many springs through the area, affording a domestic water supply. Sinkholes clogged either by natural or artificial means are plentiful and furnish water for stock; good wells are difficult to obtain. In few places where sinks of considerable size have been filled with water, and the inwash of soil from the surrounding fields has partially filled them, they present the appearance of marshes. Willow, cattails, water lilies and other water-loving plants grow in abundance in these borders and farther out in the washed lands is the typical growth of sassafras, sumac and briars. The soils in general are fairly productive, but great care is required in cultivation to keep them up to the standard. Large application of stable manure renders the soil very fertile, and this is due probably to two things: by adding a large amount of humus to the soil, and by rendering available larger amounts of the potash and phosphates contained in the cherty soils.

Corn yields on the average from 35 to 50 bushels per acre, and in places where the ground has been carefully fertilized the average has been 50 to 75 bushels. Wheat grows fairly well and yields from 10 to 15 bushels per acre. Clover and timothy are usually in excellent condition and yield an average of one and one-fourth bushels per acre. Some clover seed is also produced. Alfalfa and cowpeas are grown on limited areas; but the yields have been very satisfactory. Potatoes yield about 40 bushels per acre under ordinary conditions. The growing of tomatoes has proved successful and promises to become a leading occupation in this section of the county. All fruits are grown to a limited extent.

The soil produces good pasture, except that when long continued in one place the briars and sassafras spring up and soon produce a thick growth; more attention has been given recently to grazing and stock raising. Some dairying is engaged in, and sheep raising might be made a paying industry. The area is abundantly supplied with the best road material in the State. Some of the roads are now being improved. The stone industry in the area, for road metal, lime and cement offer great opportunities and the further development of these resources will have a marked effect upon the agricultural condition. While the selling price of land has not been much over $10 per acre, it is reported that land has more than doubled in value in the vicinity of Milltown since the opening of the quarries there, causing an increased demand for farms and farm products.

Near the Huron contact the soil contains considerable sand, derived from the sandstone members of this formation. The soil is not greatly affected by this sand except as the hill slopes are approached and the change becomes marked, and such soils will be classed with the typical Huron soil. The sand is slightly colored by iron oxide, and the surface soil over the area varies from gray to brownish yellow. The soil is well adapted to fruit. A considerable number of fruit trees are found here. Strawberries and other small fruits do well and small patches of watermelons and muskmelons show that the soil is well adapted to the growing of such crops. The yield of the areas is about the same as in the general type.

The following table shows the result of mechanical analysis of these soils:.

MECHANICAL ANALYSIS OF MITCHELL SOILS.

Number.	LOCALITY.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
10	East of Marengo	Surface	.5	1.5	1.5	.5	3.5	92.5
10a	East of Marengo	Subsoil	2.0	1.5	1.0	.5	2.0	93.5
21	Milltown	Surface	1.0	.0	.4	1.5	.5	96.5
22a	Milltown	Subsoil	1.8	2.5	.5	1.0	1.0	92.5
22b	Milltown	Subsoil down to stone	6.4	3.5	.5	2.0	1.5	88.0
8	S. Milltown	Surface	.0	2.0	.5	1.0	4.0	92.6
8a	S. Milltown	Subsoil	6.0	3.0	2.0	.5	6.5	82.0
7	Southeast Marengo	Surface	2.0	4.0	2.0	12.0	4.0	76—
7a	Southeast Marengo	Subsoil	8.0	2.0	1.0	5.0	3.5	80.5

The chemical analysis of a sample of Mitchell Limestone from Milltown shows the following composition:

Alumina (AL_2O_3)	.11
Iron oxide (FE_2O_3)	.24
Lime (CaO)	52.10
Magnesium (MgO)	2.48
Insoluble (HCl)	1.82
Loss on ignition	43.45
	100.20

For composition the following analysis is given of a sample of Mitchell limestone taken in Monroe County:

Alumina and iron oxide (AL_2O_3-Fe_2O_3)	.50
Lime (CaO)	55.00
Magnesium (MgO)	Trace
Phosphoric acid (P_2O_5)	Trace
Insoluble (HCl)	1.84
Loss on ignition	42.69
	99.93

The chemical analysis of soil taken near Milltown shows the following composition:

CHEMICAL ANALYSIS OF SURFACE MITCHELL LIME STONE SOIL.

Laboratory No.	21
Reaction to Litmus	acid
Moisture at 105°C	2.00
Total soil nitrogen	.119

ANALYSIS OF FINE EARTH DRIED AT 105°C.

Volatile and organic matter	4.081
Insoluble in (1.115 sp. gr.) HCl	87.404
Soluble silica	.013
Ferric oxide (FE_2O_3)	3.265
Alumina (AL_2O_3)	4.379
Phosphoric acid anhydride (P_2O_5)	.116
Calcium oxide (CaO)	.217
Magnesium oxide (MgO)	.481
Sulphuric acid anhydride (SO_3)	.035
Potassium oxide (K_2O)	.210
Sodium oxide (Na_2O)	.304
Total	100.505

CHEMICAL ANALYSIS OF SUB. MITCHELL LIME STONE SOIL.

Laboratory No.	22
Reaction to Litmus	acid
Moisture at 105°C	3.35
Total soil nitrogen	.140

ANALYSIS OF FINE EARTH DRIED AT 105°C.

Volatile and organic matter	5.221
Insoluble in HCl (1.115 sp. gr.)	80.535
Soluble silica	.085
Ferric oxide (FE_2O_3)	4.666
Alumina (AL_2O_3)	7.578
Phosphoric acid anhydride (P_2O_5)	.128
Calcium oxide (CaO)	.938
Magnesium oxide (MgO)	.636
Sulphuric acid anhydride (SO_3)	.068
Potassium oxide (K_2O)	.325
Sodium oxide (Na_2O)	.326
Total	100.506

2. Huron.

The soils derived from the Huron formation cover more than half the county. The area is noted for its extreme ruggedness. The formation is composed of a series of limestone, sandstone and conglomerate, and weathers into very steep slopes, hence this portion of the county has a much rougher topography than the limestone area to the east. The formation is generally capped with a layer of hard sandstone; the resistance of this layer to the process of weathering has caused the rough topography. The round topped hills and flat-topped ridges rise more than a hundred feet above the general level of the county, and from 250 to 400 feet above the level of the Ohio River.

The following sections of about 50 feet each will show the varied character of the Huron formation:

Upper Part of Section Exposed North of Leavenworth.

Massive soft sandstone	4 ft.
Covered with sandstone debris	6 ft.
Gray clay, with some sand	1 ft.
Covered	2 ft.
Shaly sandstone	1 ft.
Sandy clay shale	6 ft.
Blue clay shale	5 ft.
Green sand shale with iron ore concretions	6 ft.
Blue clay shale	6 ft.
Sand shale	0 ft. 6 in.
Coarse, irony cross-bedded sandstone	3 ft. 6 in.
Blue clay shale	5 ft.
Limestone	8 ft.

Followed 60 feet below by shales, iron ore concretions, limestone, down to Mitchell limestone.

Part of Section Near Fredonia.

Massive sandstone	9 ft.
Covered	8 ft.
Gray limestone	20 ft.
Massive sandstone	8 ft.
Shaly sandstone	10 ft.
Blue clay shale	3 ft.
Sandstone	7 ft.
Blue clay shale	1 ft.
Limestone	8 ft.

Continuing with similar series down to Mitchell limestone.

From the above it will readily be seen that the soils of the Huron will present a great variety of types, but since they are so intermingled and each type covers only a small area of a given locality, the entire group is mapped together.

In general the soil grades from a brown to yellow sandy loam, underlain by a stiff white to yellow subsoil in the parts where the sandstone and shale predominate, while in the limestone residual the subsoil is of a dark brown to red color and is very tenacious. The darker brown and red color of the surface soil is due to a large amount of ferruginous sandstone and does not indicate a fertile soil. The light-colored soils are as a rule the more productive. In the region of predominating shales the subsoil grades at a depth of 8 to 10 feet into a mucky shale, which has a very sour taste. Many iron ore concretions are found in the subsoil.

The following table shows the mechanical analysis of these soils:

MECHANICAL ANALYSIS OF HURON RESIDUAL SOIL.

Number.	LOCALITY.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
5	Southwest Marengo........	Surface.........	.0 2.	.5	.8 1.5	12.0	5.0	8.15 ....
5a	Southwest Marengo........	Subsoil..........	....	1.	....	10.0	10.0	75+
4	Southeast English..........	Surface..........	.5	.4	1.0	10.0	14.0	74+
4a	Southeast English..........	Subsoil..........	5.0	.5	3.5	8.0	10.0	73+
3	Northwest Leavenworth....	Surface..........	1.0	1.5	.8	15.	2.5	79+
		Subsoil..........	3.0	1.5	1.0	8.0	10.0	76+
3a	....	Subsoil						
3b	....	Third to sixth foot down to rock ...	6.0	2.5	2.0	10.0	5.5	74+

3. Mansfield Sandstone.

The soils of the Mansfield sandstone area occupy the second largest area within the county. There is very little level land throughout the area. Rock outcrops are numerous, and much of the soil contains a large amount of broken sandstone, which makes successful cultivation very difficult. On the eastern and northern boundaries, where the streams have cut down into the Huron, the slopes are very steep and the valleys deep and narrow.

The surface soil is chiefly a yellow sandy loam, from 6 inches to 2 feet in depth. This is underlain by a subsoil of similar color, somewhat mottled with white, but the clay content is higher.

In some places where the soil has been derived from the shaly part of the formation the soils are very tenacious and the subsoil grades into a stiff white and yellow mottled clay. These more clayey areas are usually wet, or in dry seasons become baked. In other areas the soils are very sandy and of a reddish color, but the color is due chiefly to the disintegration of the ferruginous parts of the sandstone, and as a rule are very unproductive except for wild grasses and shrubbery.

The Mansfield soils have usually been considered of little value for general farming purposes, but this value has been somewhat increased in the past few years. With the exception of the very limited areas along the streams, the best land is found on the higher elevations, consisting of rather broad flat-topped ridges. Much of the area has been planted in corn continually until it has caused a complete depletion of the soil, and in very many places large tracts once cultivated are now abandoned and grown over with briars, sumac, persimmon and sasssafras. Improvements could be brought about by a systematic cropping system, the growing of cowpeas, clover, etc., and returning as much as possible the plants to the soil in order to keep up the humus content.

The improvements throughout the area are of rather poor quality. Much of the large timber has been removed and a large acreage covered with second growth, consisting chiefly of oaks. The transportation facilities are poor, and the public roads are unimproved and are so rough as to preclude economic hauling.

Corn and timothy are the principal crops. Corn yields in fair seasons from 20 to 45 bushels. but the average is much less. Some wheat is grown on the higher levels, and the yield is very good; the straw is rather short, but the heads are well matured. The soils are well adapted to fruit growing, and a large number of trees are being planted yearly.

Farms in this area vary in price from $5 to $50 per acre. Natural drainage conditions are good.

The following table shows the results of mechanical analysis of the Mansfield soils:

MECHANICAL ANALYSIS OF MANSFIELD SANDSTONE RESIDUAL SOILS.

Number.	LOCATION.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
29	Near Eckerty	Sandy loam	.0	.5	.8	1.5	15.0	82—
29a	Near Eckerty	Subsoil	2.0	1.5	1.0	.5	10.0	85
30	Three miles northwest Eckerty	Sandy loam	4.0	1.5	.6	2.0	20.0	72—
30a	Three miles northwest Eckerty	Subsoil down to stone	18.0	1.5	.4	2.5	10.0	68

4. Coal Measure.

The soils of the Coal Measure occupy but a comparatively small area in this county. A large part of the area consists of isolated patches and tortuous ridges of the higher elevation, while in the southwestern part the area of several square miles becomes much more even and of greater agricultural value.

The surface soil is of a sandy clay loam of a fairly productive type. The soils in the larger areas are more easily cultivated than of the Mansfield, and as a rule the yield is greater. Wheat yields from 10 to 25 bushels, corn from 30 to 45 bushels per acre; oats, rye, timothy and clover yield well.

The improvements are of a fair type. Fruits are successfully grown, and might be made a paying business, since the entire area is sufficiently near the railroad to admit transportation from the towns of Taswell, Eckerty and Birdseye. Land sells for about the same prices as that in the Mansfield Very little timber now remains, but there is a large amount of second growth, principally oak, beech, walnut, ash, hickory, mulberry and persimmon.

The following tables show the results of mechanical analysis of Coal Measure soils:

MECHANICAL ANALYSIS OF COAL MEASURE RESIDUAL SOILS.

Number.	LOCALITY.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
27	Near Taswell	Surface	4.5	1.5	2.0	4.0	15.0	73.0
27a	Near Taswell	Subsoil	8.5	1.5	3.5	1.5	8.0	77.5
28	Southwest corner	Surface	2.0	1.0	2.0	2.5	18.0	74.5
28a	Southwest corner	Subsoil down to rock	*10.0	4.0	3.0	5.0	12.0	66.0

*Sandstone fragment.

5. Alluvial.

The Alluvial soils of the county are confined to the limited areas found in the meander curves of Blue River and Little Blue River, and to a few square miles along the Ohio. The soil along the first-named stream is a sandy clay loam grading from a yellow to dark color according to the amount of organic matter present. This is devoted chiefly to vegetable truck and gives very good yield. The Alluvial soil here occupies very small areas, but when some distance from the streams the valleys appear of great width because of the long, colluvial slopes leading down to the streams. These slopes afford some excellent farms in the Mitchell and Huron areas.

Along the Ohio the soil is also a sandy clay loam, of varying color, but chiefly rather dark. A narrow strip along the river suddenly drops off to a lower level. This is more sandy than that which extends farther back. This lower strip is also subject to frequent overflows while the second bottoms are overflowed only by the excessive river floods. A higher terrace also skirts the upland, but there is little difference in the soil except that as the uplands are approached the surface soil contains a larger percentage of clay derived from upland wash. The subsoil of these types is chiefly of glacial origin. The Alluvial soils as a rule are very fertile. Corn is grown extensively and makes an abundant stalk growth, and the yield is from 30 to 75 bushels per acre. Some clover and alfalfa are grown. Cowpeas are also grown in the more elevated part. Some wheat is also grown and yields well when the winter and spring rains are not excessive. Small patches of tobacco are also grown in the second bottom. The drainage conditions are good. The improvements are very good, and a marked degree of thrift is manifest in the agricultural development and in the towns of Leavenworth and Alton, which provide the market and supplies for this area.

Most of the farms are composed partly of upland and partly of bottom land. Considerable fruit has been planted in the south and east slopes leading down to the valley. Where the valley is most narrow the hills rise with precipitous rock exposures to a height of 100 feet, and in many places before the summit of the ridges has been reached the hills have attained a height of 300 or 400 feet. The Alluvial types are practically without timber.

The following table shows the results of mechanical analysis of the Alluvial soils:

MECHANICAL ANALYSIS OHIO VALLEY SANDY CLAY LOAM.

Number.	LOCATION.	Description.	Gravel.	Coarse Sand.	Medium Fine Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
1	Ohio Valley..............	Surface...........	.1	.5	1.0	8.0	20.0	69.4
2	Ohio Valley..............	Surface...........	.2	1.5	1.5	6.0	15.0	74.8

SUMMARY.

Crawford County has been in a backward condition in its agricultural development, and the farming population has been hampered for lack of proper facilities and improvements to meet its needs. More railroads and improved public roads will add much to the prosperity of the county. Soil conditions should be carefully studied and a series of investigations made as to their needs. Part of the county is in a prosperous condition, and improved methods of farming are finding a place.

The red patches which occur in cultivated fields of the Mitchell area are principally on the higher elevations, and are due to the surface soil being carried to lower levels and leaving the unbleached soil exposed.

The yellow soils are of a more loamy texture on account of the mechanical action of the roots of plants, and owe their lighter color also to the bleaching action of the plant roots. In places the soils become of a darker color, due to a greater amount of organic matter.

When in a good state of tilth the surface soil is very fine, and contains much flour-like material and also a large amount of fine grit derived from impurities in the limestone and from the sandstone formations which formerly extended over the area.

No analyses have yet been made of the material in the chert beds, but they may in the future prove of some value as rock fertilizers. It has been found that by plowing deep enough to turn up some of the cherty layer and red clay that the fertility of the soil is increased.

The soils are in need of available potash, phosphoric acid and lime. It has been noted in former areas surveyed that when a fire has burned the briars over a given area, the amount of potash made available in the ash causes a very thrifty growth of the new briar.

Large applications of fertilizers are essential in the Mitchell area for hurrying the crops to maturity, because with the drainage conditions produced by the underground system the soils become dry and the crops are likely to suffer from drought in the late summer.

Some experimental work is being carried on to determine the fertilizer requirements of the soils in parts of the Mitchell area of the State, and a marked development of the soils will be brought about in a few years.

All classes of the ordinary fruits are raised on the farms, but no especial attention has been given to fruit-growing.

Each year Indiana pays other States over a million dollars for apples, and large sums for other fruits. Such apples as can be raised on this section of southern Indiana are worth from $1 to $3 per box, and from 100 to 200 boxes can be grown to the acre.

The soils of the Huron are easily tilled, but must be handled with care to prevent washing and depletion by continual cropping. The slopes and lowlands comprise good grazing lands and fruit-growing areas, while the best corn, wheat and clover are grown on the tops of the ridges.

The creeping of the surface soil from the tops of the ridges down the hillsides is due to a stiff layer of subsoil, which holds the water at the surface, and with the continual freezing and thawing the soil moves to lower levels. This inpermeable layer accounts for the wet soils often found on the higher elevation.

In the Mansfield soils a great deal of commercial fertilizer must be used to produce good crops. Those who have used the commercial fertilizer claim that the soils are, however, soon exhausted. The chief cause for the wearing out of the soils is the fact that all crops are removed from the field, this entirely doing away with the supply of humus.

A steam railway or interurban line from New Albany to Leavenworth would open up a large tract of country well adapted to fruit-raising, truck-farming and dairying.

Considerable wealth may be added to the county by the proper development of its natural resources, including the scenery, caves, rivers, stone, clay, shale and soils. Most of the towns are ready to offer sites and a bonus to industrial enterprises.

There are at present but two canning factories in the county. It has been proved that the soils are well adapted to the growing of tomatoes, peas, sweet corn, etc., and affords excellent advantages for the canning factories.

Much profit could be derived from the cheap lands by devoting them to special crops in the way of truck-farming and growing of small fruits for the market at distant points, as Louisville, Evansville and St. Louis.

Only a limited number of livestock is raised, but the opportunity in this line is good because of the advantages for grazing.

The marked improvements which have taken place during the past ten years in a few places give an encouraging outlook for greater development. Many farmers from the northern and central part of the State are being attracted here by the low-priced lands.

TABLE SHOWING THE RESULTS OF THE ANALYSES.

COLLECTOR, SOIL SAMPLE, DESCRIPTION.	Shannon Surface Mitchell Limestone Soil.	Shannon Sub-Mitchell Limestone Soil.	Shannon Surface Coal Measure.	Shannon Mansfield Sandstone Soil.	Shannon Brown Soil, Patoka Lake Plain.	Shannon White Soil, Patoka Lake Plain.	Lyons Marsh, Sandy Loam.
LABORATORY NUMBER	21.	22.	23.	24.	25.	26.	30.
Reaction to Litmus	Acid.	Acid.	Acid.	Acid.	Acid.	Acid.	Acid.
Moisture from air dry at 105° C	2.00	3.35	1.39	1.77	1.51	1.33	5.68
Total soil nitrogen	.119	.140	.096	.089	.103	.089	.174
ANALYSES OF FINE EARTH DRIED AT 105° C.							
Volatile and organic	4.081	5.221	3.366	3.563	3.451	2.819	8.311
Insoluble in 1.115 HCL	87.404	80.535	90.048	88.011	89.299	91.961	79.335
Soluble silica	.013	.085	.043	.033	.013	.083	.056
Ferric oxide (FE_2O_3)	3.265	4.666	2.490	4.072	2.691	1.415	3.256
Alumina (AL_2O_3)	4.379	7.578	2.877	2.859	3.111	2.447	6.094
Phosphoric acid anhydride (P_2O_5)	.116	.128	.120	.146	.178	.093	.183
Calcium oxide (CaO)	.217	.938	.418	.573	.358	.508	1.453
Magnesium oxide (MgO)	.481	.636	.576	.517	.525	.440	1.049
Sulphuric acid anhydride (SO_3)	.035	.068	.035	.055	.045	.052	.061
Potassium oxide (K_2O)	.210	.325	.219	.327	.331	.213	.300
Sodium oxide (Na_2O)	.304	.326	.311	.340	.409	.305	.327
Total	100.505	100.506	100.503	100.496	100.411	100.336	100.425

NOTE.—These soil analyses were made by Dr. R. E. Lyons, of Indiana University, the same methods being used as in former analyses and described in the 32d Annual Report, Department of Geology, pages 47-55. No. 30 shows the analysis of a marsh sandy loam from west of Bloomfield, Greene County.

PLANT FOODS IN THE SOILS, AND FERTILIZER REQUIREMENTS.

The great mass of soils have been produced by the weathering and disintegration of rock powder under atmospheric influence, and it is generally found in the place where formed. Any weathering rock surface shows us the process of soil making, and the mosses and lichens that grow on the rock surface aid in deepening and enriching the soil. In some places the residual soils are thick and in others they are thin. In the regions of gentle slopes the soils have considerable depth; on the steeper slopes the soil is thin, and on the steepest slopes the rocks are bare and we have a region of waste in which but little vegetation can find a foothold. So the valuable soil must have depth, and must contain more or less organic matter. Residual soils, being derived from formations consisting of one or few ingredients, are readily lacking in some of the plant foods.

In the area under consideration the various limestones, sandstones and shales with their resulting soils are of special interest and importance, both from a geological and an agricultural standpoint, and many questions arise as to the origin, composition, requirements, adaptability and general value. The soil types in the residual soils are varied and numerous. The limestone soils grade from a light or a reddish yellow to a dark red; ferruginous sandstone and shales produce a variety of colors in their soils; the purer sandstone and shale break down into yellow soils. In passing from east to west over the residual soils the topography is varied on account of the succession of hard and soft strata, with their different rates of disintegration. The shale weathers faster than the limestone, and the limestone more rapidly than the massive sandstones.

Some of the things to be considered in regard to the proper cultivation and fertilizer needs of these soils are:

1. Topographic position.
2. Drainage condition.
3. The use of different fertilizers and leguminous crops.
4. The lasting effects of fertilizer.
5. A comparison of the various forms of the plant foods, nitrogen, phosphoric acid, potash and lime, and the amount to be used.
6. The value of commercial fertilizer as compared with stable manure.

7. Injurious effects of fertilizer on various crops.
8. Effect of fertilizer on the land.
9. Adaptability of the soils.
10. Systematic cropping system.

To carry out the above investigation a large number of soil analyses, both mechanical and chemical, are necessary, and extensive experimental work must be carried on. By mechanical analysis the soil particles are separated into different grades, and the various percentage relationship determines the class of soil, as sand, sandy loam, clay, etc.; and in addition to the fine earth the soil contains particles of larger size, it is called gravel, and of still larger called stones, so that it is possible to have gravelly or stony members of the various classes—as a gravelly loam or a stony clay.

The most important things to be considered in the determination of a type, are the texture, which deals with the size of the particles; the structure, which deals with the arrangement; the organic vegetation content, origin, color, depth, drainage, topography, nature vegetation and natural productiveness—all factors that influence the relation of soils to crops must be taken into consideration.

Accurate chemical analyses made by proper methods show much of value in determining the plant food requirements. The analysis may be made as to origin, in which case the total amounts of each element would be given; or as to food requirement, in which the available amount would be shown in most of the constituents. The objection to chemical analysis is that the total amounts of nitrogen, phosphorus, potash and other food materials may be ascertained, but that by far the greater part of the materials shown cannot be secured by the plants, and as the proportion varies greatly in different soils and for different crops, the determination of the total amount is of rather uncertain value as showing the fertilizer needs of a soil.

The experimental plan is to ascertain by the use of a number of fertilizers or the use of the individual plant foods, on the soil itself, the needs of each soil. Such tests must be carefully and systematically carried out if they are to be of any value. The purpose is to judge the effect of fertilizer from the actual increase from their use. The greatest care must be made in selecting the plots and the time of planting. The harvesting and determination of the yields must be carefully performed. Successful experimental work, requiring care and intelligence, should be performed by intelligent men and not by careless workmen.

All farmers should know that what is commonly called "plant foods" comprise three ingredients: potash, phosphoric acid and nitrogen. Eighteen elements require some consideration in connection with either soil formation or plant growth. But the three substances named above, together with lime, are needed by all plants and crops for food. These are taken up by the roots of plants and are contained in the crop which is harvested and removed from the farm. Hence, by continued cropping, a soil becomes depleted of its plant foods, or "worn out" and unproductive.

For example, as shown in the work of Prof. Wagner of the experimental station of Darmstadt, Germany, clover cut for hay removes from the soil per acre about 184 pounds of potash, 152 pounds of phosphoric acid and 212 pounds of nitrogen. Other investigations show meadow hay to contain about 2 per cent potash, and that under ordinary circumstances in a good soil at least 260 tons of soil water would be required for the hay to give its supply of potash. Clover failure is very common, but the farmer rarely stops to think that exhaustion of the soil in potash and phosphoric acid may be the cause of it.

In addition to the mineral constituents already named, it must be kept in mind that certain other elements have important places, and occur in all plants, chiefly, carbon, hydrogen, oxygen, sulphur and iron. The two groups named occur in all plants, and if any one of them is absent, growth becomes abnormal if not impossible. Plants cannot assimilate their food unless it is in a liquid or gaseous form. Of the gases, carbon dioxide and hydrogen can be freely taken from the air or from water with various substances in solution, but most plants cannot take in nitrogen direct from the air but absorb it from nitrates in the soil, hence the importance of ammonia and other nitrogenous compounds in commercial fertilizer.

Different species and different varieties of plants absorb these substances in varying proportions, and upon this fact depends largely the principle of the rotation of crops.

Potash is necessary for the formation of starch, sugar and woody fiber in plants. Phosphoric acid is needed for the formation of seed, and nitrogen is necessary for the production of leaves and stalks. But when nitrogen is in excess it will cause a rapid and excessive, watery and unnatural growth of the wood at the expense of fruitfulness.

The Value of Legumes.—The leguminous plants are those which bear on their roots little tubers formed by minute organisms called bacteria, which have the power of extracting nitrogen directly from the free air through the soil. Whenever these tubers bearing legumes are present the soil is found to be enriched with nitrogen in an available form. Such crops are clover, alfalfa, cow peas and soy beans. The ordinary crops do not have the power of taking nitrogen from the air. It has been shown that a 75-bushel crop of corn and stalks removes about 140 pounds of nitrogen from the soil. If the supply of nitrogen be profitably maintained in soils, some other method than commercial fertilizer must be used to secure the supply at an economic cost. By turning under legume crops, the non-leguminous crops, such as corn, wheat, timothy, secure their supply of nitrogen from the decay of the legume plant. The growing of such plants also enriches the soil in organic matter, thus improving the mechanical texture, making soils more retentive of moisture and consequently less subject to the effects of drouth. In order that leguminous plants may accumulate the nitrogen, it is necessary that potash and phosphoric acid be supplied if the soils be deficient in available form. Reference to the adequate amount of nitrogen will be given in a following paragraph.

"The only possible substitute for the use of stable manure is found in green manuring with leguminous crops conjointly with the use of commercial or mineral fertilizers, unless this is done by the use of the latter alone, which ultimately leads to a depletion of humus substances, which renders the acquisition of proper tilth by seed-beds impossible, and causes a compacting of the surface soil which no tillage can remedy."*

Sources of Fertilizers and Methods of Application.—All stable manure contains potash, phosphoric acid and nitrogen, but nearly always too much nitrogen in proportion to the amount of potash and phosphoric acid.

The principal sources of potash are the potash soils of Germany, and the most important of the potash salts are sulphate of potash, muriate of potash and kainit. The former two contain about 50 per cent pure potash, and kainit contains about 12½ per cent. The sulphate is best for tobacco, while muriate is somewhat cheaper and is useful for most crops. Kainit is useful also for killing grub

*Soils, E. W. Hilgard, p. 74.

worms and other insects in the soil. Wood ashes are also a source of potash.

Phosphoric acid is derived chiefly from the large deposits of phosphate rock in South Carolina, Florida and Tennessee. It is also secured from bone, acid phosphate, basic slag and other sources. Rock phosphate is insoluble and must be rendered available by chemical treatment. In chemical analysis the soils of southern Indiana usually show phosphoric acid content great enough to prove adequate, but the available amount is in most cases very low, and the proper supply of the material becomes an essential factor in the crop production.

The most important nitrogen fertilizers are nitrates of soda, sulphate of ammonia, cotton-seed meal and animal refuses, such as dried blood, dried fish, etc. For the permanent improvement of soils it should not be overlooked that time and organic matter are also important and are often deficient.

Fertilizer may be applied broadcast or drilled in. Broadcasting is best when intensive culture is practiced and large quantities are used. Where small quantities are applied it is better to drill, since in this way it comes in closer contact with the growing plants. Fertilizers will produce injury when coming in direct contact with seeds or roots of young plants. To prevent this the fertilizer may be drilled in a diluted state by mixing with a large amount of mellow soil.

Sometimes potash and phosphoric acid are applied in the fall, so that they will become thoroughly mixed with the soil before the seed is planted. Nitrogen is usually a very soluble compound, and will give best results if used at planting time or as a top dressing after planting. Several applications of nitrogen are beneficial, since any amount not readily taken up by the plant is likely to be carried away by the drainage waters.

Injurious Effects of Fertilizers.—It is claimed by many farmers that the use of commercial fertilizer has injured the land. Especially is this said to be true in the case of getting stands of clover on soil where fertilizers have been used. Others think that the purchase of fertilizers for any crop does not pay. In most cases, however, the true cause of poor yields is due to improper drainage condition of the land and careless methods in the use of fertilizers and care of the soil. Fertilizers alone will not produce good crops. Fertilizer crops should be grown and the products returned to the soil as much as possible to keep up the humus supply and improve the texture. Since the soil of southern Indiana contains very little lime, the use of acid phosphates might cause acidity of the soil, but this could be readily overcome by the application of lime in any of the various forms. A top dressing of manure will often aid in securing a stand of clover. Where fertilizer tests have been made continually for a number of years the use of the fertilizer materials have not proved injurious to the soils.

Plant Food Contents Shown by Analysis of Southern Indiana Soils.—In the soils of Indiana derived from the limestone formations, while they have a marked degree of fertility, the lime content is low. In most cases these soils are "acid" or "sour." At first thought it would appear that soils produced from formations containing about 98 per cent lime carbonate would be strongly calcareous. But since this lime carbonate is highly soluble, the penetrating roots and heavy rainfall have leached these soils of the lime, and one of the things necessary for high productions is the application of lime on the surface. In the presence of high lime content relatively low percentages of phosphoric acid and potash prove adequate, while the same or even higher amounts, in the absence of satisfactory lime percentage, prove insufficient for good production. It has been found by observation and numerous analyses that the higher the clay content of a soil the more lime carbonate it must contain to have the value of a lime soil; and that while in sandy lands growth may follow the presence of only .10 per cent lime, in heavy clay soils not less than about .6 per cent should be present to bring about the same results. The dark-tinted humus characteristics of calcareous lands do not appear in clay soils until the lime percentages rise to nearly 1 per cent, while in sandy lands a much smaller amount, or about 2 per cent, will produce this effect. In heavy clay soils where the lime content falls below .5 per cent, lime vegetation is lacking and a growth of black jack and post oaks is found, which indicates soil too poor for profitable cultivation. While phosphoric acid, potash and nitrogen are the leading plant foods, lime is an important factor in soil fertility and exerts a wide influence upon plant distribution.

The analyses of limestone soils of Indiana show in the surface soil about .50 per cent calcium oxide, and .35 per cent potassium oxide and .15 per cent phosphoric acid anhyd. The first foot below the surface soil shows an average of about .55 per cent calcium oxide, .45 per cent potassium oxide and .18 per cent phosphoric acid anhyd. The third foot down to rock mass shows an average of about 1.5 per cent calcium oxide, .60 per cent potassium oxide and .17 per cent phosphoric acid anhyd. We see from the above that the lime content is lower than that of true calcareous soil, the amounts of total phosphoric acid and potassium oxide are low and that the amount contained within these percentages of readily obtainable material would be very small, and these soils are likely to call for earily fertilization.

The analysis of Indiana soils from the Huron, Mansfield and Coal Measure sandstones show in the surface from .41 to .58 per cent calcium oxide; from .20 to .35 per cent potassium oxide; from .12 to .15 per cent phosphoric acid anhyd, and total soil nitrogen from .089 to .096. Ferruginous sandstones derive no important ingredients from their cementing materials, which are chiefly iron hydrate, and since the sand itself is very siliceous the soils derived from the distintegration of these formations is very poor. Clayey sandstone, or where a series of thin-bedded sandstone and shale occur, the product of disintnegration is usually sandy loam with a fair degree of fertility.

The alluvial and lake plain soils show in the surface soil from .35 to .50 per cent of calcium oxide in Patoka Lake plain soil, to .85 per cent in those of the Ohio valley; potassium oxide varies in the former from .21 to .35 and in the latter to .49 per cent; phosphoric acid, .09 to .17 per cent in the former to .27+ per cent in the latter. The total soil nitrogen is about the same in each, showing from .08 to .10+ per cent. These soils show that they have formerly been subjected to the leaching power of stagnant waters.

Various shale soils show calcium oxide from .52 to 1.30 per cent; potassium, .41 to .85 per cent; phosporic acid about .15; total soil nitrogen about .15 per cent. The shales upon disintegration produce heavy, clayey soils, and are usually fairly rich in the various plant food, but usually the texture of the soil prevents successful tillage.

Iron colors clay, either red, yellow, green or blue; the latter two colors turning to red or yellow upon exposure to the air.

By careful investigation less than one-fourth of one per cent of potash is likely to constitute a deficiency. One-fourth of one per cent is usually high for phosphoric acid content. One-tenth of one per cent of P_2O_5 may prove adequate, but soils showing between .1 per cent and .05 per cent are weak and liable to need phosphate fertilization very early. In soils with a weak phosphoric acid content a high percentage of lime carbonate or the presence of a large supply of humus often produce good results by bringing about greater availability of the phosphates. In the absence of lime carbonate, ferric hydrates may render phosphoric acid inert by the formation of insoluble ferric phosphate. The nitrogen content in soils is variable and the amount necessary for plant growth depends largely upon other soil conditions, as moisture, etc., and upon the nitrification of the organic matter of the soil. In determining the nitrogen content of soils a great many methods have been used; but all agree that about one-tenth of one per cent (.10) is the ordinary adequate amount. Since the amount of nitrogen in humus is very variable, such cannot be used as a basis of estimation. The total amount of nitrogen in the humus varies from 1.7 to nearly 22 per cent. In dry regions, however, it has been found that one per cent would indicate that the soil would not be in need of nitrogen-fertilization for a number of years. It has also been shown that for the growth of grain a nitrogen-percentage in the humus of 1.7 is wholly inadequate, although a large amount of humus be present. It is impossible to give the exact amount, for all plants and soils, of the nitrogen content necessary; but "it appears to be necessary to keep the nitrogen-percentage of soil-humus near 4 per cent to insure satisfactory production."

SUMMARY.

Southern Indiana soils show marked deficiency in plant food, having been derived from formations containing but few chemical ingredients. They are low in organic content and of such texture as to be difficult of cultivation in many cases.

Rock phosphate is a cheap source of phosphorus where immediate returns are not required. Such might be applied to the land and acid phosphate used for the immediate crops. Large quantities of phosphorus, and potassium and in many places lime will have to be applied to southern Indiana soils if their conditions are to be improved.

To use legumes profitably they must be supplied with potash and phosphoric acid, and the crop turned under as green manure, or used as forage and returned to the soil in the form of manure.

When the crops such as wheat, corn, oats, barley, and potatoes, are sold from the farm, they should be followed by leguminous crops. In corn, wheat and clover rotation, the clover should be plowed under for the corn crop, as it requires more nitrogen than wheat, and is also better adapted to using it in the form of organic matter.

It is usually better for farmers to buy ready-mixed fertilizers but they should also understand the needs of the soils and be sure they are paying out money for the proper ingredients.

Many of the sandy and loamy soils of southern Indiana are well adapted to the growing of potatoes, and this industry should be engaged in far more extensively. A good fertilizer to use on these soils for the growing of potatoes is as follows:

Ammonia	6 per cent.
Available phosphoric acid	7 per cent.
Potash	8 per cent.

The sulphate instead of muriate of potash is recommended.

The growing of tomatoes for canning factories is becoming of importance, and by the proper care and fertilization the crop can be made a most profitable one. Tomatoes should not be grown continuously on the same land, or on that which has been devoted to potatoes or melons, as all of these are subject to blight. Tomatoes respond well to heavy nitrogenous fertilization. About fifty pounds per acre of nitrate of soda should also be used around the plants during the cultivation of the crop.

The following fertilizer is recommended:

Ammonia	5 per cent.
Available phosphoric acid	6 per cent.
Potash	7 per cent.

Or as an equivalent:

Nitrate of soda	200 pounds
Cotton-seed meal	700 pounds
Acid phosphate	840 pounds
Muriate of potash	260 pounds
Total	2,000 pounds

Not less than one thousand pounds per acre of fertilizer should be used for the crop.

Careful cultivation of the soils in this section of the State did not receive much attention. The virgin soil is naturally productive, but by the continual cropping, especially of successful corn crops, the soils were soon depleted. Then the value of fertilizers and crop rotation began to receive attention. The farmer of today must experiment to see what his soil needs. The State would add much to its wealth by carrying on extensive experimental work on these soils. The work of the present survey and additional information to be gained should prove beneficial to the farming population of that region, and will give to those in other parts of the State, who may be seeking new locations, some idea as to the agricultural conditions, general improvement and facilities of the counties herein discussed.

SOIL SURVEY OF DAVIESS COUNTY.

By L. C. Snider.

History.—Daviess County was settled by immigrants from Kentucky, who located in the hills along the East Fork of White River. The first white settler of whom there is any record came to the county about 1806. The growth of population was tolerably rapid, although retarded somewhat by Indian troubles. During the early years of the settlement previous to the War of 1812, five white settlers and one Indian were killed in the county.

Daviess was originally part of Knox County, but was organized as a separate county in 1816, and named in honor of Colonel Joseph Daviess, who fell at the Battle of Tippecanoe. It then contained all of Greene and Owen counties east of the West Fork of White River and all of Martin County north of Lick Creek. Gosport was at the northeast corner of the county. The formation of Greene County in 1821 and of Martin County in 1820 reduced the county to its present size. The county seat was located at Liverpool in 1817, and at the same time the name was changed to Washington.

Geography and Geology.

Location and Area.—Daviess County is located in the southwestern part of the State, about midway on the line from the center to the southwest corner. It is bounded on the north by Greene County, on the east by Martin County, on the south by Pike and Dubois counties, with the East Fork of White River between, and on the west by Knox County, with the West Fork of White River between. It averages about twenty-five miles in length from north to south and about fifteen miles in width. It has an area of 426 square miles.

Land Surveys.—Practically all of the land is laid off according to the U. S. system of land surveys, but in Washington Township there are several plots that date back to the old French surveys. These are called donations and locations.

In 1771 each head of a family in Vincennes was granted 400 acres of land by the French government. This grant was confirmed by the United States government when it acquired the territory and an additional grant of 100 acres was made to each man of the settlement who had served in the American army or militia.

These lands were surveyed back from the Wabash, one set of boundary lines running at right angles to the general course of the river and the other set at right angles to the first. The rectangles thus formed were called donations.

In laying off the donations previous grants were disregarded, but the owners of these grants were allowed to locate an equal tract of land in an area outside the donation land. These locations may be of any size or shape, but those in Daviess County are all rectangles, with the boundaries running north and south, and east and west. There is a strip of donation land along White River northwest of Washington and several locations, all within a few miles of the same city.

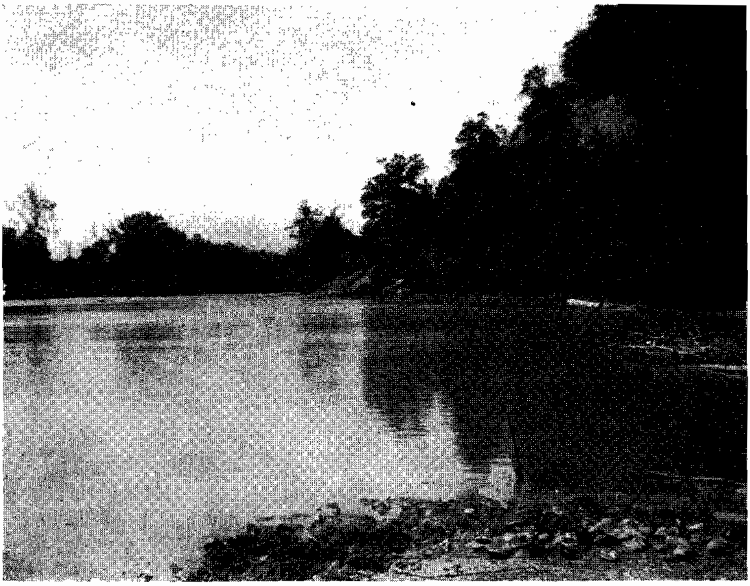
Townships.—There are ten civil townships as follows: North row, Elmore and Madison; second row, Steele, Bogard and Van Buren; third row, Washington and Barr; south row, Veale, Harrison and Reeve.

Drainage.—The county lies between the two forks of White River, and is drained by this river and its tributaries into the Wabash. The principal tributaries of the West Fork are Furst Creek, Indian Pond Creek, Smothers Creek, Prairie Creek, and Veale Creek. Those of the East Fork are Aikman's Creek, Camp Creek, Mud Creek, Sugar Creek, and Slate Creek.

Stratigraphy.—The entire county is underlaid by the rocks of the Coal Measures or Pennsylvania system, and is consequently an important coal producing county. Several layers of coal occur which vary from a few inches to five or six feet in thickness.* The remainder of the Coal Measure exposed consists of shales, sandstones and fire-clays of varying thicknesses. One heavy ledge of sandstone outcrops along the East Fork of White River forming "High Rock," but most of the layers are thin and soft, and do not stand out in relief.

Glacial Action.—The ice-sheet of the Illinois invasion covered the whole county. The surface was leveled to some extent, the hills smoothed down and the valleys filled up, in some instances to the depth of seventy or eighty feet. Many of the smaller streams run in their pre-glacial channels, but at a level of several feet higher than before the ice age. In almost every well and coal bore evidences of this ice invasion are found in the gravels, clays and sands, which are passed through before solid rock is reached. The major portion of this drift is a clay or till which contains many

* For complete report on the coal of Daviess County, see the Report of the Department of Geology and Natural Resources for 1898.



"High Rock," East Fork of White River.

Ferry Southwest of Washington.

pebbles, some of granite and foreign rocks, and other of chert and hard limestone of the Mississippian system to the northeast. In many places leaves, stems and even trunks of trees have been found beneath the blue clay which forms the lowest layer of the drift sheet.

The average depth of the drift is several feet, but over much of the area it is very thin, and in some places altogether absent, and the residual soil derived from the weathering of the bed rock comes near the surface. Spread over the surface of the drift and the residual soil is a layer of fine yellow silt and clay which is from a few inches to several feet in thickness. This is the "loess" or outwash from a later glacial invasion, the Iowan. It covers all the uplands of the county and is the dominant soil type. It will be discussed more fully under "loess" of the soil types.

Elevations and Topography.—The highest elevation is a little over 600 feet, in the northeast part of the county near Raglesville, and the lowest is 396 feet at the extreme southwestern corner. Washington is 484 feet above sea level, and this is about the level for a large part of the county.

The Mansfield Sandstone which outcrops in the northeastern townships gives this section a broken topography, with rather high hills and steep slopes. This portion includes most of Madison and Van Buren townships. The country to the south and west is much more level and there is much prairie land along Smothers and Prairie creeks in Elmore and Bogard townships. Washington and Barr townships are mostly level, becoming rolling in some portions, with a few tolerably high hills. The village of Montgomery is located on one of the highest of these hills. The townships along the East Fork (Veale, Harrison and Reeve) are rolling in the northern portions, but become broken and hilly as one approaches the river.

The West Fork has a valley of from one to three miles in width in the northern part of the county, but it becomes much narrower along the southern third, where in some places the river runs against the bluffs on the east side. The valley of the East Fork is about one mile wide through Veale Township, but farther up the river it is very narrow, seldom reaching a breadth of one-fourth mile.

Cities and Towns.—Washington, the county seat, is located at the intersection of the B. & O. S.-W. and the E. & I. railroads, about three miles back from the West Fork of White River. It was platted in 1817 and made a city in 1871. At present it has a population of between 9,000 and 10,000. It is the trading center for most of Daviess County and a portion of eastern Knox County. The manufacturing industries include a seating company, two foundries, two grain elevators, a canning company, a sawmill, a planing mill, etc. The shops and roundhouses of the B. & O. S. W. Railroad are located here, and give employment to many men. Coal is obtained very cheaply from mines in the vicinity. Improved roads lead out from Washington in all directions.

Odon (923)* is situated in the southwest part of Madison Township, on the S. I. Railroad. It was platted in 1846, and has grown to be an important mining and trading center.

Elnora (908) is located at the intersection of the E. & I. and the S. I. railroads in Elmore Township. It was platted in 1885 and has enjoyed a very rapid growth. It is the center of the agricultural trade for the northwest part of the county, and has a large canning factory.

Plainville (400), on the S. I. Railroad, in Steele Township, is a great shipping point for watermelons.

Montgomery (600) and Cannelburg (280) are on the B. & O. S. W. Railroad in Barr Township. They are both mining and trading centers.

Alfordsville (254), Raglesville (132), Epsom (106), Glendale (98), Cornettsville (70), Cumback (60), Corning (25), and Waco (20) are small country villages.

Sandy Hook, Jacobs, Thomas, Jordan, Albright, Hyatt and Graham are merely stops with sidetracks along the E. & I. Railroad. They serve as loading points for much of the produce from the West Fork valley.

TYPES OF SOIL.

The soils of Daviess County may be divided into the following general types:

(a) River and stream bottom land.
(b) Prairie or low flat land.
(c) Sand knolls and ridges.
(d) Upland clays and loams.

Each type will be taken up and discussed somewhat fully and the variations noted as far as possible.

(a) *River Bottom Lands.*—These soils cover the low-lying flat lands along the East and West Forks of White River and narrow

* Population according to census of 1900.

belts along the principal streams. They are generally black sandy loams, although in some localities they are more nearly silt or clay loams. The sand is usually more plentiful in a belt following the stream, and in another along the foot of the sand hills. Between these two belts the soil is usually more clayey in texture. However, the percentage of sand may vary greatly within small areas.

The subsoil is ordinarily a stiff, tenacious, black clay, with much sand. This is often underlaid by gravel.

Mechanical analyses of samples of this type of soils show the following percentage composition:

MECHANICAL ANALYSES OF RIVER BOTTOM SOIL.

Number.	LOCATION.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
1	Valley of West Fork, five miles northwest of Washington	0.3	0.8	12.6	28.0	26.8	31.5
16	Subsoil of same	0.8	2.9	18.4	27.8	25.8	24.3
2	Prairie Creek Valley, North of Washington	0.0	0.2	0.8	17.0	50.6	31.4
2b	Subsoil of same	0.0	0.4	1.8	19.2	51.4	27.2
3	Valley of West Fork, two miles southwest of Plainville	0.0	0.0	1.6	40.0	38.8	20.0

The principal crop on the bottom lands is corn, which usually does very well, producing from sixty to eighty bushels per acre. Much wheat is raised and yields well unless injured by overflows. The present season was a very hard one on this type of soils. There was a general overflow in May, and since that time there has been practically no rain, so that the ground became extremely hard and difficult to tend.

As a rule there are few improvements on the bottom lands, and these are not first class. The people who farm these soils mostly live on the sand or clay uplands farther back from the river in order to avoid the floods and bad roads as much possible.

The soil in the lower parts of the valleys of the smaller streams is very much the same as in the river bottoms, except that it contains less coarse sand. Nearer the heads of the streams it grades into a white clay or "crawfish" land. This occurs only where the valleys are narrow and there is not a great amount of it. The largest areas are along Furst Creek and in the upper part of the Prairie Creek valley.

(b) *The Sand Areas.*—The principal sand area is a broad belt averaging about a mile in width which extends almost parallel to the West Fork of White River and lies between the bottom lands and the clay soils. The width of the belt varies greatly. Near Elnora it is over three miles, while south of Veale Creek there is a place where the sand is absent, and the clay soil comes directly up to the river bottoms. There are many small knolls of sand occurring occasionally through the bottom land, most of which are too small to be mapped, although some of the larger ones cover several acres.

As shown by mechanical analysis this soil is almost a pure sand, over eighty per cent grading as fine sand and very fine sand. The sand is usually of a brown or reddish color on the knolls and ridges, while on the level places and in the small troughs or valleys it is black and contains a larger percentage of silt and loam. There is little difference between the surface soil and the subsoil, except that the surface is darker in color due to the presence of organic matter. The sand is of different thicknesses, often being several feet in depth along the side next to the river, but becoming very thin on the hills along the eastern side of the belt.

The sand is a very productive soil and is very easily tended. All crops do well except during excessively dry seasons, when they are liable to be more or less injured on account of the drying of the soil to a considerable depth. Corn and wheat are grown extensively and fine crops of hay are produced. The soil is unequaled for the growing of watermelons and there are usually between 800 and 1,000 acres planted to this crop.

As the soil contains a relatively small amount of fine material (silt and loam) it is easily exhausted and must be cropped judiciously to be kept in good condition. Nearly all the farmers practice crop rotation to accomplish this result. Clover is used extensively as a rest crop and for hay, but in the last few years cowpeas have replaced it to some extent on this soil. By many farmers they are considered preferable to the clover both for their effect on the land and for feed. Hundreds of acres are grown in the county, the greater part on this soil. Little commercial fertilizer is used and this is sown with wheat to insure a good stand of clover. As a rule the improvements on the sand are fair, much better than those in the bottoms.

There is one large sand area along the East Fork in the southeastern part of Veale Township. It seems to be similar in every way to the sand belt of the West Fork except that it is usually of a more pronounced red color. A few narrow strips of sand occur farther up the river, but they are too small to be mapped.

Another area which is mapped as sand, but which varies somewhat from the area just described, lies in the western part of Bogard Township, north and west of Cornettsville. This soil is almost a prairie soil, the flat, level portions are black in color, but the low, rounded knolls and ridges are covered with sand which is almost white. It is seldom over a few feet (two or three) in thickness, and is underlaid by the yellow clay. The black portions are also very sandy, being apparently the same as the white, but with a higher percentage of organic matter. It is a very productive soil except where the white sand is too thick. The sand is very fine and seems to have been carried by the wind from the large sand belt lying to the west, and spread as a thin mantle over the level land.

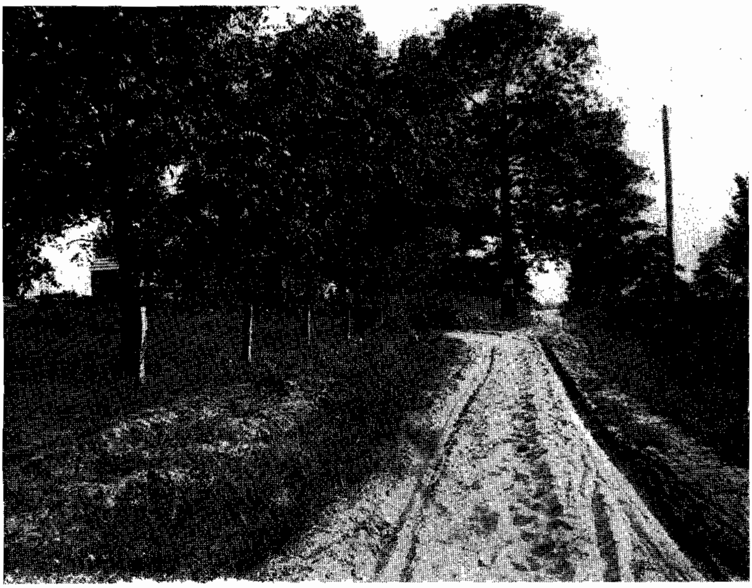
The origin of the sand of the large belt has not been worked out definitely, but it is probably due to wind action during and following the Wisconsin glacial epoch, while the wind was prevailingly from the northwest and before the land was extensively covered with vegetation. This seems to be borne out by the obscure stratification of the sand which may be noticed on steep faces of road cuts and similar localities.

Mechanical analyses of the sand show the following percentage composition:

Number.	LOCATION.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
4	N. W. Cor. Sec. 5, Washington Tp., southwest of Washington	.0	.0	.1	17.8	65.0	16.4
4b	Subsoil of same	.0	.0	.3	22.4	72.2	8.1
5	S. W. Cor. Sec. 31, Elmore Tp	.0	.0	1.0	36.2	56.0	6.8

(c) *The Prairie Areas.*—"The Marsh." This is an area of ten or twelve square miles lying in southeastern Elmore Township and the north row of sections of Bogard Township. It is a level, low-lying tract of land, most of which was formerly covered with water during much of the year, but which has been drained by the dredging of Smothers Creek and by the digging of many tributary ditches. At present the crops are somewhat injured by wet seasons, but there is little or none of the area which is not tillable.

The soil is of a black color and of varying texture. The lowest portions are mucky with very little sand. There are many small sandy knolls scattered through the area, but the prevailing type is intermediate between the sand and the muck, a sandy black loam. Along the eastern side is a rather narrow belt of white clay. This



Road Through the Sand Land, 2½ Miles Northwest of Washington.

Showing Contact of Lighter Colored, Fine Textured Loess with the Coarser Underlying Drift, 3 Miles Southeast of Washington.

soil is very productive, corn yielding sixty to eighty bushels per acre, and wheat from twenty to thirty bushels. Clover and timothy meadow both produce very well. Wet seasons are the worst on this soil, but it can withstand long drouths.

"Alkali Land."—Throughout this marsh region are many spots varying in size from a few square feet to five or six acres, which are called "alkali land." These spots produce fair yields of wheat and other small grains, but will not produce corn. The corn usually comes up and starts well, but soon turns yellow and stops growing. It seldoms reaches over two feet in height and rarely bears even a "nubbin."

Although called alkali these spots are probably acid, due to the incomplete oxidation of the vegetable matter of the old marsh. They are also poorly drained as is shown by the fact that the soil in these spots is wet and "mushy" at the depth of a few inches, even in very dry seasons. The methods of improving this condition are to improve the drainage which may often be done by tiling, and by adding postash either by plowing under straw or by giving a dressing of kainit or some other potash fertilizer. These plans have been used very successfully in reclaiming similar soils in the northern parts of the State.

"The Lagoon."—This is an area of approximately one and one-half square miles, principally in section 23 in the south part of Steele Township. The soil seems similar in every way to that of the marsh.

(d) *The "Loess" or Upland Clay.*—This soil, which covers by far the greatest area of any of the soil types, is the outwash and wind blown deposit from the last or Wisconsin glaciation. The ice-sheet did not reach this far south, but the wind and the high waters caused by the melting of the glacier, spread this soil as a covering over the land for some distance in advance of the ice.

The soil is classed as a silt loam. It is of fine texture, containing no gravel and only a small percentage of sand. It has a yellow to brownish color where not exposed to the action of the atmosphere and of vegetation. Cultivated fields when dry are of an ash-gray color. Owing to its fine clayey texture the soil holds moisture well, and where it is sufficiently deep the crops are seldom injured by drouth. The depth of the soil varies greatly. On the hills in the northeast part and in the southern part of the county it is not over two or three feet in depth, and on the steeper slopes is often lacking. In the broad level belt which extends across Washington and Barr Townships it often reaches a much greater depth.

The "Loess" is well suited to the general crops and produces very good yields of them. Wheat on the level lands yields from twenty to thirty bushels per acre, corn from forty to seventy bushels, and hay does well. Clover is used extensively for hay and to keep the land in good condition. On the more hilly regions, where the loess is thinner the yields of the grains are much lower, wheat producing from ten to twenty bushels, and corn from twenty to forty bushels per acre. There is little done in the way of attempting to grow diversified crops.

In the eastern part of Barr Township, this soil lies very low, and has been leached out until it is a white instead of a yellow clay. It is not quite so productive as the yellow clay, and is more injured by wet weather, but is otherwise the same, and as the boundaries are not well defined no attempt was made to separate them in mapping.

Following are several mechanical analyses of the loess:

Number.	LOCATION.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
6	Near R. R., one mile north of Sandy Hook......	0.1	0.2	1.2	1.0	7.2	90.8
6b	Subsoil of same..............................	0.3	0.2	2.8	9.8	20.0	66.4
7	North part of Sec. 20, Barr Tp., north of Canelsburg..................................	0.0	0.0	0.7	3.5	6.5	89.2
7b	Subsoil of same..............................	0.0	0.0	0.8	3.4	12.6	82.4
8	South of Veale Creek in Sec. 16, Veale Tp......	0.0	0.0	0.2	1.0	3.4	95.2
8b	Subsoil of same..............................	0.0	0.0	0.8	2.0	4.2	93.0
9	Three miles north of Oden, Madison Tp.........	0.0	0.2	1.2	4.8	8.6	84.6
9b	Subsoil of same..............................	0.0	0.2	0.8	5.0	7.4	85.8
10	Northeast Cor. Bogard Tp. (white clay).........	0.2	0.4	0.8	1.2	10.0	87.4
11	East part of Barr Tp., southwest of Loogootee (white clay)...............................	0.0	0.0	0.4	1.2	6.8	92.4

Drift and Residual Soils.—As has been said the drift and residual soils underlie the surface soils of the whole county, but are too deeply buried to affect agricultural conditions very much except in a few localities. In northeast Madison Township the loess is very thin, and the soil and conditions resemble those of the Mansfield residual area to the east. Along the East Fork of White River is another area of thin loess and on the slopes it is often removed and the drift exposed or this may be removed and the residual soil be at the surface. These areas are small and mostly uncultivated so they are not mapped separately. Although the drift and residual soils do not affect the grains and grasses very extensively there is no doubt that they are a prominent factor in determining the tree growth over much of the county.

Areas of Each Type.—The approximate area in square miles of each of the types described is as follows:

River and stream bottoms	90
Sand areas	50
Prairie areas	25
Loess or yellow clay	260

Names of Types.—The names selected for the different types in this report are those in common use by the residents of the county. No attempt has so far been made to bring the soils under the classification adopted by the Bureau of Soils of the U. S. Department of Agriculture. However, it may be well to bring the types under this classification for the purpose of comparison with other sections of the country. The following table is believed to give the relations between the common names and those of the Bureau of soils.

Name in This Report.		*Bureau of Soils Survey Name.*
Loess or yellow clay		Miami silt loam
River Bottom	Sandy	Yazoo sandy loam
	Silts	Yazoo clay and Yazoo loam
Sand areas		Miami sand
Prairie and Marsh Soils	Sandy	Waverley sandy loam
	Silts	Waverley silt loam
White clay (of small streams)		Memphis silt loam

Agricultural Statistics.—Daviess is a leading county in many agricultural products. The following statistics are for 1906, the latest complete reports available:

Corn, 52,836 acres, average yield 37.96 bushels; oats, 15,898 acres, average yield 24.54 bushels; wheat, 38,471 acres, average yield 15.57 bushels; timothy, 16,264 acres, average yield 1.16 tons; clover, 4,424 acres, average yield, 1.18 tons.

Of what may be called special crops the acreage was as follows: Potatoes, 328 acres; tomatoes, 59 acres; peas, 438 acres; watermelons, 648 acres; canteloupes, 52 acres; tobacco, 27 acres.

Live stock statistics were as follows: Horses sold in previous year 1,069, horses on hand 7,188; mules sold in previous year 689, mules on hand 1,289; dairy cattle on hand 6,176, beef cattle 3,606, cattle sold in previous year 4,076; hogs on hand 22,182, hogs sold in previous year 37,122, hogs died of disease 2,486; sheep on hand 4,364, sheep sold in previous year 2,695; wool clip, 27,046 pounds.

In 1906 Daviess ranked seventh of the counties of the State in average yield of clover hay, seventh in acreage of peas, fifth in acreage of watermelons, and ninth in number of bearing apple trees.

ECONOMIC CONDITIONS.

Improvements.—The general conditions on the farms of Daviess County compare favorably with those in other parts of the State. On the level clay around Washington the houses and other buildings are far above the average, and the fencing and general appearance correspond. As has been said there are very few improvements on the bottom lands. Those on the sand land and the hilly clay are fair to good as a rule.

Land Values.—As nearly as could be ascertained the range of prices for land of the different types is as follows: Level, yellow clay, $90 to $100 per acre; bottom land, $70 to $90; sand land and level white clay, $50 to $80; hilly clay, $15 to $30; rolling clay, $30 to $50; "marsh" land, $90 to $110. The price naturally depends largely on distance from market, improvements, roads, etc.

Transportation.—Daviess County is tolerably well supplied with railroads. The Evansville & Indianapolis crosses it from north to south, following the line of the old Wabash and Erie Canal, parallel to the general direction of the West Fork of White River. The Baltimore & Ohio Southwestern crosses from east to west a short distance south of the middle, and the Southern Indiana crosses the northern part from northwest to southeast. The greatest distance from a railroad station is about fifteen miles, in the southeast corner of the county.

Although the county is practically without material for the construction of improved roads, much is shipped from other places and many of the roads are in good condition. Most of the improved roads are built of river gravel shipped from Vincennes on the Wabash River or from Elliston on the West Fork of White River. In the northern half of the county there are some limestone roads, the material being brought in over the Southern Indiana from the quarries near Bedford.

The expense of building these roads is very great, as the gravel costs from sixty to seventy cents on board cars at Washington and then must be hauled as high as ten or twelve miles. In many localities the cost would be considered prohibitive, but the people of the county seem to be impressed with the value of the improvement and are willing to pay the price.

All the roads leading from Washington are improved for several miles into the country and many of the "feeders" are improved for some distance from the principal roads. Reeve Township is the only one with no improved roads.

Of the natural roadways little need be said. Those in the bottoms are little better than lanes between the fields. The sand roads are fairly good in wet weather. In dry season, however, the roadbed becomes a mass of loose sand several inches deep, which makes traveling tremendously laborious. The clay roads are very muddy when wet, very rough when frozen and very dusty in dry weather.

Water Supply.—In no section of Daviess County is there any great difficulty in obtaining a good supply of water. In the valleys, good veins are found at the level of the water in the streams and rivers. Where the drift is thick over the level and rolling portions good veins are usually found in some of the sand or gravel layers. In the sand areas the water usually lies a short distance below the bottom of the sand. The extremely hilly regions are not so fortunate, but even here water is often obtained in one of the loose textured sandstone layers of the coal measures at a moderate depth.

Fruit and Special Crops.—Fruit growing for market does not receive the attention it deserves. The soil is fitted for almost any kind of fruit and the transportation facilities for most of the county are fair. Apples and peaches do very well and the yield of both is far above the average for the State. Many of the peach trees are of selected varieties, but the majority are seedlings which produce only a fair quality of fruit.

Of what may be called special crops, watermelons are of greatest importance. All of these are grown on the sand land near the E. & I. Railroad. The cost and labor of raising them are considered to be about twice that of an equal acreage of corn. There are usually between 600 and 1,000 acres planted. Cowpeas are used in rotation with watermelons to keep the land in good condition.

There are cainning factories at Washington and Elnora and at Loogootee, just over the line in Martin County. These use the tomatoes from about 500 acres annually. The yellow clay is good for tomatoes, but they seem to do best on the white clay in the eastern part of Barr Township and in a belt around the eastern edge of the marsh. No effort is made to utilize any products other than tomatoes.

Use of Fertilizer.—While large quantieies of commercial fertilizer are used, it is not depended upon to nearly so great an extent as in the counties farther east. Practically none is used in the bottoms or on the sand. On the clay it is often used to insure a good stand of clover. A few farmers use it with corn. When it is used there is little care taken in selecting a fertilizer of the proper composition to suit the soil or the crop for which it is intended. Great attention is paid to crop rotation and as a result most of the land is in fair producing condition.

Ditching.—Much of the valuable land of the prairie and marsh areas was formerly too wet to be of any value, but with the dredging of Smother's, Indian Pond and Prairie creeks the water level was made low enough to make these lands some of the most productive in the county. Several branches to these streams were also dredged. Two of these branches occupy the bed of the old canal, one draining into Smother's Creek and the other into Prairie Creek. The "sugar lands" were also improved by the construction of a branch to the Prairie Creek ditch.

The land lying along these big ditches is fairly well provided with smaller open and tile ditches. A good deal of the level clay is ditched, but much more could be greatly improved by tiling.

Renting.—By far the greater number of farms in the county are of moderate size, and are farmed by the owners. However, there are a few large land holders and, especially in the bottoms, the land is farmed by renters. The usual terms are for the renter to give two-fifths of the crop and haul it to market. A farmer's union has been formed in the south part of the county to have the owners share reduced to one-third.

Native Trees.—The common trees of the uplands are chestnut, white, post, yellow and Spanish oak, shagbark hickory, black walnut, yellow poplar, sassafras, wild cherry, sugar and black maples, black gum, persimmon, and white ash. Those of the lower lands are white walnut, shellbark hickory, willow, cottonwood, paper birch, beech, bur, red, pin, water, and swamp white oaks, slippery and white elm, sweet gum, sycamore, silver and white maple, and red and black ash.

General Summary.—Daviess easily ranks as one of the leading agricultural counties of the south part of the State. There are four general soil types, the river and stream bottoms, the sand, the marsh or prairie areas, and the upland clay. The predominance of the last type makes the production of the staple crops (corn, wheat, hay and live stock) the leading feature. The transportation facilities are fair. The most encouraging feature is the interest the farmers take in improving their condition and in the betterment of the soil.

THE PETROLEUM INDUSTRY IN INDIANA IN 1908.

BY

W. S. BLATCHLEY.

The Petroleum Industry in Indiana in 1908.

By W. S. Blatchley.

The history of the petroleum industry in Indiana for the year 1908 can be written in few words, chief among which is retrogression. The number of bores sunk and the output in barrels were both less than in any year since 1893, when the industry was in its infancy; while the number of former producing wells abandoned was far greater than ever before, there being more than five wells abandoned for every bore put down.

This great decline was not due to the lack of productive territory, for large areas which undoubtedly contain oil in commercial quantities lie along the borders of the former producing Trenton rock area, or in the intervals between the wells within its bounds. Nor was the decline due to the price of the product, which averaged higher than in any year since 1904. Rather was it due to the absence of the principal operators formerly producing in Indiana, they having migrated to Illinois and other fields, where the output per well is much greater than in this State. The average oil operator is ever on the lookout for a "gusher" or big producer, and quickly abandons a territory where the wells are light, even though they are lasting and the profits fair, for one which promises a bigger yield per well, though his final profits are often less. Added to this absence of the leading operators were three other contributory causes of the decline in operations, viz.: (a) lack of investive capital, due to the monetary panic of the year; (b) the excitement and unrest due to a presidential campaign; (c) the unprecedented drought of the summer and autumn months which brought about a lack of water for drilling and pumping in many portions of the field. These were the reasons why Indiana's once chief mineral resource was outranked in value by three or four others in the year just past.

THE OIL PRODUCING ROCKS OF INDIANA.

Crude petroleum or "rock oil" is known to occur in commercial quantities in three geological formations or horizons of the State, viz.: *The Trenton Limestone* of the Lower Silurian Age; the *Cor-*

niferous Limestone of the Devonian Age and the *Huron Sandstone* of the Subcarboniferous Age. In each of these it occurs in quantity only where the rock is sufficiently porous to form a holding or storage reservoir. Moreover, this reservoir must be immediately overlain by an impervious cover of shale and must be located in the flanks or crest of an anticline. Where these three conditions exist in connection with the geological formations above mentioned, oil in commercial quantities *may be* found. Wherever any one of the three is absent, it will never be found.

It is from the Trenton limestone formation, in an area northeast of the center of the State, that the great bulk of the crude petroleum has been and is being produced.* The different counties which are in part underlain by this productive area will be mentioned in order, and a very brief statement of the industry for the year within their bounds be given.

THE TRENTON ROCK OIL FIELDS OF INDIANA FOR THE YEAR 1908.

Grant County.—This county five years ago headed the list in the Trenton field in oil development, but in 1908 the great majority of the new bores sunk were small producers, starting at less than ten barrels, many of them at only three to five barrels each. The lack of gas for fuel and, in the latter part of the season, of water for pumping, greatly retarded active operations.

The best wells sunk in the county during the year were in Van Buren Township, which comprises one of the oldest and best productive areas of the State, every one of its 36 square miles having yielded oil in quantity. Bores on the Ballhofer lease in the southwest quarter of section 5, on the Kily farm in section 9 and on the Reed farm in section 26 started at 80 to 100 barrels each. These were on undrilled locations in the midst of wells sunk several years ago, and prove that a bore in good territory only drains a few acres in its immediate vicinity. Another bore of a similar kind was No. 13 on the Creviston lease in section 1, Washington Township, which pumped 80 barrels the first day.

The only new territory opened up in the county during the year was in the southern half of Monroe Township, where a number of small producers were finished on leases which had hitherto yielded only gas. Some of the tests in this area, however, came in dry, two of these being in the southwest quarter of section 28. A few

*For a map of this area and a detailed report on the oil industry therein see the paper "The Petroleum Industry in Indiana in 1906" by W. S. Blatchley, in the Thirty-first Annual Report of this Department, pp. 429-558.

fair producing test bores were also finished on sections 33 and 36, Mill Township.

Altogether but 90 bores were sunk in the county during the year, seven of which, or 7.7 per cent, were dry. The average initial output of the producing wells was nine barrels each, or a gain of 1.5 barrels over that of 1907. Much of the productive area in the county yields heavy salt or "blue lick" water, and the gas supply has become so meager that most of the oil must be pumped with steam engines using coal for fuel. Small producing wells cannot, therefore, be pumped with profit, and as a result no less than 657 of them were abandoned in the county during the year; the iron in most of them being pulled and shipped to more productive territory in other States. Should the Illinois and other fields fall off greatly in area and a dearth of new territory be lacking, many of the former operators of Grant County would doubtless return and start new work in the undrilled intervals between the older wells of its area. However, the county will never be what it was in the halcyon days of 1903, when the cough of the gas engine and the churn of the drill were heard on every side, and 1,383 bores, or nearly seven times as many as were sunk in the entire State in 1908, were put down within its bounds.

Huntington County.—Only about 45 square miles of this county, immediately bordering the Grant County field, on the north, have yielded oil in commercial quantity. While this territory has never produced any big wells, it has been profitable to operate, as very few bores have been dry, and the production has held up remarkably well for an area on the borders of a productive field. Only 17 bores were sunk in the county during the year, two of which were dry. The others were mostly small producers, the best one, in the northwest quarter of section 34, Jefferson Township, starting at 70 barrels. The average initial output was 10.3 barrels, as against 10.6 in 1907. No new territory was opened up and 165 wells were abandoned. Of the 993 bores sunk in the county within the past six years, but 26, or 2.6 per cent, have been dry, so that the oil business there is much less of a gamble than in most other sections of the United States.

Wabash and Miami Counties.—But one bore was sunk in the Rich Valley pool during the year, and it was soon abandoned. The Rich Valley and Peru pools together yielded a total of only 13,358 barrels for the year.

Blackford County.—The northern part of this county is one of the oldest producing territories in the State, and in the past has yielded many good wells. During the year but 40 bores were sunk, nine, or 22.5 per cent, of which were dry. The average initial output was only 8.5 barrels. However, the record, except in the percentage of dry holes, was better than in 1907, when only 22 bores were sunk, averaging 7.4 barrels each. During the year 319 old wells were abandoned. No new territory was opened up, several tests coming in dry or so nearly so that they were not pumped. In many localities in both this and Wells County the iron from the old wells was painted and piled up to use in future development, there being thousands of available locations which in the future will yield much oil.

Wells County.—This county also embraces some of the oldest and most productive territory in the State. Many of the first wells drilled were sunk only a few feet into Trenton and the undrilled intervals offer inducements for future operators. But 70 bores were sunk in the county during the year, four of which were dry. The average initial output of the producers was 8.1 barrels as against 8.9 barrels in 1907. The best well drilled was on the southeast quarter of section 12, Jackson township, it yielding 110 barrels the first day. Other good ones in the same township starting at more than 50 barrels were on the Lee farm in section 29 and the Spaulding lease in section 24. In Chester Township the Gruver farm in section 17 produced two which started at 80 and 50 barrels each. These were all among old wells which had been yielding for ten years and more.

Many of the first producers in this and Nottingham Townships have ceased to yield, no less than 610 having been abandoned in the county during the year, as against 224 in 1907.

But few important sales of oil territory have been made in the Indiana Trenton rock field in recent years, investors putting their spare cash in the Illinois and other territory. One sale of 700 acres and 72 producing wells in Jackson and Chester townships was made for $30,000. The daily net production was 65 barrels, and five years ago the property would have brought as many thousand dollars.

Adams County.—Only the southern third of this county has in the past produced petroleum in paying quantities, and here as elsewhere there was little doing during the year. Only 15 new bores were sunk, while 82 old wells were abandoned. Of the new ones, two, or 13.3 per cent, were dry, while the average initial output of the others was 13.6 barrels, as against 5.7 barrels for 1907. However, the greatest part of this gain was due to one big well or "gusher" on the H. M. Fogle farm in section 32, Jefferson Township, which started at 150 barrels. This well was located in old territory which formerly furnished a number of good producers, but which in late years had produced only small pumpers.

Such a well as this in the midst of numerous small ones, starting at 5 to 15 barrels, puts new hope in the heart of the operator, and goes to prove that each new bore, even though surrounded by well drilled territory, is almost as much of a gamble as the rankest wildcat, far outside of productive limits. It is this element of chance, ever present, which adds to the excitement and pleasure of the oil industry, and so tends to keep the beginning operator a life-long devotee before its shrine.

Jay County.—This county again led all others in the State in new work, 107 bores, or more than one-fourth of the total sunk in the Trenton rock area, having been drilled within its bounds. Of these 25, or 23.3 per cent, were dry. This large percentage was due to a number of wildcat bores put down in search of new territory, the majority of which came in dry. The best of the yielding bores were located on undrilled locations within well defined, but old productive territory in Bear Creek Township, a part of which had been abandoned. Some of the best of these which came in at 50 to 100 barrels each were located on the Armentrout and Walters farms in sections 7 and 9, and on the Beal lease in section 8. No. 11 on the latter lease, situated in the midst of the good ones, came in dry, as did also a test on the Bone farm, in the northeast quarter of section 9, while another test bore on the Downing lease in the southeast of 18 resulted in a light gas producer.

About the only extension to the previously defined field in the county was opened up by the Fulton Drilling Company in the west half of section 34, and the southeast quarter of 33, Bear Creek Township. On the Aiman farm this company was drilling for gas, and having drilled below the gas-bearing stratum discovered an oil pay at 30 feet in Trenton, which resulted in a production of 40 barrels initial output. Four more producing wells starting at 20 to 60 barrels each were afterward drilled on the same lease.

On the Hughes tract in section 33, three or four good wells were also bored, No. 2 of which started at 120 barrels, while on the Prilliman tract just east, No. 3 was of the same caliber. The top of Trenton in a big gas well on this farm was 1,024 feet below the surface; while in the oil wells on it and adjoining leases it was 1,027 to 1,042 feet below. The best of these strikes were made near the close of the year, and quite an area of new territory may be opened up in this vicinity next season.

In Wayne Township tests in the northeast quarter of sections 2 and 5, adjoining the new territory in Bear Creek, resulted in 10- to 15-barrel wells, showing that the productive area may extend southward toward Portland. A number of the older wells in the county, especially in Jackson and Penn townships, were abandoned during the year, but the total was only 68, being proportionally much less than in any of the former producing counties. At the present time the county offers more chances of success to the prospective operator than any other within the Trenton rock area.

Randolph County.—The number of bores sunk in this county for the year was but five, the same as in 1907. Of these one was dry, while the others had an average initial output of only 8.7 barrels.

A test on the Deeds farm in section 21, Stony Creek Township, started at only five barrels, while others in the vicinity of the former great producing Cecil pool did not exceed 15 barrels. Forty-five wells were abandoned in Randolph County during the year.

In Jackson Township, in the eastern part of the county several small gas wells were drilled during the year, some of them showing a small amount of oil. Just across the State line, in Darke County, Ohio, a number of good gas wells, and five or six small oil producers, have been recently developed, and a paying oil territory may in the near future be opened up in this vicinity.

Delaware County.—Nowhere in the State has the petroleum industry shown greater retrogression during the past four years than in Delaware County. The original home of the deep pay bores, it enjoyed a boom during 1904 and 1905 which resulted in a big producing but short-lived pool. Backing up an abundance of oil was an inexhaustible flow of salt water which drowned out many of the best wells while yet in their prime. The early operators who were fortunate enough to hold big leases and sell them before the water made its appearance made some money, but the purchasers lost hundreds of thousands of dollars by the quick flooding of the field.

The rise and fall of the industry in the county is graphically shown by the number of producing wells and dry holes sunk during the years 1903 to 1908, inclusive, as follows:

Year.	Producing Wells.	Dry Holes.	Average Initial Output, Bbls.
1903	74	48	20.7
1904	831	121	44.4
1905	570	83	32.6
1906	141	39	33.2
1907	49	16	14.6
1908	15	14	20.8

The best of the 15 producing wells drilled in the county during the year was on the Pogue farm in the southwest quarter of section 23, Delaware Township, in territory marked as fair on the last oil map. It was finished in May and pumped 175 barrels the first 24 hours. Another one which started at 100 barrels was completed on the Goings lease in section 15. These two increased the average initial output for the year more than six barrels per well.

In Hamilton Township a 100-barrel well was drilled on the Wilson farm in section 25, in territory already marked as good, but the next one on the same lease produced only salt water. On the Campbell lease in section 35, Liberty township, two bores resulted in a 90-barrel producer and a light gas well. A test in the northeast quarter of section 35, Niles Township, developed only a dry hole. The number of wells abandoned in the county during the year was 205, or 125 less than in 1907.

The following table gives the output of the Muncie-Selma-Parker field by months, for the year 1904 to 1908, inclusive:

Number of Barrels of Oil Piped or Shipped from the Muncie-Selma-Parker Oil Field in 1904 to 1908, Inclusive, by Months.

	1904.	1905.	1906.	1907.	1908.
January	42,835	358,483	182,927	74,970	45,243
February	33,081	282,773	143,410	70,681	35,125
March	40,869	321,650	145,442	72,206	41,866
April	46,504	305,129	143,823	72,139	42,333
May	73,162	320,287	151,860	76,545	44,005
June	115,048	311,030	143,309	65,516	45,488
July	176,624	277,177	134,479	68,111	45,662
August	240,050	255,854	132,482	59,618	41,281
September	311,098	230,970	107,129	54,434	35,561
October	384,380	218,052	113,151	53,985	37,256
November	356,173	210,724	90,742	49,603	31,748
December	382,302	200,163	85,905	50,340	32,359
Totals	2,202,126	3,292,292	1,574,659	768,148	477,927

Madison County.—Operations were practically at a standstill in this county in 1908, but two bores having been sunk. They were both on the Gray lease, section 22, Monroe Township, and started at respectively five and ten barrels each, the latter one yielding also a large amount of salt water. This farm is located east of Alexandria in a region which has produced only light or fair wells and much blue lick water. Five old wells were abandoned in the county during the year, and the total shipment amounted to only 108 barrels.

Hamilton County.—The pools in the vicinity of Olio and Horton in this county continued to yield small quantities of oil, but only one new well was drilled. It was No. 5 on the J. F. Horton lease in Washington Township, and its initial output was only 10 barrels. There was produced in the Olio pool and shipped from Noblesville during the year 4,001 barrels, while the Horton pool yielded for the same time only 508 barrels.

Marion County.—All the wells in the old Broad Ripple pool have been abandoned and plugged and there was not a barrel of oil produced in the county during the year.

Statistics of the Indiana Trenton Rock Petroleum Industry for 1908.

For four years in succession the output of Trenton rock petroleum in Indiana has been on the decline. The loss in 1905 was 388,592 barrels, or 3.4 per cent of the output of the previous year; in 1906 it was 3,129,613 barrels, or 28.8 per cent; in 1907 the loss was 2,803,717, or 36.1 per cent, while in 1908 it was 1,749,062 barrels, or 35.3 per cent. The cause for this great decline has been chiefly due to a loss in the number of new bores sunk, the operators seeking other fields in Illinois and Oklahoma, where the prospective outlook was better.

The fluctuation in price during 1908 was very little. Starting the year at 89 cents, the maximum price in 1907, it held this figure until February 24, when it was advanced to 94 cents and again on February 28 to 99 cents, the maximum, which price it held to the end of the year. The average price for the year, taking both days of time and amount received into consideration, was 97¼ cents, as against 88 2-5 cents in 1907 and 88 3-5 cents in 1906. The price of practically one dollar per barrel, which held for ten months of the year, should have stimulated active drilling inside of well defined territory, as it has been proven that the average cost of production in the Indiana field is less than 40 cents per barrel.

The total production of Trenton rock oil in Indiana in 1908 was 3,210,036 barrels, which at the average price of 97¼ cents, had a value of $3,121,639, this sum being $1,262,212, or 28.7 per cent less than was received by the producers in 1907.

The first of the following tables gives a complete record of the monthly production of petroleum from the Trenton limestone fields of Indiana for the eighteen years beginning January 1, 1891, and ending December 31, 1908. This does not include the amount used in the field for fuel and other purposes, or that wasted by the burning of tanks or the leaking of pipes, but only that shipped or piped by the companies who purchase the oil from the operators. The second table shows the annual production, the average yearly price and the total value by years for the same period.

I. TOTAL PRODUCTION OF TRENTON LIMESTONE PETROLEUM IN INDIANA FROM 1891 TO 1909 BY MONTHS.

(Barrels.)

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.
January	6,171	15,841	111,824	259,000	300,568	365,582
February	5,981	18,946	96,025	232,107	230,559	241,743
March	5,159	24,794	134,549	282,376	310,303	386,586
April	4,973	26,184	146,493	287,330	352,077	395,032
May	5,757	31,033	186,939	321,502	397,001	417,963
June	8,136	40,888	209,616	333,479	403,569	434,167
July	10,809	49,203	241,666	327,349	434,376	422,968
August	11,603	56,109	248,353	345,031	420,132	407,238
September	16,500	66,034	245,615	319,588	409,169	415,675
October	19,029	95,699	252,568	339,424	393,153	394,283
November	20,801	129,270	245,607	304,030	373,789	337,331
December	21,715	144,067	236,038	337,450	361,436	362,164
Totals	136,634	698,068	2,335,293	3,688,666	4,586,132	4,680,732

MONTH.	1897.	1898.	1899.	1900.	1901.	1902.
January	290,746	317,014	297,291	353,451	425,140	554,038
February	309,922	272,780	220,440	302,493	384,735	460,073
March	341,961	325,301	290,257	364,590	432,922	573,412
April	328,779	310,034	325,774	381,804	447,261	579,711
May	340,023	311,208	344,831	426,363	482,118	635,752
June	369,803	320,477	334,282	446,492	481,807	633,452
July	375,249	314,861	329,086	437,087	506,065	696,911
August	371,921	332,777	347,621	466,127	523,106	697,040
September	362,528	326,264	332,283	418,716	519,087	672,611
October	408,179	319,490	326,781	467,521	532,960	725,973
November	430,958	300,644	326,802	406,684	510,788	656,457
December	423,069	300,457	332,266	441,347	479,485	650,131
Totals	4,353,138	3,751,307	3,807,714	4,912,675	5,725,474	7,535,561

MONTH.	1903.	1901.	1905.	1906.	1907.	1908.
January	651,355	714,594	1,038,324	759,518	471,926	314,490
February	568,789	664,058	804,100	657,201	438,332	253,016
March	724,969	797,133	1,037,320	678,788	447,174	285,337
April	680,921	804,121	964,242	684,810	457,286	293,333
May	751,348	851,071	1,011,859	701,766	466,270	293,468
June	809,438	940,391	1,011,965	692,390	423,333	288,516
July	831,005	998,229	937,960	684,056	446,740	284,400
August	838,615	1,084,560	916,803	673,721	410,881	265,057
September	857,117	1,104,771	840,804	563,100	366,752	255,722
October	873,160	1,139,000	791,881	607,178	369,255	238,717
November	778,323	1,098,832	765,078	547,134	334,146	215,204
December	796,291	1,084,270	772,102	513,163	327,013	222,776
Totals	9,161,331	11,281,030	10,892,438	7,762,825	4,959,108	3,210,036

II. PRODUCTION OF TRENTON ROCK PETROLEUM IN INDIANA FROM 1891 TO 1909, WITH VALUE.

	1891.	1892.	1893.	1894.	1895.	1896.
Total production (barrels of 42 gal.)	136,634	698,068	2,335,293	3,688,666	4,386,132	4,680,732
Total value at wells of all oils produced, excluding pipeage	$54,787	$260,620	$1,050,882	$1,774,260	$2,807,124	$2,954,411
Value per bbl	$0 40	$0 37	$0 45	$0 48	$0 64	$0 63

	1897.	1898	1899.	1900.	1901.	1902.
Total production (barrels of 42 gal.)	4,353,138	3,751,307	3,807,714	4,912,675	5,725,474	7,535,561
Total value at wells of all oils produced, excluding pipeage	$1,871,849	$2,228,276	$3,331,750	$4,740,731	$4,775,045	$6,450,440
Value per bbl	$0 43	$0 59$\frac{2}{5}$	$0 87$\frac{1}{2}$	$0 96$\frac{1}{2}$	$0 83$\frac{2}{5}$	$0 85$\frac{3}{5}$

	1903.	1904.	1905.	1906.	1907.	1908.
Total production (barrels of 42 gal.)	9,161,331	11,281,030	10,892,438	7,762,825	4,959,108	3,210,036
Total value at wells of all oils produced, excluding pipeage	$10,457,659	$12,127,107	$9,236,788	$6,877,863	$4,383,851	$3,121,639
Value per bbl	$1 14$\frac{3}{20}$	$1 07$\frac{1}{2}$	$0 84$\frac{4}{5}$	$0 88$\frac{3}{5}$	$0 88$\frac{2}{5}$	$0 97$\frac{1}{4}$

From the first of the above tables it will be found by addition that the total production of Indiana Trenton rock oil for the 18 years reached the enormous sum of 93,278,192 barrels, which sold for $78,505,082, or an average of $4,361,393 per year.

In the third table there is shown the number of wells completed in the Indiana Trenton limestone fields by months from June, 1891, to January, 1909.

III. NUMBER OF WELLS COMPLETED IN THE INDIANA TRENTON LIMESTONE OIL FIELDS FROM 1891 TO 1909 BY MONTHS

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
1891	......	......	......	......	......	......	6	6	15	15	15	8	65
1892	11	13	18	13	17	19	17	30	25	52	33	47	295
1893	20	30	31	36	45	47	47	55	27	72	56	76	542
1894	90	103	103	80	110	107	84	123	100	107	97	85	1,189
1895	61	45	81	111	122	153	132	140	129	106	102	85	1,267
1896	76	90	86	136	148	150	113	121	70	58	66	66	1,180
1897	41	35	40	47	49	52	60	45	55	89	119	54	686
1898	41	23	29	43	38	55	53	80	72	82	92	86	694
1899	75	48	68	64	87	99	77	104	106	118	106	105	1,057
1900	113	67	98	148	165	163	158	155	135	152	118	108	1,580
1901	111	72	81	121	167	171	167	169	184	207	220	132	1,802
1902	176	113	169	182	247	297	288	279	323	295	320	243	2,932
1903	168	178	233	236	331	408	377	387	337	366	375	290	3,686
1904	235	157	234	202	296	393	394	383	378	388	320	344	3,724
1905	194	130	149	185	196	157	159	145	120	108	163	166	1,882
1906	135	90	84	68	106	142	120	100	93	69	66	59	1,132
1907	46	40	63	44	49	63	56	52	40	52	38	41	584
1908	29	17	28	19	28	35	35	39	44	38	33	31	376
Total	......	......	......	......	......	......	......	......	......	......	......	......	24,673

From this table we learn by subtraction that 208 fewer bores were sunk for oil in the Trenton rock fields of Indiana in 1908 than in 1907. This was a loss of 35.6 per cent, as against a loss in 1907 of 48.4 per cent over the previous year.

From the table it may also be learned that up to January 1, 1909, 24,673 bores had been drilled in the Trenton rock fields of Indiana for oil alone. On that date there were 13,301 producing wells in the Trenton rock fields, as against 15,210 on January 1, 1908, a loss of 1907 for the year.

By subtraction it will be noted that of the total number of bores sunk for oil in the Trenton rock fields of the State, 11,371 have proven dry, or have been abandoned as nonproductive. The number abandoned in 1908 was 2,157, or 647 more than in 1907, while the number of dry holes drilled during the year was 64, or 21 less than in 1907. Of the total number of bores sunk in 1908, 17 per cent were dry, as against 14.5 per cent of those drilled in 1907 and 10.9 per cent of those sunk in 1906.

The following table shows the number of producing wells, number of dry holes, total bores, average initial production of wells drilled, and number of wells abandoned in each of the Trenton rock oil producing counties of Indiana in 1907 and 1908:

COUNTIES.	Producing Wells, 1907.	Producing Wells, 1908.	Dry Holes, 1907.	Dry Holes, 1908.	Total Bores, 1907.	Total Bores, 1908.	Percentage of Dry Holes, 1907.	Percentage of Dry Holes, 1908.	Average Initial Output of Productive Wells, Bbls., 1907.	Average Initial Output of Productive Wells, Bbls., 1908.	Abandoned Wells, 1907.	Abandoned Wells, 1908.
Adams	30	13	3	2	33	15	9.1	13.3	5.7	13.6	125	82
Blackford	19	31	3	9	22	40	13.6	22.5	7.4	8.5	156	319
Delaware	49	15	16	14	65	29	24.6	48.2	14.6	20.8	330	205
Grant	103	83	12	7	115	90	10.4	7.7	7.5	9	418	657
Hamilton	0	1	3	0	3	1	100	0	0	10	4	0
Huntington	46	15	2	2	48	17	4.1	11.7	10.6	10.3	70	165
Jay	122	82	30	25	152	107	19.7	23.3	11.2	11	72	68
Madison	3	2	2	0	5	2	40	0	16.6	7.5	25	5
Randolph	3	4	2	1	5	5	40	20.0	18.3	8.7	71	45
Wabash	4	0	0	0	4	0	0	0	0	5	2	1
Wells	120	66	2	4	122	70	1.6	5.7	8.9	8.1	224	610
Totals	499	312	85	64	584	376	*14.5	*17	*9.7	*10.1	1,510	2,157

*Denotes average.

From the table it will be seen that in most of the counties the number of productive wells drilled was less than in 1907. Jay County continued to hold the lead in new work, a position which she took for the first time the year before. The average initial output of the new wells gained four-tenths of a barrel per well, which proves that the oil is still present and that the slump in the industry is due solely to the lack of drilling. In 1906 and 1907 there was a loss in initial output of six and four and nine-tenths barrels, respectively, per well.

In most of the counties there was a gain in the percentage of dry holes and the average rose from 14.5 to 17 per cent, due to the drilling on the borders of productive territory, rather than in the intervals among producing wells.

The great number of abandoned wells was largely due to the lack of gas in most localities for pumping small producers. Many of those abandoned would yield from one-half to one barrel per day and if gas had been available for power, they would have been kept in action at a profit for a year or two longer, but the cost of coal was prohibitive.

Unless some large strikes are soon made or the price of oil rises 25 or more cents per barrel, the future outlook is not encouraging for much activity in the Trenton rock area of the State. The only other cause which would bring it about would be a great decline in the production in Illinois and Oklahoma and the chances for this are at present remote.

CORNIFEROUS ROCK PETROLEUM.

The "Corniferous rock" or Corniferous limestone is the oldest and lowest division of the Devonian system of rocks in Indiana. It ranges up to 65 feet in thickness and is immediately overlain by a thick bed of blackish or brownish shale, known as the New Albany or Genesee shale. This ranges up to 195 feet in known thickness, and forms the necessary impervious cover which has retained the oil of the Corniferous in the limestone in which it is found.

Petroleum in commercial quantities is being produced from the Corniferous rocks in Indiana at present only in or near Terre Haute, Vigo County, and in an ill-defined area in eastern Gibson and southern Pike counties, where several new wells were opened up in virgin territory during the year.

Vigo County.—A full and detailed history of the production of oil in this county up to January 1, 1907, was given in the thirty-first report of this department. This was followed by a brief record of the new developments and output for the year 1907 in the report for that year. Not a bore was sunk in the county during the year just past.

The Phoenix well, operated by Prox and Brinkman, and located near the center of the city of Terre Haute, still continues to yield a good supply of oil. This well was finished in May, 1889, and is the oldest and best paying oil well ever sunk in Indiana. For twelve or more years it yielded an average of 1,000 barrels per month. In the last few years this has gradually lessened, and in 1908 it averaged about 340 barrels per month. Two other wells, located but a short distance from the Phoenix, are producing oil from the same stratum at a depth of about 1,660 feet. One of these, known as the McWhinney well, has been a small producer since it was finished in 1899, but was shut down during the greater part of the past year, and its total yield was only about 300 barrels. The other was completed by George C. Foulkes in May, 1907, and is located on a lot just across the street from the Phoenix. It started at only about 25 barrels, and the output was about the same as that of the McWhinney well.

The total amount of oil produced from the three wells during the year was 4,637 barrels. This was sold to local consumers at an average price of $1.09 per barrel, the whole amount received being $5,077.

In the so-called Riley field, ten to fifteen miles southeast of Terre Haute, but one bore was started during the year, and it has not yet been completed. It is located on the Clingerman lease about 800 feet south of the No. 1 or pioneer well of the Vi-Clay Company. During the year there were eight wells producing in the Riley pool, but their output was small as shown by the following table:

Number of Barrels of Oil Sold from the Riley, Vigo County, Pool by Months for the Year 1908.

January	1,652
February	1,096
March	2,246
April	1,075
May	1,616
June	1,083
July	1,536
August	1,617
September	1,070
October	532
November	1,595
December	1,105
Total	16,223

This was sold at the same price as the Trenton limestone oil, viz., 89 cents to the end of February and 99 cents for the remainder of the year; the total sum received being $15,787. Adding to this the amount received for the oil produced at Terre Haute, we have a total of $20,864 received for the Corniferous rock petroleum produced in the State in 1908.

Pike County.—The Indiana strike which caused most excitement among oil men in 1908 was one made in August by Messrs. Murphy and Heydrick, representatives of the Pure Oil Company. This was on the Yeager farm, northeast quarter of the southwest quarter section 26 (2 S., 8 W.), Monroe Township, Pike County, one-half mile west of the town of Arcadia; four miles southeast of Oakland City, Gibson County, and twelve miles south of Petersburg. This bore was sunk mainly on account of the fact that a fair showing of oil had been found in one of three bores put down between it and Arthur, a small town about two miles to the northeast.

One of these bores, located on the Burnett farm, about 1,500 feet northeast of the Yeager strike, completed April 27th, 1908, had also shown a gas pressure of 525 pounds. In it a vein of coal seven feet thick was found at a depth of 85 feet; a small showing of oil between 1,136 and 1,143 feet and the stratum yielding a large amount of gas between 1,146 and 1,157 feet.

The Yeager well started at about 30 barrels of oil per day, spouting the same at intervals on account of a high gas pressure.

A partial record of the well furnished by J. A. Lash, the superintendent, showed the strata passed through to be about as follows:

Record of Yeager No. 1 Well.

		Feet.	Feet.
1.	Surface, mud, loam and quicksand	52	52
2.	Coal measures, shale, coal, etc	408	460
3.	Sandstones (Mansfield and Huron)	410	870
4.	Limestone	30	900
5.	Shale	15	915
6.	Limestone	40	955
7.	Shale	10	965
8.	Limestone	70	1,035
9.	Shale	5	1,040
10.	Limestone	54	1,094
11.	Shale	46	1,140
12.	Limestone and shale	41	1,181
	Total depth	1,181	

The first gas was found at a depth of 1,148 feet and the first oil at 1,162, the pay streak continuing unbroken to the bottom.

The record of the iron used in the well was as follows:

	Feet.
Drive pipe, 13-inch	52
Casing, 10-inch	303
Casing, 8-inch	960
Casing, 6¼-inch	1,074

The usual excitement following a strike in new territory ensued. Leases were taken in every direction, large bonuses being paid for those in the immediate vicinity. Up to February 1, 1909, the time of the writing of this report, nine additional bores had been drilled into or through the producing stratum, five of which were dry. Of the nine, six were in Monroe township, Pike County, two of these being dry, the others starting at 33 to 100 barrels each. Three of the producing wells were on the Moses Skinner lease, southeast quarter of the northeast quarter, and southwest quarter of the northwest quarter of section 24 (2 S., 8 W.), about one and a half miles northeast of the Yeager well. A driller's record of these three bores showed as follows:

Record of Wells on M. Skinner Lease.

	No. 1. Feet.	No. 2. Feet.	No. 3. Feet.
Drive pipe, 12½-inch	57	73	98
Casing, 10-inch	320	....	....
Casing, 8¼-inch	785	510	490
Casing, 6¼-inch	1,055	1,057	1,080
Depth to top of sand	1,146	1,137	1,161
Depth to pay sand	1,154	1,149	1,173
Total depth	1,196	1,206	1,207
Production first 24 hours (bbls.)	33	75	35
Number quarts nitroglycerin used in shooting	40	60	100

Bore No. 3 showed quite a quantity of gas, the rock pressure being about 150 pounds.

On the Amelia Skinner farm, in the southeast quarter of the northeast quarter of section 27, Monroe Township, one-half mile northwest of the Yeager well, a bore completed on December 25th had the following record:

	Feet.
Drive pipe, 10-inch	60
Casing, 8¼-inch	417
Casing, 6¼-inch	1,067
Depth to top of sand	1,130
Depth to pay sand	1,139
Total depth	1,178
Initial production, bbls.	100

Gas was found in the sand between 1,130 and 1,139 feet. From 1,139 to 1,169 feet the sand was quite porous, and between these depths most of the oil was produced.

One of the two dry holes in Monroe Township was drilled on the Joel Skinner lease, northeast quarter of the northeast quarter of section 3 (3 S., 8 W.), about one and a half miles southwest of the Yeager well, and the other on the Gillum farm, southwest quarter of the northeast quarter of section 28 (2 S., 8 W.), two miles west of the Yeager well. A record of these bores showed:

Record of Bores on J. Skinner and Gillum Leases.

	Skinner. Feet.	Gillum. Feet.
Drive pipe, 10-inch	117	50
Casing, 8¼-inch	376	330
Casing, 6¼-inch	1,109	1,120
Top of sand	....	1,186
Total depth	1,343	1,210

In the Gillum well a four-foot vein of coal was passed through at a depth of 154 to 158 feet, and another six feet thick at 190-196 feet.

Two dry holes were drilled in Warrick County in an endeavor to trace the oil stratum of the Pike County wells southward. One of these, on the John N. Miller lease, southeast quarter of the northwest quarter of section 19 (5 S., 8 W.), Boone Township, is reported to have passed through the following strata:

Record of J. N. Miller Bore.

		Feet.	Feet.
1.	Surface, loam and shale	..	40
2.	Shale	20	60
3.	Lime and shale	25	85
4.	Shale	20	105
5.	Fire clay	15	120
6.	Black shale (cave)	10	130
7.	Black shale	13	143
8.	Coal	6	149
9.	Hard shale	3	152
10.	White shale	50	202
11.	Black shale	20	222
12.	Fire clay and shale	100	322
13.	Shale and shells	11	333
14.	Limestone	3	336
15.	Coal	5½	341½
16.	Shale and shells	48½	390
17.	Limestone shells	25	415
18.	Brown shale	50	465
19.	White shale	102	567
20.	Brown shale	50	617
21.	Shale and shells	100	717
22.	Black shale	50	767
23.	Lime shells	20	787
24.	Gray shale	40	827
25.	Black shale	10	837
26.	White sand (full of salt water)	70	907

		Feet.	Feet.
27.	White shale	40	947
28.	Brown shale	100	1,047
29.	Shale	218	1,265
30.	Brown lime	15	1,280
31.	Black shale	12	1,292
32.	Red cave	8	1,300
33.	Soft black shale	23	1,323
34.	Salt sand, yielding salt water	60	1,383

A driller's record of the iron used showed:

	Feet.
Drive pipe, 12½-inch	40
Casing, 11-inch	78
Casing, 8¼-inch	882
Casing, 6⅝-inch	1,055
Casing, 5 3/16-inch	1,323
Depth to sand	1,323
Total depth	1,383

The sand was full of water and caved very badly.

The other dry hole in Warrick County was on the Jessie Barkley lease in the southeast quarter of the northeast quarter of section 21 (4 S., 8 W.), Hart Township, its record showing:

	Feet.
Drive pipe, 10-inch	60
Casing, 6¼-inch	900
Casing, 4⅞-inch	1,070
Total depth	1,310

A very slight showing of oil occurred at 1,220 feet.

In Center Township, Gibson County, a bore which came in dry was drilled on the land of Anna Hawles, southeast quarter of the southwest quarter of section 36 (2 S., 10 W.), about four miles southwest of Francisco. The strata passed through as recorded by the drillers were as follows:

Record of Bore on Hawles Farm Near Francisco.

		Feet.	Feet.
1.	Surface silt and sand	......	65
2.	Mixed mud and gravel	65 to	80
3.	Soft shale	80 to	150
4.	Coal	150 to	155
5.	Soft shale	155 to	195
6.	Coal	195 to	200
7.	Soft light shale	200 to	445

		Feet.		Feet.
8.	Coal	445	to	448
9.	Light shale	448	to	715
10.	Coal	715	to	717
11.	Brown shale	717	to	735
12.	Gray sand	735	to	750
13.	Black shale	750	to	825
14.	Gray sand	825	to	835
15.	Coal	835	to	837
16.	Black shale	837	to	870
17.	Gray sand, coarse	870	to	885
18.	Salt sand and water	885	to	890
19.	Shale	890	to	900
20.	Gray sand	900	to	940
21.	Shale	940	to	1,070
22.	Salt sand	1,070	to	1,100
23.	Shale	1,100	to	1,120
24.	Salt sand, water	1,120	to	1,180
25.	Shale	1,180	to	1,254
26.	Salt sand, water	1,254	to	1,325
27.	Shale, hard sandy	1,325	to	1,327
28.	Shale	1,327	to	1,340
29.	Sand	1,340	to	1,360
30.	Shale	1,360	to	1,368
31.	Red rock	1,368	to	1,370
32.	Shale	1,370	to	1,382
33.	Limestone, caved	1,382	to	1,445

In the bore a plentiful supply of good water was found between 65 and 80 feet, and a small amount of gas at 335 feet. The Princeton oil-bearing stratum was struck at 840 feet, but was barren.

It is very probable that the formation in which the oil occurs in the Yeager and Skinner wells is the Corniferous limestone, or the same horizon in which the oil near Birdseye, Dubois County, about 35 miles to the east, was found in 1902 and 1903. In the Birdseye wells the average depth to the pay streak was 980 to 1,010 feet below the surface. Fourteen bores were sunk near Birdseye, seven of which came in as light to fair producers, but they were too far apart, one from another, to pump with profit, and as a consequence the field was abandoned.

While the high gas pressure in the Burnett and other wells in this part of Indiana indicates the near presence of quite a large quantity of oil, the chances are that it will be found in small, isolated pools, and that its development will show a very spotted area resulting in a large percentage of barren bores.

Huron Sandstone Petroleum.

Petroleum from the Huron sandstone, one of the upper formations of the Subcarboniferous or Mississippian period, has been produced for a number of years near Princeton, Gibson County, and was formerly produced near Loogootee, Martin County. A full account of the Princeton field to January 1, 1907, with accurate detailed map, was prepared by R. S. Blatchley and published in the 1906 report of this department. Up to the beginning of the year 1908, 195 bores had been sunk in the Princeton field. Of these 47 were wholly dry and 11 were abandoned after producing a short time, leaving 137 producers on January 1, 1908. During the year 1908 only nine bores were drilled in the field, two of which were dry. The average initial output of the seven producers was 12.8 barrels. No one of the new wells increased the limits of the known productive area to any great extent.

The output of the Princeton field by months for the years 1904 to 1908, inclusive, is shown in the following table:

Number of Barrels of Huron Sandstone Oil Piped or Shipped from the Princeton Field in the Years 1904 to 1908, Inclusive, by Months.

	1904.	1905.	1906.	1907.	1908.
January	1,412	4,043	8,026	9,163	7,470
February	1,399	3,637	6,127	9,875	7,799
March	2,920	5,400	7,322	9,534	8,257
April	1,319	5,262	9,033	7,713	8,114
May	2,047	5,559	8,463	10,894	7,073
June	2,315	4,523	10,201	10,209	7,021
July	2,971	5,569	9,498	9,693	6,346
August	2,991	6,296	9,429	11,029	7,029
September	3,345	6,141	9,469	8,484	5,661
October	3,093	6,865	9,312	11,372	7,242
November	4,554	6,116	8,294	10,056	6,158
December	3,841	5,395	8,382	8,957	5,942
Totals	32,207	64,806	103,843	116,979	84,112

By subtraction the loss in the field for the year was 32,867 barrels, or 28.1 per cent, as against a gain of 13,136 barrels, or 12.6 per cent, in 1907. Of the amount produced in 1908, 56,054 barrels were sold to the Indiana Pipe Line and Ohio Oil companies at an average price of 68 cents per barrel, the price being 31 cents lower than that paid for Trenton rock oil during almost the entire year. The remainder, amounting to 28,058 barrels, was sold to independent purchasers at an average price of 89.2 cents per barrels, the total value of the oil produced in the Princeton field being $63,145 for the year.

Wildcat Bores Outside the Areas Mentioned.

A number of test bores were put down in western and southern Indiana outside the counties mentioned during 1908. No one of these produced anything more than a slight showing of gas or oil. As far as we have records these bores were as follows:

Putnam County.—One on the Bower's lease, section 28 (16 N., 5 W.), Russell Township, about four miles southeast of the town of Russellville. This bore was sunk by Crawfordsville parties to a depth of about 800 feet, or about 50 feet into the Corniferous limestone. A good flowing well of sulphur water and a slight showing of gas were the only results.

Parke County.—A bore was sunk by Brazil parties to a depth of 1,200 feet near Diamond, in the southern part of this county, but was wholly dry.

Sullivan County.—Four dry holes were completed in the western part of this county during the year. Two were in Gill township on the Gill and Springer leases; one in Fairbanks township on the Russell lease and one in Turman Township on the Dunham farm. The latter one was drilled to a depth of 2,100 feet.

Knox County.—Two test bores were completed in this county during the year. One on the Emison farm in Busseron Township, five miles south of Oaktown, was sunk to a depth of 1,700 feet without results. The other, on the Chipson farm near Orville, was abandoned at 1,600 feet with no showing whatever of either oil or gas.

Greene County.—This county had four dry holes to its credit during the year. They were located near Clayton, Ben Harrison, Graywinkle and Burns City. In no one of these or the other tests drilled in the southwestern part of the State in 1908 was the bore sunk to the Trenton limestone. To thoroughly test any locality in Indiana it should pierce this formation at least 300 feet. No oil has ever been found in the State between the Corniferous and the Trenton and if a bore is sunk to the Corniferous it is money thrown away to drill deeper unless it is intended to go to Trenton, which lies 850 to 1,000 feet below the Corniferous.

Bores were also completed in Martin County near Rutherford and in Daviess County near Odon, both of which came in dry.

Clark County.—A bore which was drilled clear through the Trenton limestone was put down on the the grounds of the American Car and Foundry Company at Jeffersonville. In it the top of the Jeffersonville or Corniferous limestone was the surface rock, being struck at a depth of 32 feet. The top of Trenton was found at 855 feet and that of the St. Peter's sandstone at 1,550 feet, showing the Trenton to be 695 feet in thickness. The drilling continued in the sandstone to a depth of 1,800 feet. Fresh water was struck at 40 and 90 feet, and brackish or salt water at 1,550, 1,645, 1,700, 1,710, 1,725, 1,770 and 1,785 feet. No Magnesian limestone, a formation usually found separating the St. Peters and Potsdam sandstones, was shown in the records furnished. The St. Peters was therefore 250+ feet thick, or a greater thickness than heretofore reported from the State.

* * *

Adding to the output of the Trenton rock petroleum fields that produced by the Corniferous limestone at Terre Haute and Riley, and by the Huron sandstone at Princeton, we find the total production and value of petroleum in Indiana for the last five years to be as follows:

TOTAL PRODUCTION AND VALUE OF CRUDE PETROLEUM PRODUCED IN INDIANA IN THE YEARS 1904 TO 1908 INCLUSIVE.

	1904.		1905.		1906.		1907.		1908.	
	Barrels.	Value.	Barrels.	Value.	Barrels.	Value.	Barrels.	Value.	Barrels.	Value.
Trenton Rock Petroleum	11,281,030	$12,127,107	10,892,438	$9,236,788	7,762,825	$6,877,863	4,959,108	$4,383,851	3,210,036	$3,121,639
Corniferous Rock Petroleum	18,103	21,040	12,064	13,270	7,269	8,456	27,210	21,867	20,860	20,864
Huron Rock Petroleum	32,405	28,951	64,806	55,413	103,843	81,770	116,979	83,495	84,112	63,145
Total	11,331,538	$12,177,098	10,969,308	$9,305,473	7,873,937	$6,968,089	5,103,297	$4,489,213	3,315,008	$3,205,648

REPORT OF THE STATE NATURAL GAS SUPERVISOR FOR THE YEAR 1908.

BY

B. A. KINNEY.

Office of State Natural Gas Supervisor,

MARION, IND., February 1, 1909.

Prof. W. S. Blatchley, State Geologist, State House, Indianapolis, Indiana:

Sir—I have the honor to submit to you herewith, my Annual Report as State Natural Gas Supervisor, for the year 1908, being the Seventeenth Report from this Department.

There have not been any extensive new developments of natural gas territory in the State since my report of a year ago; nor have there been many changes in conditions with respect to developments and production in the old gas fields, which have been discussed in my former reports.

I have endeavored to give by this report such information as I have acquired in my visits over the gas fields of Indiana, and offer such suggestions and recommendations as I think are proper for the purpose of conserving the gas supply of the State.

I hope this report will meet with your approval, and that it may be read by all who may be interested or affected by the subjects on which it dwells.

Respectfully yours,

BRYCE A. KINNEY,
State Natural Gas Supervisor.

Annual Report of the State Natural Gas Supervisor.

The act of the Legislature in creating the office of State Natural Gas Supervisor was, no doubt, to the end and purpose of having an official to observe, study and report conditions of the gas fields, and to offer suggestions for consideration relative to the proper conservation of the gas supply of Indiana.

As supervisor I have always believed it a duty to report the glaring evils and abuses which have grown out of the gas operations in this State, which have come to me through observation and experience, and in previous reports have made full mention concerning the subject, with suggestions to correct and cure the same.

In my last annual report, February 1, 1907, I gave considerable space to the subject of the injurious effect upon the natural gas fields resulting from the failure of gas and oil operators to properly plug abandoned wells. It is probably unnecessary to repeat in this report what has been heretofere reiterated, any further than to say—that the waste of gas from open, abandoned wells still continues, and that by reason of wells being left unplugged, the surface and subterranean waters flow into and permeate the gas bearing rock strata, the result of which stops the flow of gas in wells for many miles adjacent to the unplugged well where the mischief originates.

It is well known by geologists that the gas-bearing strata of rock in the main gas fields of Indiana are connected, and that an injury to one section is an injury to the entire territory.

As there are twenty-seven counties in Indiana in which natural gas is produced, and in which drilling continues, I could not be expected to be present at all times when wells are drilled in and abandoned—hence, I am able to detect but few of the violations of the law in that respect.

The provisions made by law for the office of State Natural Gas Supervisor are not now adequate for the proper performance of the duties of the office. I think that a proper appreciation of the importance of the office—that is to say—of what might be accomplished for the good of the people of the State by an officer armed with proper authority and with legal resources, would lead to the enactment of salutary legislation which would make this office a power for good. Remedial legislation is needed to make the powers of this office more extensive and effective.

PUMPING STATIONS.

The subject of pumping stations was dwelt upon at some length in my last report. As was stated therein the gas-bearing strata are rapidly exhausted by this artificial pressure, and in all the gas territories wherein these stations exist, or have existed, the gas supply has failed, or is steadily failing and growing weaker.

Certain gas companies having chains of hundreds of wells use pumps to increase the natural pressure from the wells and then reinforce this by artificial pressure applied to the gas mains or pipe lines. The result has been that wells drilled by other parties in the same fields were weakened and destroyed by the drawing from them of the gas by the pumping plants, and the gas fields in which these plants exist, or have existed, are prematurely exhausted. The first legislation aimed at preventing this very evil shot wide of the mark. The law was an attempt to prevent the piping of gas out of the State. This law was declared to be unconstitutional by the Supreme Court. It seems likely that a law to prevent the addition of artificial pressure to the gas flow would have been the proper enactment, and would have been under the power of the State, and would have answered the desired purpose. The pumping stations also by the suction of their pumps have the effect of drawing the subterranean waters into the gas-bearing strata, which permeate for many miles and affect the gas fields at great distances from the point where the injury originated.

I believe there should be some wholesome legislation on this matter. The pumping station is an evil and threatens the existence of the gas field wherever it is placed. It should be prohibited by law.

At the present time the only pumping stations existing in Indiana are the following: That of the Hazelwood Gas Company at Anderson; the station at Richmond of the Richmond Natural Gas Company; the station of J. M. Leach on the east side of Howard County; the two stations of the Indiana Natural Gas and Oil Company—one near Fairmount, Grant County, the other at Greentown, Howard County; the stations of the Southern Indiana Gas Company of Decatur County; the Shelbyville Gas Company of Shelby County, and the station near Upland of the Huntington Light and Fuel Company.

THE OLD FIELD.

In Madison County many wells are being drilled for natural gas and a steady production is maintained—sufficient to keep up with the consumption. Gas, of course, is only used for domestic purposes. The same may be said of the Delaware County field adjoining. Gas wells in these two counties show a pressure of from twenty to one hundred pounds.

In Grant County many wells are being drilled. Wells lately drilled, and within the last year, show a pressure of from forty to one hundred pounds. The Marion Gas Company, which supplies the natural gas to the city of Marion, has drilled a great many wells within the last year, showing a pressure of from forty to one hundred pounds. This company also buys the gas from oil operators when gas appears in a well drilled for oil. A great many of these wells have been developed.

In Jay County wells have been drilled within the past year showing a pressure of from twenty to one hundred and sixty pounds. Drilling there continues, although no particularly strong wells have been developed.

Howard County gas conditions claim particular mention: It is claimed by parties qualified to make the statement that the gas supply in that region is better than for two years past—both as to production and capacity of wells. Among those who have been active in the drilling of new wells which have proven valuable producers are J. M. Leach, the Kokomo Plate Glass Company and the Indiana Natural Gas and Oil Company.

Conditions continue favorable in the gas fields in Hancock and Shelby counties. Drilling continues and gas is found in fair quantities.

Decatur County citizens are fortunate in that they have a good gas supply—still undiminished, which is furnished them for domestic use at the rate of fifteen cents per thousand cubic feet. The wells drilled in that field show a pressure of three hundred pounds. In that field they have more gas and cheaper gas than in any field in the State.

THE NEW FIELD.

My last report contained considerable information concerning the Sullivan fields in Sullivan County. At that time, from developments, it appeared that that field would be one of the richest in production in the entire State, but the record of that field during the past year has not materialized its earlier promises, and I am forced to say that the latest operations there have not been profitable, at least to the extent that had been anticipated. Gas is still produced in paying quantities, and all wells drilled show some gas, but the flow of oil found in that territory interferes with the gas pressure and retards the production of gas. As is well known that has been the history of other gas fields. Where the oil comes in the gas supply suffers. Still, I am pleased to report that in that field drilling still continues, and a few paying wells have been developed, from which the gas finds a ready market. These wells all show oil in small quantities.

In the counties of Pike, Warrick and Gibson gas and oil operations are at the present time very active, and have been for the past year.

The same may be said of Dubois county, where operations are now being carried on for both oil and gas.

In all these counties oil operators have leased thousands of acres for drilling purposes and are paying liberal bonuses for the same. This field has promise of being very fruitful, both in oil and gas—many of the wells drilled showing a paying flow of both.

Operations in Gibson County still continue—and there is found an ample flow of gas. Almost all operations there are for oil, but gas is found in all wells from which an oil flow is developed. My last report states that all oil wells have uniformly shown a fair flow of gas, and the same statement can be made as to wells in that field within the past year.

In Pike County one or two old wells have been revived and are now producing gas just as if they were newly drilled. However, this field is not particularly promising.

Within the past year, and prior thereto, active operations have been carried on in the counties of Floyd, Scott, Clark, Harrison and Crawford by hopeful seekers after natural gas. This field has proven a great disappointment. Drilling is still extensively carried on within this territory, but without any profitable results, as no wells of profit have been developed.

In continuation of the statements above concerning the gas fields in Pike and Gibson counties, it may be said that at the present time about fifteen strings of tools are busy in that territory, and so far in many of the wells drilled there has been a fair showing of gas, and in the majority of wells produced the gas is in paying quantities.

Herewith I present the record of two wells drilled in Pike County:

The following figures relate to a well drilled by the Pure Oil Company in April, 1908, located on the Maynard Burnett farm in Monroe Township, Pike County:

393 feet	10 in.
873 feet	8¼ in.
1,070 feet	6¼ in.
1,146 feet	To sand
1,181 feet	Finished
Pressure	522 pounds
Daily capacity	5,000,000 cu. ft.

The following figures relate to a well drilled by the Rogers Oil Company, one-half mile north of the above described well:

314 feet	10 in.
884 feet	8¼ in.
1,080 feet	6¼ in.
1,150 feet	To sand
1,176 feet	Finished

This last-named well was drilled in the month of December last, and has a capacity of 2,000,000 cubic feet daily, with a pressure about the same as the well first above described.

Cox & Gibson, during December last, drilled in a gas well in Monroe Township, Pike County, one mile distant from the Rogers Oil Company well, on the Skinner farm, which shows a daily capacity of two million cubic feet. This well was drilled to about the same depth as the two wells above mentioned.

The prospects for this gas field appear very bright.

GENERAL SUMMARY.

There are at the present time twenty-four counties in the State of Indiana in which natural gas is produced and used as a fuel. These are as follows:

Adams,	Hancock,
Blackford,	Jay,
Delaware,	Miami,
Decatur,	Madison,
Dubois,	Pike,
Franklin,	Randolph,
Grant,	Rush,
Gibson,	Shelby,
Huntington,	Sullivan,
Howard,	Tipton.
Hamilton,	Wabash,
Henry,	Wells.

In none of these counties is gas being used to any extent for manufacturing purposes, but is only available for domestic use.

In the gas producing localities where the well-plugging laws are best observed, and lived up to and best enforced, the gas pressure from old and weak wells has oft times been revived, and it may also be stated that at places in the gas field where pumping stations formerly were maintained, the gas wells, old and new, showed a renewed pressure immediately upon the abandonment of these pumping stations, which shows the ruinous effects of these stations upon the gas-bearing rock strata.

At this time there is, speaking approximately, being produced in the State of Indiana 10,000,000 cubic feet of gas per day. The average price of gas per thousand cubic feet, over the State, is 30 cents. This represents a daily production from the flow of gas of $3,000 or $900,000 in one year.

The natural gas supply of Indiana is one of the most valuable of our natural resources, and is the one most easily wasted and destroyed by the negligence of persons who are only interested in the immediate profits of drilling into gas or oil territory and making a profit from a lucky strike, and who will if a well shows no oil production abandon the same without plugging. Many wells are "pulled" by dealers in second-hand pipe and casing without proper attention to the wells, in all cases leaving an opening to the gas-bearing strata whereby the gas can seep out and be lost and the underground water may permeate the gas-bearing rock and destroy the free flow thereof—all of which has been set forth in this report, and was at more length made a part of my previous annual reports from this department.

I have in this report stated that the present laws are inadequate to bring about the results for which the Office of State Natural Gas Supervisor was created. As I have said herein, many violations of the laws respecting natural gas regulations go unpunished and are not detected, as it is impossible for one person to cover efficiently all parts of the State.

Respectfully submitted,

BRYCE A. KINNEY,
State Natural Gas Supervisor.

Marion, Indiana, February 1, 1909.

THE STRATIGRAPHIC AND FAUNAL RELATIONS OF THE WALDRON FAUNA IN SOUTHERN INDIANA.

BY

E. M. KINDLE AND V. H. BARNETT.

The Stratigraphic and Faunal Relations of the Waldron Fauna in Southern Indiana.[a]

By E. M. Kindle and V. H. Barnett.[b]

INTRODUCTION.

The rich Silurian fauna occurring at Waldron, Indiana, became known to paleontologists through Prof. James Hall[c] more than 40 years ago. The very complete collections which Hall had made and the excellent descriptions and illustrations which he published[d] left but little for later workers to add to our knowledge of the composition of the fauna at Waldron. Concerning the stratigraphic relations of this interesting fauna and its distribution beyond the original locality, Prof. Hall's valuable paper contributed nothing, however. The principal additions to our knowledge of the distribution of the fauna since Hall's work comprise various notes in the papers of Prof. Foerste[e] incidental to the discussion of other parts of the Silurian in Indiana and a list of the fauna at Tarr Hole by Prof. Cummings.[f] The latter paper confines itself to a single locality twelve miles south of the original locality of the Waldron fauna.

The writers have, while occupied in part with other problems, given considerable attention to the distribution of the Waldron shale and its fauna in southern Indiana during two field seasons. These observations have brought out most of the essential facts regarding the distribution and stratigraphic relations of this fauna in southern Indiana. The direct studies of the fauna have been supplemented by the field work of the senior author on the eastern side of the Cincinnati geanticline in Ohio and Kentucky.

---

[a]Published by permission of the Director of the U. S. Geological Survey.

[b]The collections on which the paper is based were made by both authors; the stratigraphic section is based upon the notes of the senior author.

[c]Notice of some new species of fossils from a locality of the Niagara group in Indiana with a list of identified species from the same place.—Trans. Albany Inst., Vol. IV, 1862.

[d]The fauna of the Niagara group in central Indiana, 28th Ann. Rept. N. Y. State Mus., 1879, pp. 99–199, plates III–XXXIV.

[e]21st Ann. Rept. Ind. Dept. Geol. and Nat. Res. 1897, pp. 213–288; 22d Ann. Rept. Ind. Dept. Geol. and Nat. Res. 1898, pp. 195-255; 24th Ann. Rept. Ind. Dept. Geol. and Nat. Res. 1900, pp. 41–80.

[f]On the Waldron fauna at Tarr Hole, Indiana. Proc. Ind. Acdy. Sci., pp. 174–176, 1900.

It will be the purpose of this paper to indicate the stratigraphic relationship of the Waldron shale to the other subdivisions of the Silurian and to present the available data regarding the composition and distribution of its fauna. The relationship of the Waldron fauna to the faunas of the Laurel and the Louisville limestones which were respectively its predecessor and successor in this region will also be considered.

STRATIGRAPHY.

The Silurian rocks of southern Indiana comprise three distinct limestone formations, which are separated by two shale horizons. The higher of the two argillaceous beds is called the Waldron shale and separates the Laurel limestone from the Louisville limestone, which is the highest division of the Silurian series in this area. The general relationship of the several formations of the Silurian in southern Indiana is expressed in the following table showing their order of superposition:

Silurian	Niagaran group	Louisville limestone.
		Waldron shale.
		Laurel limestone.
		Osgood beds.
		Clinton limestone.

The so-called Clinton rests directly upon the Richmond formation, the uppermost beds of the Ordovician. The Guelph dolomite, which terminates the Niagaran group in New York, is absent in southern Indiana, the Devonian limestone resting unconformably on the Louisville limestone.

Dr. M. N. Elrod[a] first introduced the name Waldron shale for the beds from which Prof. James Hall[b] had previously described the rich fauna at Waldron.

The Waldron shale is composed mainly of fine textured blue to greenish clay shale. Thin bands of impure limestone and calcareous nodules sometimes occur in the shale but represent a comparatively insignificant proportion of the formation. The Waldron shale has a thickness ranging generally from four to ten feet. So far as observed by the writers the Waldron beds are conformable with the Niagara limestone beds above and below it. Elrod[c] reports that the shale is unconformable with the Laurel limestone at the Tarr

[a] Geology of Decatur County, 12th Ann. Rept. Ind. Dept. Geol. and Nat. Hist., 1882, pp. 109-111.

[b] 28th Rept. N. Y. State Mus., 1879, pp. 100-199, pls. 3-34.

[c] Niagara group unconformities in Indiana. Proc. Ind. Acad. Sci. 1901, p. 212.

Hole near Hartsville. The evidence which he presents, however, is not conclusive and may be equally well accounted for by local warping of the beds. Under the influence of a gentle westerly dip, averaging probably about 30′ to the mile, the Waldron shale passes under the later formations to the westward. The westerly dip and slight thickness of the formation combined with the absence of very strong topographic relief confines the outcrop of the Waldron shale to a rather narrow north and south belt. Although a very thin formation the Waldron is very persistent and extends southward from southern Shelby and Rush counties to the Ohio River, a distance of about 85 miles. The Waldron shale is not known north of the central part of the State. The heavy mantle of drift to the north of its northernmost exposures in Rush and Shelby counties conceals a large area in which important stratigraphic changes take place, the precise nature of which is unknown. All that we know certainly about them is that they result in a Silurian section in the Wabash Valley in which neither the Waldron shale nor its two accompanying limestone formations have been identified. It may be that the Cincinnati geanticline which is believed to have been in existence during the Waldron shale interval, as pointed out elsewhere in this paper, swung to the westward across north central Indiana making distinct marine basins in northern and southern Indiana. Certain differences in the faunas as well as the stratigraphy of the Silurian of the northern and southern Indiana sections could be cited in support of this hypothesis.

From the Shelby county localities southward the Waldron shale can be seen in numerous sections. In the northern part of its area of outcrop the approximate position of the Waldron shale is indicated when it does not outcrop by the junction of the Louisville limestone lying above it and the Geneva limestone. The latter, which is the lowest division of the Devonian, is a chocolate or buff colored saccharoidal magnesian limestone presenting a marked contrast with the lighter colored Louisville limestone. These two formations as previously shown by one of the writers[a] and others[b] are unconformable.

The Louisville limestone decreases from a thickness of 50 feet or more at the Ohio River to less than ten in many places in the northern part of the Waldron shale area.

[a] Kindle. 25th Ann. Rept. Ind. Dept. Geol. and Nat. Res. 1901, p. 557, pl. 16.

[b] Foerste. 22d Ann. Rept. Ind. Dept. Geol. and Nat. Res., 1898, pp 233-234; Price, 24th Ann. Rept. Ind. Dept. Geol. and Nat. Res., 1900, pp. 99, 121; Elrod, Proc. Ind. Acad. Sci., 1901 (1902), p. 210.

The Waldron shale and its relations to the above named formations is well shown in the following section which occurs on the east bank of Flat Rock Creek 1½ miles above Geneva near the original locality of the Waldron fauna:

Section on East Bank of Flat Rock Creek 1½ Miles Above Geneva.

	Feet.
Chocolate colored dolomitic saccharoidal limestone (Geneva).........	3
Hard light gray limestone (Louisville)..............................	5½
Waldron clay with irregular masses of limestone....................	5
Hard gray limestone..	1¼

The Waldron shale outcrops in the vicinity of Hartsville along the three forks of Clifty Creek. It generally has a thickness of about four feet and is richly fossiliferous, particularly at the Tarr Hole, Anderson Falls and a small ravine ¾ of a mile southwest of Hartsville. The overlying Louisville limestone is in places very thin in this vicinity, measuring less than 5 feet at some points.

At Harris City, which is 9 miles east of Hartsville, the Waldron shale and the Louisville limestone are both absent—the Devonian resting upon the Laurel limestone as shown by the following section of the rocks in the quarry at Harris City:

Section in Quarry at Harris City.

		Feet.
c.	Buff magnesian limestone of saccharoidal texture (Geneva limestone)	3 to 4
b.	Hard light gray crystalline limestone with numerous crinoid stems; small brachiopods not uncommon..................	5
a.	Hard bluish gray limestone; fossils scarce except an occasional Cephalopod	15

The fossils collected from the 5 feet of limestone underlying the Geneva, b of the section, includes the following species:

Pisocrinus gemmiformis
P. baccula
Stephanocrinus n. sp.
Camarotechia indianensis var.
Atrypa reticularis
Uncinulus stricklandi
Spirifer cf. *radiatus*
S. crispa var. simplex
Coelospira sp.
Clorinda sp.
Dalmanites verrucosus.

The genus *Pisocrinus* is unknown both in the Waldron and the Louisville limestone and the presence of the two species *P. gemmiformis* and *P. baccula* clearly indicates that this fauna represents the Laurel limestone. The Devonian limestone which follows unconformably the bed containing this fauna does not contain fossils at the Harris City quarry, but its lithologic peculiarities are so striking as to leave no doubt of its identity with the same beds elsewhere in which Devonian fossils are known to occur. The evidence seems therefore conclusive that the Waldron shale and the Louisville limestone are both absent from the Harris City section.

At Milroy, which is 13 miles north of Harris City, the Waldron shale according to Mr. Price[a], is absent in the more northerly sections, the Devonian resting unconformably on the Laurel limestone as at Harris City. A more southerly exposure in the town of Milroy shows the shale to be present. It is probable that in the drift covered region to the north of Waldron the Devonian generally rests unconformably on the Laurel limestone, as at the locality just noted, and terminates the extension of the Waldron shale to the northward.

The Louisville limestone separating the Waldron shale from the Devonian thickens to the south until at Vernon, 16 miles south of Hartsville, it has about twice the thickness shown at the Hartsville localities. The outcrop at the old tunnel near Vernon shows the following section:

Section at Old Tunnel Near Vernon, Ind.

	Feet.
Massive dark chocolate colored magnesian limestone with saccharoidal texture (Geneva limestone)	12
Hard, gray, heavy bedded limestone (Louisville limestone)	10 to 11
Blue calcareous sandstone	3
Blue clay shale (Waldron)	4 to 5
Hard, bluish, arenaceous limestone	2
Hard, gray, thin bedded limestone	10

The Waldron shale here contains a fauna almost if not quite as rich as the one at Waldron. Other richly fossiliferous localities occur to the south and southeast of Vernon along Big Creek, near Paris and Dupont. East of Dupont about two miles the Waldron shale reaches perhaps its maximum thickness—about 14 feet. At Hanover on the Ohio River, which is located south and east of the above-mentioned localities, the Waldron shale is much reduced in

[a] 24th Ann. Rept. Ind. Dept. Geol. and Nat. Res., 1900, p. 138.

thickness, while the Louisville limestone is greatly attenuated, if not entirely absent. The explanation of this fact is to be found in the greater comparative proximity of this locality to the broad crest of the Cincinnati geanticline, the limestone thinning in that direction as well as toward the north. The following section is exposed along the ravine crossing the village just west of the school house:

Section at Hanover West of Schoolhouse.

	Feet.
Light gray limestone with an abundance of Devonian fossils.........	3½
Dark buff saccharoidal magnesian limestone, massive or heavy bedded, usually rather soft (Geneva limestone)........................	8
Bluish gray calcareous and argillaceous shale and covered (Waldron)	3
Thin bedded, hard, drab limestone................................	35
Bluish arenaceous magnesian, thin bedded, shaly limestone and shale.	6
Brownish buff limestone, weathering in thin layers (Clinton)........	2½

The above section shows the Laurel limestone and Osgood beds to have together a thickness of 41 feet at Hanover, while the Louisville limestone, if present, is represented by but a small fraction of the three feet which includes the Waldron shale horizon.

The only locality at Hanover where the Waldron shale is known to be both fossiliferous and so exposed as to permit its fossils to be separated from the shale by weathering is on the schoolhouse grounds. The fossils collected here are the following: *Mariacrinus carleyi* (*Hall*), *Eucalyptocrinus sp.*, *Atrypa reticularis*, *Spirifer radiatus*, and *Dalmanites verrucosus*. This fauna, though small, represents a combination that might be expected anywhere in the Waldron shale, but is such as would not be found in the limestone above or below it. *Mariacrinus carleyi* is known only in the Waldron shale. The meager character of those found is no doubt due in part to the accessibility of the locality in the center of the village where its weathered fossils have long been collected.

The Fourteen Mile Creek drainage basin includes the southernmost outcrops of the Waldron shale. Northwest of New Washington, near the Sulphur Springs, the shale shows a thickness of about 6 feet, overlaid by 9 feet of the Louisville limestone. The southernmost appearance of the Waldron shale in Indiana is at Charleston Landing, on the Ohio, a short distance below the mouth of Fourteen Mile Creek, where Foerste reports[a] it to be 6 feet in thickness. In the lower Fourteen Mile Creek basin the Laurel limestone has considerably changed in composition and color, and become an argil-

[a] 21st Ann. Rept. Ind. Dept. Geol. and Nat. Res., 1897, p. 234.

laceous and shaley limestone, often brownish in color. The Louisville limestone shows its maximum thickness in this region. At the Utica lime quarry 30 feet of it are exposed without showing the total thickness. It probably has a total thickness of 50 feet or more at this point.

Two significant facts appear in connection with the distribution of the Waldron shale. Its outcrops occupy a narrow belt parallel to the axis of the Cincinnati geanticline. This belt is about 90 miles in length in Indiana and reappears again in west Tennessee[a] flanking the western slope of the southern extension of the same general uplift. Correlative with this considerable north and south extension amounting to about 280 miles, is the notable fact that the formation is entirely unknown in Ohio and Kentucky on the eastern side of the uplift. Professor Foerste[b] has shown that the Clinton is represented by a similar fauna and lithology on both sides of the geanticline and that the only evidence which we have of land masses at that time relates to one or more small islands in southeastern Indiana.

The evidence furnished by the distribution of the Clinton and its similarity in Ohio and Indiana, even to the salmon brown color, is opposed to the existence of any considerable land area in the region of the present Cincinnati geanticline during the deposition of the Clinton. The distribution of the Waldron shale, however, furnishes equally strong evidence of the existence of such a land mass separating the Silurian basin of southwestern Ohio and northeastern Kentucky from that of southeastern Indiana and northern Kentucky during the latter part of the Niagaran epoch. The Ripley island and probably other undetermined small land masses were doubtless the early Silurian forerunners of the later and more extended uplift, of which the Waldron shale is believed to be an off shore deposit. In harmony with the evidence furnished by the absence of the Waldron shale in Ohio is the lithologic unlikeness of the upper Silurian section on the two sides of the Cincinnati geanticline.

The Ohio section contains no formations which can be considered identical with the Louisville limestone and the Waldron shale. On the Ohio side the Silurian limestones above the Clinton are almost invariably dolomites or highly magnesian limestones,

[a] Bull. Geol. Soc. of Am., Vol. 12, 1901, p. 407.

[b] The Ordovician-Silurian contact in the Ripley Island area of southern Indiana, with notes on the age of the Cincinnati geanticline. Am. Jour. of Sci., Vol. XVIII, 1904, pp. 321-342.

while in southeastern Indiana they are non-magnesian limestones or limestones with a very small percentage of magnesia. All of the available evidence appears to indicate that there was a succession of periods of gradual and areally progressive development of the Cincinnati geanticline from Clinton time to the close of the Louisville epoch. The last of these intervals of uplift terminated Silurian deposition in this area and extended the land conditions to the westward of most of the present outcrops of the Silurian in southern Indiana. The evidence of the last phase of the uplift is found in the unconformity which has been shown to exist between the Silurian and Devonian both in northern and southern Indiana.[a] At Harris City the Geneva limestone, which is the basal Devonian formation, rests directly on the Laurel limestone; the Waldron shale and the Louisville limestone both being absent. Nine miles west of this point both the Louisville limestone and the Waldron shale are present, the latter having about its maximum faunal development. The absence of the two upper formations of the Silurian at Harris City is the result either of erosion during the interval represented by the Siluro-Devonian unconformity or of non-deposition resulting from a retreating shore line at the end of the Laurel limestone epoch. The extension of the latter formation 20 miles eastward of Harris City, without any known out-liers of the Louisville limestone or Waldron shale, favors the latter hypothesis.

A map and report by Mr. J. A. Price[b] affords important evidence in this connection. Mr. Price's map attempts to show the eastern limit of the Waldron shale across Decatur County, a north-south distance of about 30 miles. The field work was evidently done with considerable care, but the line which purports to be the eastern limit of the Waldron shale marks in reality the parting between the Geneva limestone (Devonian) and the Laurel limestone (Silurian). The map, which shows all of the Waldron shale outcrops observed by Mr. Price, indicates that these are to be seen frequently three to ten miles west of his assumed eastern limit of the shale, but not a single outcrop is shown on or near the line supposed to represent its eastern border. It appears clear from the report[c] that wherever the uppermost Silurian beds were observed near this line they represent the Laurel limestone and are followed directly by

[a] Kindle, E. M. The Devonian fossils and stratigraphy of Indiana. 25th Ann. Rept. Dept. Geol. and Nat. Res. of Ind., 1901, pp. 557, 562, 566, pl. 16.

[b] "A report upon the Waldron shale and its horizon." 24th Ann. Rept. Ind. Dept. Geol. and Nat. Res., 1900, pp. 81-143.

[c] Ibid., pp. 85-92.

the Devonian. Mr. Price evidently held this opinion with reference to the immediate vicinity of Greensburg, since he states:[a] "The Waldron shale is absent and was probably never deposited in this locality." The important fact for our present purpose, which this map shows, is that for a distance of about 30 miles along its eastern border the Waldron shale and the Louisville limestone are overlapped by the Devonian limestone. It appears highly improbable that erosion during the Devono-Silurian unconformity intervals would have completely removed both formations to the east of the Devono-Silurian parting and left them both with rather slight evidences of erosion a short distance to the west of that boundary.

Composition and Distribution of the Waldron Fauna.

The luxuriant fauna which characterizes the Waldron shale at Waldron retains a considerable number of the 160 odd species known at Waldron for fifty miles south of this place. Paris Crossing and Dupont are the most southerly localities at which the fauna retains its characteristic richness in the number of species and individuals. South of the Big Creek locality, near Dupont, the fauna is still represented, but in a depauperate condition. At Hanover, on the Ohio River, less than half a dozen species have been found to represent the rich fauna at Hartsville and Waldron. At many localities near the Ohio, it appears to be almost if not quite barren of fossils. While all the outcrops of the Waldron within 25 miles of the Ohio are but very slightly fossiliferous it should be observed that numerous nearly barren outcrops occur also in the same general region as the richly fossiliferous exposures. These semi-barren localities so far as noted seem to lie to the east of the highly fossiliferous ones. It may be that the faunal poverty of these outcrops, together with those near the Ohio River, is due to the fact that they represent an in-shore zone lying slightly to the east of the belt most favorable to the growth of a luxuriant fauna. Shallower water, a slightly different temperature, or difference in salinity may have made the extreme in-shore zone unfavorable to the rich fauna living just outside it. That all of the Waldron outcrops near the Ohio would belong to this more easterly belt follows from the fact that the greater westerly dip near the river reduces the width of the outcropping belt of the Silurian rocks from 30 miles or more near Waldron to 10 miles or less from Jef-

[a] Ibid., 3, p. 89.

ferson County southward. If we may judge from the rich fauna which characterizes the Waldron shale in western Tennessee,[a] the sparse fauna of the shale in the southern part of Indiana is not connected with any conditions unfavorable to life which were associated with the southern part of the Waldron shale basin of deposition. It seems probable that the Waldron shale a few miles to the west of its outcrops in Clark and southern Jefferson counties contains a fauna similar in richness to the Waldron localities. The distribution of the Waldron fauna, as we know it from the outcrops of the Waldron formation, is shown in the following list. The names of the several localities are arranged from left to right in the same order as their relative geographic position from north to south. Hartsville lies 12, Vernon 30, Dupont 38, Paris Crossing 42, and Hanover 50 miles south or southeast of Waldron.

LIST OF THE WALDRON FAUNA IN SOUTHERN INDIANA.[b]

	Waldron.	Hartsville.	Vernon.	Dupont.[c]	Paris.[d]	Hanover.
PLANTAE.						
Buthrotrephis gracilis var. crassa, Hall	×	....	....	....	....	....
SPONGIAE.						
Receptaculites subturbinatus Hall	×	....	....	....	....	....
Receptaculites sacculus Hall	×	....	....	....	....	....
Astylospongia praemorsa Goldf	×	× ?	....	....	....	....
Astylospongia praemorsa var. nuxmoschata, Hall	×	....	....	....	....	....
Astylospongia imbricato-articulate F. Roem	×	....	....	....	....	....
Astylospongia (Palaeomanon) bursa Hall	×	....	....	....	....	....
HYDROZOA.						
Chaunograptus novellus (Hall)	×	....	....	....	....	....
Inocaulis divaricata Hall	×	....	....	....	....	....
ANTHOZOA.						
Streptelasma radicans Hall	×	....	....	×	....	....
Duncanella borealis Nicholson	×	×	....	×	....	....
Zaphrentis celator Hall	×	×	....	....	....	....
Aulopora precius Hall	×	....	....	....	....	....
Favosites spinigerus Hall	×	....	....	×	....	....
Favosites forbesi, var. occidentalis, Hall	×	×	....	....	....	....
Cladopora sarmentosa Hall	×	....	....	....	....	....

[a] Foerste, Aug. F. "Silurian and Devonian limestones of western Tennessee." Jour. of Geol., Vol. XI, 1903, p. 707.

[b] This list includes all of the species recorded by Hall from Waldron and by Cummings from Hartsville. The 12 species added to Cummings' list of the fauna at Tarr Hole are mainly from two localities near Hartsville not represented in the Cummings collection, viz.: Clifty Falls and a ravine southwest of Hartsville, ¾ of a mile.

[c] The fossils from Dupont are given on the authority of Foerste, 21st. Ann. Rept. Ind. Geol. Surv. p. 257.

[d] A very small collection was made at Paris and the few species here listed from this locality are not representative of the richness of the fauna.

WALDRON FAUNA—Continued.

	Waldron.	Hartsville.	Vernon.	Dupont.	Paris.	Hanover.
BRYOZOA.[1]						
Berenicea elegans (Hall)	×	×				
Ceramopora ? confluens Hall	×	×				
Ceramopora ? raripora Hall	×					
Ceramopora ? nothus Hall	×					
Ceramopora ? explanata Hall	×					
Chilotrypa varia (Hall)	×	×				
Chilotrypa variolata (Hall)	×					
Fistulipora halli Rominger	×					
Fistulipora neglecta Rominger	×	×	×			
Fistulipora neglecta-maculata (Hall)	×	×				
Monotrypella ? consimilis (Hall)	×	×				
Leptotrypa ? sphaerion (Hall)	×	×				
Lioclema ? exsul (Hall)	×					
Eridotrypa echinata (Hall)	×	×				
Batostomella granulifera (Hall)	×	×				
Trematopora ? spiculata Miller	×					
Trematopora (Chaetetes) crebripora Hall	×					
Trematopora ? singularis (Hall)	×					
Callopora elegantula Hall	×			×		
Callopora ? cervicornis Hall	×					
Callopora ? diversa Hall	×					
Drymotrypa niagarensis (Hall)	×					
Loculipora ambigua (Hall)	×					
Semicoscinium acmeum (Hall)	×	×				
Polypora punctostriata (Hall)	×					
Fenestella pertenuis Hall	×					
Fenestella bellistriata Hall	×					
Fenestella prolixa Hall	×					
Fenestella parvulipora Hall	×	×				
Polypora conferta (Hall)	×					
Polypora tentulas (Hall)	×					
Nematopora macropora (Hall)	×					
Nematopora minuta (Hall)	×	×				
Ptilodictya angusta (Hall)	×					
Stictotrypa orbipora (Hall)	×					
Stictotrypa similis Hall	×	×				
Diamesopora osculum (Hall)	×	×				
Diamesopora infrequens (Hall)	×					
Diamesopora subimbricata (Hall)	×	×				
Paleschara ? offula Hall	×					
Paleschara maculata Hall	×	×				
Paleschara ? incrassata Hall	×					
PELMATOZOA.						
Periechocrinus whitfieldi (Hall)	×	×	×			
Platycrinus siluricus Hall	×					
Macrostylocrinus striatus Hall	×					
Macrostylocrinus granulosus (Hall)	×					
Macrostylocrinus fasciatus Hall	×	×				
Mariacrinus carleyi (Hall)	×					×
Acacocrinus elrodi W. & Sp.		×				
Thysanocrinus occidentalis, (Hall)	×	×				
Thysanocrinus occidentalis, var. crebescens, (Hall)	×					
Thysanocrinus inornatus, (Hall)	×					
Botryocrinus polyxo, (Hall)	×					
Botryocrinus nucleus, Hall	×					
Botryocrinus (Poteriocrinus) aemulus, (Hall)	×					
Poteriocrinus ? calyx, Hall	×					
Lecanocrinus pusillus, Hall	×	×	×	×		
Ichthyocrinus subangularis, Hall	×					
Melocrinus obconicus, Hall	×					
Lyriocrinus melissa, Hall	×	×				
Dendrocrinus ancilla, Hall	×					
Eucalyptocrinus sp						×
Eucalyptocrinus crassus	×	×	×	×		
Eucalyptocrinus ventricosus W. & Sp	×	×	×			
Eucalyptocrinus ovalis, (Troost) Hall	×	×				
Eucalyptocrinus tuberculatus Miller & Dyer	×	×				

[1]The Bryozoa in this list are with but few exceptions quoted on the authority of Hall and Cummings. Their absence from the last four columns indicates only that they were not studied from these localities.

WALDRON FAUNA—Continued.

	Waldron.	Hartsville.	Vernon.	Dupont.	Paris.	Hanover.
PELMATOZOA—Continued.						
Ampheristocrinus typus, Hall	×					
Stephanocrinus gemmiformis, Hall	×					
Codaster (Stephanocrinus ?) pulchellus, Miller & Dyer	×	×				
Codaster pentalobus Hall	×					
Calceocrinus stigmatus Hall	×					
BRACHIOPODA.						
Lingula gibbosa Hall	×					
Pholidops ovalis Hall	×	×				
Crania siluriana Hall	×					
Crania setifera Hall	×	×				
Crania spinigera Hall	×					
Dictyonella reticulata Hall	×	×				
Leptaena rhomboidalis (Wilckens)	×	×		×		
Plectambonites sp				×		
Stropheodonta profunda Hall	×		×			
Strophonella striata Hall	×	×				
Strophonella semifasciata Hall	×					
Schuchertella tenuis Hall	×	×				
Schuchertella subplanus (Conrad)	×	×	×	×		
Mimulus waldronensis (Miller & Dyer)	×					
Chonetes novascotius Hall	×	×	×			
Chonetes undulatus Hall	×					
Rhipidomella hybrida (Sowerby)	×	×	×	×		
Dalmanella elegantula (Dalman)	×	×	×	×		
Orthis (?) subnodosa Hall	×					
Bilobites bilobus (Linnaeus)	×					
Anastrophia internascens Hall	×	×	×	×		
Clorinda fornicata (Hall)	×					
Rhynchotreta cuneata var. americana Hall	×	×	×			
Uncinulus stricklandi (Sowerby)	×	×				×
Camarotoechia (?) neglecta Hall	×	×		×		
Camarotoechia (?) acinus Hall	×	×	×	×		
Camarotoechia (?) indianensis (Hall)	×	×	×			
Camarotoechia whitei Hall	×	×	×	×		
Zygospira (?) minima Hall	×					
Atrypina disparilis (Hall)	×	×				
Atrypa reticularis (Linnaeus)	×	×	×	×	×	×
Spirifer eudora Hall	×					
Spirifer crispus (Hisinger)	×	×	×	×		
Spirifer crispus var. simplex, Hall	×	×	×			
Spirifer radiatus Sowerby	×	×	×			×
Spirifer cf. niagarensis (Hall)		×		×		
Reticularia bicostata petila (Hall)	×	×				
Meristina maria Hall	×	×	×			
Whitfieldella nitida Hall	×	×	×	×		
Meristina rectirostris Hall	×	×				
Nucleospira pisiformis Hall	×	×				
Homoeospira evax Hall	×	×	×			
Homoeospira sobrina (Beecher & Clarke)	×	×	×?			
LAMELLIBRANCHIATA.						
Amphicoelia leidyi Hall	×					
Ambonychia acutirostra Hall	×					
Modiolopsis perlatus Hall	×	×				
Modiolopsis subalatus Hall	×					
Mytilarca sigilla, Hall	×	×				
Pterinea brisa, Hall	×					
Goniophora speciosa, Hall	×					
Cypricardinia arata, Hall	×	×				
GASTEROPODA.						
Platyostoma niagarense, Hall	×	×		×		
Platyostoma plebeium. Hall	×					
Strophostylus cyclostomus, Hall	×	×	×			
Strophostylus cyclostomus, var. disjunctus, Hall	×	×				
Loxonema ——— ?	×					
Bellerophon tuber, Hall	×					
Cyrtolites sinuosus, Hall	×					

WALDRON FAUNA—Continued.

	Waldron.	Hartsville.	Vernon.	Dupont.	Paris.	Hanover.
CONULARIA.						
Conularia infrequens, Hall	×	....	....	....	....	....
Coleolus spinulus, Hall	×	....	....	....	....	....
Enchostoma n. sp	....	....	×	....	....	....
CEPHALOPODA.						
Orthoceras simulator, Hall	×	....	....	....	....	....
Orthoceras medullare, Hall	×	....	....	....	....	....
Orthoceras subcancellatum, Hall	×	....	....	....	....	....
Orthoceras undulatum, His	×	....	....	....	....	....
Orthoceras amycus, Hall	×	....	....	....	....	....
Nautilus oceanus, Hall	×	....	....	....	....	....
Gyroceras abruptum, Hall	×	....	....	....	....	....
Trochoceras waldronense, Hall	×	....	....	....	....	....
ANNELIDA.						
Spirorbis inornatus, Hall	×	....	....	....	....	....
Cornulites proprius, Hall	×	×	×	×	....	....
CRUSTACEA						
Leperditia faba, Hall	×	×	....	....	....	....
Beyrichia granulosa, Hall	×	....	....	....	....	....
Beyrichia sp	....	....	×	....	....	....
Calymene niagarensis, Hall	×	×	....	....	....	....
Homalonotus delphinocephalus, Green	×	....	....	....	....	....
Cyphaspis chrystyi, Hall	×	×	....	....	....	....
Acidaspis fimbriata, Hall	×	....	....	....	....	....
Illaenus armatus, Hall	×	....	....	....	....	....
Illaenus (Bumastus) ioxus, Hall	×	....	....	....	....	....
Ceraurus niagarensis, Hall	×	....	....	....	....	....
Dalmanites vigilans, Hall	×	....	....	....	....	....
Dalmanites verrucosus, Hall	×	×	....	....	....	×
Dalmanites bicornis, Hall	×	....	....	....	....	....
Lichas breviceps, Hall	×	....	....	....	....	....
Lichas boltoni, var. occidentalis, Hall	×	×	....	....	....	....

Relation of the Waldron to Preceding and Succeeding Faunas.

The amount and kind of difference which distinguishes the Waldron fauna from that of the Laurel limestone which was its immediate predecessor in this region is a matter of much importance in connection with any adequate interpretation of the history of the fauna. Comparison of the Waldron fauna with the fauna which preceded it is necessary in order to ascertain what elements if any are of foreign and what of indigenous origin. For the purpose of such comparison a list of the fauna of the Laurel limestone which preceded the Waldron is introduced here. In order to make the list as complete as possible all of the species which have been recorded from this fauna are included in it.

Fauna of the Laurel Limestone.[1]

Unless otherwise stated, the fossils are from St. Paul.

Anthozoa.

Amplexus cinctutus Miller.
Favosites spongilla Rominger.
Streptelasma spongiaxis Rominger.
Striatopora gorbyi Miller.
Plasmopora follis Milne-Edwards.
Plasmopora scita Milne-Edwards.

Pelmatozoa.

Aethocystites sculptus Miller.
Allocrinus benedicti Miller.
Calceocrinus indianensis Miller.
Callicrinus beachleri Wachsmuth and Springer.
Caryocrinus ellipticus Miller and Gurley.
Cyclicocrinus canaliculatus Miller.
Callicrinus corrugatus Weller[a].
Cyclicocrinus ? indianensis Miller and Gurley.
Emperocrinus indianensis Miller and Gurley.
Holocystites pustulosus Miller, a few miles from Waldron.
Hyptiocrinus typus Wachsmuth and Springer.
Idiocrinus elongatus Wachsmuth and Springer.
Idiocrinus ventricosus Wachsmuth and Springer.
Indianocrinus punctatus Miller and Gurley.
Macrostylocrinus indianensis Miller and Gurley.
Mariacrinus aureatus Miller.
Mariacrinus granulosus Miller.
Melocrinus equalis Miller.
Melocrinus oblongus Wachsmuth and Springer.
Melocrinus parvus Wachsmuth and Springer.
Pisocrinus baccula Miller and Gurley[a]. H. and St. Paul.
Pisocrinus globosus Ringueberg.
Pisocrinus gemmiformis Miller[a]. H.
Periechocrinus ? ornatus.
Periechocrinus howardi Miller.

[1] Species marked with an *a* are included upon the evidence of specimens collected and determined by the senior author. Other species are included on the authority of S. A. Miller (18th Ann. Rept. Ind. Geol. Surv.); Wachsmuth and Springer (Mem. Mus. Comp. Zool. Harvard Coll., vols. XX-XXI, pp. 1-837, pls. 1-83, 1897) and Foerste (Am. Jour. Sci., Vol. XVIII, 1904, pp. 341-342).

Saccocrinus umbrosus Miller and Gurley.
Stribalocystites gorbyi Miller.
Stribalocystites tumidus Miller.
Stribalocystites spheroidalis Miller and Gurley.
Zophocrinus howardi Miller.

Brachiopoda.

Stropheodonta cf. striata[a].
Schuchertella cf. subplana[a]. O.
Dalmanella elegantula[a] Dalman. O.
Platystrophia dentata (Pander)[a]. O. H.
Anastrophia internascens[a] Hall. G.
Clorinda sp.[a] H.
Camarotoechia indianensis Hall var.[a] H.
Uncinulus stricklandi (Sow.)[a]. H.
Atrypa reticularis[a] Linn. H.
Atrypa nodostriata Hall[a]. G.
Spirifer radiatus Sowerby. Madison and Harris City.
Spirifer crispa var. simplex[a]. H.
Coelospira sp.[a] H.

Cephalopoda.

Cyrtoceras howardi Miller.
Cyrtoceras indianense Miller.
Orthoceras undulatum His.[a]
Orthoceras imbricatum.
Orthoceras subcancellatum Hall.
Orthoceras crebescens Hall[a]. Hartsville.
Cyrtoceras elrodi White.

Crustacea.

Lichas byrnesanus Miller and Gurley. From neighborhood of Madison.
Lichas hanoverensis Miller and Gurley. Hanover.
Calymena niagarensis Hall. Hanover.[a]
Dalmanites verrucosus Hall. H.[a]

Exceptional conditions of preservation have made possible a very complete knowledge of the Waldron shale fauna. The much less perfect conditions of fossilization and collecting, conditioning

Note.—The capital letters after the name of the species indicate the following localities: H = Harris City; G = Greensburg; O = Osgood.

the study of a limestone fauna as well as the comparatively limited amount of study outside the *Pelmatozoa* which it has received, make the fauna of the Laurel limestone, as here listed, less complete and representative of the formation than that of the Waldron shale. Too little is known of the *Anthozoa* of the Laurel limestone to make profitable the comparison of the representatives of that group in the two faunas. The entire absence from this list of the *Bryozoa* and their abundance in the Waldron fauna is without significance except as indicating that the conditions of preservation are incomparably better in the Waldron shale than in the Laurel limestone, and that no attempt has been made to study the material which is preserved in the limestone.

In the case of the *Pelmatozoa,* however, the faunas are probably equally well known and consequently invite comparison. The crinoids described from St. Paul were obtained largely by local collectors, who secured very complete collections of these fossils, so that it is safe to assume that this part of the Laurel limestone fauna is known with a fair degree of completeness. Comparison of the representatives of the groups in the two faunas shows 26 species in the Waldron and 28 in the Laurel limestone fauna. Not a single one of these, however, is common to the two faunas. A complete change in the crinoidal life of the time seems to have been introduced in this province with the initiation of Waldron shale sedimentation. This element of the Waldron fauna evidently came into this region from some outside area at the close of the Laurel limestone interval. It does not appear to have been present in the region at any earlier period in the Silurian and cannot be considered in any degree a recurrent element of the fauna. If it had been present at all during any earlier period in this region the *Pelmatozoa* of the Waldron fauna might be expected to appear in the Osgood beds, which represent sedimentary conditions very similar to those which produced the Waldron shale. Comparison of the listed *Pelmatozoa*[1] of this fauna, which numbers 56 species, shows, however, that none of the Waldron species are present in it.

Comparison of the *Brachiopoda* of the Waldron and Laurel limestone faunas shows a marked contrast with the results noted for the *Pelmatozoa.* A comparatively small number of brachiopods is known from the Laurel limestone, altogether, but of these all but three occur in the Waldron fauna. One of the three is *Platystrophia dentata;* the other two have not been determined specifically. Of the *Brachiopoda* in the two faunas the comparison

[1] Am. Jour. Sci., Vol. XVIII, 1904, p. 341.

shows that 76 per cent. of the Laurel brachiopods are present in the Waldron.

The list affords no information regarding the groups *Pelecypoda, Gasteropoda,* and *Conularia,* each of which will probably eventually be found to be represented in the Laurel fauna.

In the *Cephalopod* group the Waldron and Laurel faunas are represented by about equal numbers of species according to the lists, the former having 8 and the latter 6 species. Two are common to the two faunas; thus showing a percentage of 33 1-3, which survived the Waldron shale conditions of sedimentation.

The *Crustacea* at present known in the Laurel fauna numbers but four species. Two of these or 50 per cent are present in the Waldron fauna.

These comparisons show that while the Waldron fauna is rather closely allied to its predecessor through the *Brachiopoda* and the *Cephalopoda,* it introduced in the *Pelmatozoa* a faunal element entirely new to the region.

Very few fossils have ever been found in the Louisville limestone in the region where the Waldron fauna is best developed. But at Louisville the formation contains an abundant fauna, which has been made known through the work of Nettleroth, Hall and others. In order to compare the Waldron fauna with its successor, the Louisville fauna, and to note the general effect on the composition of the fauna of a change from shale to limestone conditions of sedimentation, a list of the latter, which follows, has been compiled:

FAUNA OF THE LOUISVILLE LIMESTONE AT LOUISVILLE.[a]

Spongia.

Cyathospongia excrescens H. & W.

Hydrozoa.

Dictyonema pergracilis H. & W. (H. & W.)

Anthozoa.

Heliolites megastoma McCoy. (Davis.)[b]
Heliolites interstinctus Linnaeus. (Davis.)
Heliolites pyriformis Guettard. (Davis.)

[a] This list is compiled mainly from the papers of Hall (24th and 25th Ann. Repts. N. Y. State Mus. Nat. Hist.); Nettleroth (Ky. Fossil Shells, Ky. Geol. Surv.), and Davis (Ky. Fossil Corals, Ky. Geol. Surv.).

[b] The authority for each species is given in parenthesis after it.

Heliolites subtubulatus McCoy. (Davis.)
Plasmopora follis Edwards and Haime. (Davis.)
Plasmopora elegans Whiteaves. (Davis.)
Lyellia glabra Owen. (Davis.)
Lyellia papillate Rominger. (Davis.)
Lyellia americana Edwards and Haime. (Davis.)
Coenites laminata Hall. (Davis.)
Coenites crassa Rominger. (Davis.)
Favosites favosus Goldfuss. (Davis.)
Favosites niagarensis Hall. (Davis.)
Favosites forbesi Edwards and Haime. (Davis.)
Favosites spongilla Rominger. (Davis.)
Favosites cristatus Edwards and Haime. (Davis.)
Favosites venustus Hall. (Davis.)
Thecia major Rominger. Davis.)
Thecia minor Rominger. (Davis.)
Thecia swindernana Goldfuss. (Davis.)
Coenites verticillata. (Davis.)
Alveolites niagarensis Nicholson. (Davis.)
Cladopora reticulata Hall. (Davis.)
Cladopora laqueata Rominger. (Davis.)
Striatopora huronensis Rominger. (Davis.)
Halysites catenulatus Linnaeus. (Davis.)
Aulopora precius Hall. (Davis.)
Hallia scitula Hall. (H.)
Hallia devisa Hall. (H.)
Omphyma verrucosa Rafinesque and Clifford. (Davis.)
Anisophyllum mulargum Hall. (H.)
Anisophyllum trifurcatum Hall. (H.)
Anisophyllum ? bilamelatum Hall. (H.)
Ptychophyllum stokesi Edwards and Haime. (Davis.)
Ptychophyllum fulcratum Hall. (H.)
Diphyphyllum huronicum Rominger. (Davis.)
Diphyphyllum rugosum Edwards and Haime. (Davis.)
Strombodes pentagonus Goldfuss. (Davis.)
Strombodes striatus D'Orbigny. (Davis.)
Heliophyllum gemmiferum Hall. (H. & W.)
Heliophyllum parvum Hall. (H. & W.)
Heliophyllum dentilineatum Hall. (H. & W.)
Heliophyllum mitellum Hall. (H. & W.)
Heliophyllum puteatum Hall. (Hall.)
Cyathophyllum intertrium Hall. (H.)

Cyathophyllum bullulatum Hall. (H.)
Cyathophyllum granilinatum Hall. (H.)
Cyathoxonia herzeri Hall. (H.)
Strombodes pygmaeus Rominger. (Davis.)
Strombodes mamillaris Owen. (Davis.)
Cystiphyllum niagarense Hall. (Davis.)
Zaphrentis spongiaxis. (Davis.)
Zaphrentis radicans. (Davis.)
Amplexus shumardi Edwards and Haime. (Davis.)
Zaphrentis patula. (Davis.)
Zaphrentis conulus. (Davis.)
Calceola pusilla Hall. (H.)
Chonophyllum vadum Hall. (H.)
Chomophyllum capax Hall. (H.)

Pelmatozoa.

Macrostylocrinus meekii Lyon. (H. & W.)
Periechocrinus infelix Winch and Marc (Saccocrinus christii Hall). (H. & W.)
Eucalyptocrinus elrodi Miller (Eucalyptocrinus coelatus Hall). (H. & W.)
Eucalyptocrinus crassus Hall. (H. & W.)
Melocrinus obconicus Troost. (Hall.) (H. & N.)
Haplocrinus maximus Troost. (H. & W.)
Caryocrinus ornatus Say. (H. & W.)
Pentremites reinwardtii Troost. (H. & W.)

Brachiopoda.

Stropheodonta profunda Hall. (Nettleroth.)
Strophonella striata Hall. (Nettleroth.)
Leptaena rhomboidalis Wilckens. (Nettleroth.)
Schuchertella tenuis Hall. (Nettleroth.)
Schuchertella subplanus Conrad. (Nettleroth.)
Orthis flabellites Foerste. (Nettleroth.)
Orthis (?) nisis Hall and Whitfield. (Nettleroth.)
Orthis (?) rugiplicata Hall and Whitfield. (Nettleroth.)
Orthis (?) subnodoso Hall. (Nettleroth.)
Rhipidomella hybrida Sowerby. (Nettleroth.)
Dalmanella elegantula Dalman. (Nettleroth.)
Platystrophia biforata Schlotheim. (Nettleroth.)
Anastrophia interplicata Hall. (Hall.)

Anastrophia internascens Hall. (Nettleroth.)
Stricklandinia louisvillensis Nettleroth. (Nettleroth.)
Hyattella congesta Conrad. (Nettleroth.)
Gypidula globulosa. (Nettleroth.)
Gypidula knotti Nettleroth. (Nettleroth.)
Gypidula nucleus Hall and Whitfield. (Nettleroth.)
Gypidula uniplicata Nettleroth. (Nettleroth.)
Conchidium tennicostatum Hall and Whitfield. (Nettleroth.)
Conchidium knappi Hall and Whitfield. (Nettleroth.)
Conchidium littoni Hall. (Nettleroth.)
Conchidium nysius Hall and Whitfield. (Nettleroth.)
Pentamerus oblongus Sowerby. (Nettleroth.)
Pentamerus oblongus, var. cylindricus Hall and Whitfield (Nettleroth.)
Pentamerus pergibbosus Hall and Whitfield. (Nettleroth.)
Clorinda ventricosa Hall.
Rhynchotreta cuneata var. americana Hall. (Nettleroth.)
Camarotoechia (?) acinus Hall. (Nettleroth.)
Camarotoechia (?) indianensis Hall. (Nettleroth.)
Rhynchonella belliformis Nettleroth. (Nettleroth.)
Rhynchonella louisvillensis Nettleroth. (Nettleroth.)
Rhynchonella pisa Hall and Whitfield. (Nettleroth.)
Rhynchonella rugicosta Nettleroth. (Nettleroth.)
Rhynchonella tennesseenis Roemer. (H.) (H. & W.)
Wilsonia saffordi Hall. (Nettleroth.)
Wilsonia saffordi var. depressa Nettleroth. (Nettleroth.)
Uncinulus stricklandi Sowerby. (Nettleroth.)
Atrypa rugosa Hall. (H. & W.)
Atrypa nodostriata Hall. (H. & W.)
Atrypa marginalis Dalman. (H.) (H. & W.)
Atrpya reticularis var. niagarensis Nettleroth. (Nettleroth.)
Cyrtia myrtia Billings. (Nettleroth.)
Spirifer crispus var. simplex. Hall. (Nettleroth.)
Spirifer foggi Nettleroth. (Nettleroth.)
Spirifer eudora Hall. (H. & W.)
Spirifer rostellum Hall. (Nettleroth.)
Spirifer radiatus Sowerby.
Spirifer niagarensis (?) Conrad. (H.)
Reticularia bicostata Vanuxem. (H.)
Rhynchospira helena Nettleroth. (Nettleroth.)
Anoplotheca hemispherica Sowerby. (Nettleroth.)
Meristina maria Hall. (Nettleroth.)

Whitfieldella nitida Hall. (Nettleroth.)
Whitfieldella nitida var. oblata Hall. (H. & W.)
Nucleospira elegans Hall. (Nettleroth.)
Nucleospira pisiformis Hall. (Nettleroth.)

Lamellibranchiata.

Orthonota curta Conrad. (H.)

Gasteropoda.

Pleurotomaria casii Meek and Worthen.
Euomphalus (Cyclonema) rugaelineata Hall and Whitfield. (H. & W.)
Platyostoma niagarense Hall.
Murchisonia petila Hall and Whitfield. (H. & W.)
Cyclonema cancellata Hall.
Trochonema fatua Hall.

Cephalopoda.

Lituites marshi Hall.

Crustacea.

Illaenus barriensis Murchison. (H.)
Illaenus cornigerus Hall and Whitfield. (H. & W.)

One of the most striking contrasts between the two faunas appears in the corals. But one of the Waldron species is recorded from the Louisville fauna, while a second is represented in the latter by a variety. Instead of the half dozen species of the Waldron fauna we have in the Louisville limestone according to Davis and Hall, 57 species. Too little is known of the Bryozoa of the Louisville limestone to permit profitable comparison. In the *Pelmatozoa* we find but two of the Waldron species recorded from the Louisville limestone by Hall. The other 24 species known in the Waldron fauna have not been recorded from the Louisville fauna.

In the case of the Brachiopoda both lists represent fairly complete and accurate knowledge and are probably about equally exhaustive as regards this group in both faunas. Comparison of the species listed in the two faunas shows that 21 of the Waldron brachiopods fail to appear in the Louisville limestone. Some of the Waldron species which are not found in the later fauna and which may be considered characteristic Waldron species are *Mimulus waldronensis, Meristina rectirostris, Homeospira evax, Camero-*

toechia whitei, and *Dictyonella reticulata*. In the Louisville limestone fauna 39 brachiopods appear which are unknown in the Waldron shale. These represent 65 per cent of the total brachiopod fauna of the Louisville formation and include several large species of the pentameroid group of which *Pentamerus oblongus* and *Conchidium knappi* are examples. The two lists show that 47 per cent of the Waldron brachiopods continue into the Louisville limestone. Nettleroth's observations on some of these show that many of them are represented in the later fauna by dwarfed specimens.

In the groups not yet discussed it is believed that the list of the Louisville fauna is too incomplete to justify close comparison.

THE MAMMALS OF INDIANA.

A Descriptive Catalogue of the Mammals Occurring in Indiana in Recent Times.

BY

WALTER LOUIS HAHN, Ph D

LETTER OF TRANSMITTAL.

SPRINGFIELD, SOUTH DAKOTA, February 5, 1909.

Hon. W. S. Blatchley, State Geologist, Indianapolis, Indiana:

Dear Sir—I herewith transmit for publication by your department a report on the Mammals of Indiana. The preparation of this report was begun almost five years ago while the writer was employed as aid in charge of the Division of Mammals in the United States National Museum at Washington. During the past two years the work has been continued, at such times as opportunity offered, with your co-operation and under your direction. Field work was carried on for a short time in 1904, 1905 and 1906, with the co-operation of the National Museum; in 1906 and 1907 with the co-operation of Indiana University, and in 1907 and 1908 with aid from your department. While the collections made are by no means exhaustive, it is believed that nearly all of the species occuring in the State have become known, either through specimens or authentic records.

Respectfully yours,

WALTER L. HAHN.

INTRODUCTORY REMARKS.

Considering the size, abundance and economic importance of the group, probably no branch of natural history has been so much neglected in Indiana as the study of mammals. In seeking information in any locality it is usually necessary first to explain what is meant by "mammal." Then the resident, whether he be farmer, hunter or amateur naturalist, is usually unable to enumerate more than six or eight kinds of fur-bearing and game animals.

If asked concerning shrews, it is probable that he will say very positively that there are none. Possibly he may admit the existence of some kind of mouse other than the house mouse, but on being shown specimens of meadow mice he will call them moles, and when the collector brings in shrews, trapped perhaps within sight of his house, he will either say that he has never before seen such animals or assert that they are young moles, and he is usually astonished if a collector secures twenty or more species of small mammals in his locality in a week or ten days.

The professional naturalist is but little better informed concerning the mammals of this region. The Central States have been passed over for more fruitful fields by the government agents and museum collectors. When the writer began gathering material for this paper five years ago, there were not a dozen Indiana specimens in the national collections at Washington. The State Museum at Indianapolis contains a fairly representative mounted collection, but lacks a number of species of mice, shrews and bats, and has no reserve material for study. With the exception of Indiana University, where there is a small collection, there are no specimens available in any Indiana college.

The primary purpose of this paper is to furnish a contribution to the zoology of the State which will enable students to identify the species of Indiana mammals, and which will give the principal facts known regarding their distribution, life history, habits, food and relation to man.

MATERIAL AND ACKNOWLEDGMENTS.

Work on this article was begin in 1904 while the writer was employed in the United States National Museum at Washington, as an aid in charge of the Division of Mammals, and much of the preliminary work was done in that institution. The National Museum also afforded an opportunity to spend a month in field work in the Kankakee Valley during the summer of 1905. The Field Museum of Chicago and the collections of the Cincinnati Society of Natural History each contains a few specimens of mammals from Indiana, and the writer is indebted to the authorities of these institutions for the privilege of examining them.

Since 1904 the writer has spent a short time each summer in collecting at his home in Ohio County. A part of the specimens obtained there have been sent to the National Museum and others are retained in the private collection of the author.

During two years the author held a fellowship in zoology in Indiana University, residing one year at Bloomington and one year on University Farm at Mitchell. Considerable time was spent in collecting and studying mammals at both places, the University furnishing the necessary equipment, and this article is No. 100 of the contributions from the zoological laboratory of that institution.

Finally, the Indiana Department of Geology and Natural Resources has made possible two short collecting trips, one to the lake region of the northeastern part of the State and the other to the cypress swamps of the Wabash Valley.

No one realizes more fully than the writer that the material thus brought together is not adequate for all purposes. It is believed that all the species occurring in the State have been collected, with the exception of a few that are not at all common, and only the most intensive collecting in all parts of the State, or fortunate accident, can discover them. But the central part of the State has scarcely been touched, and it is not possible to give, with even approximate definiteness, the limits of the subspecies which intergrade in this region. The limits of some other species which do not have a range including all of the State are also but poorly defined. Discussions of geographic distribution must therefore be limited, but it is hoped that the accounts of the habits will partly make up for this deficiency.

The writer has not hesitated to use information from every available source. The preliminary list and bibliography of Indiana mammals published by Evermann and Butler in the Proceedings of the Indiana Academy of Science for 1893, and the additional notes of Butler in the same publication for 1894, have been an invaluable basis for the work. Of the general works, American Animals, by Stone and Cram; Merriam's Mammals of the Adirondacks, and Rhoads' Mammals of Pennsylvania and New Jersey, have been relied on for much information. The numerous monographs published by the Department of Agriculture and the National Museum have also been invaluable, and most of the figures of skulls and teeth have been borrowed from them. The nomenclature is that of Miller and Rehn's List of North American Mammals, with a few corrections, made necessary by discoveries since its publication. The keys are modified from Miller's Key to the Land Mammals of Northeastern North America. A full list of the works consulted in the preparation of the paper will be found in the bibliography.

Much information has been received from men in all parts of the State whose names it is not possible to enumerate. But special thanks are due to Mr. E. J. Chansler, of Bicknell, for notes and information very carefully collected by him in that locality during many years; to Prof. Van Gorder for similar notes from Noble County; to Dr. C. H. Eigenmann, of Indiana University, for assistance in many ways, and to Prof. W. S. Blatchley for information and assistance, and for the assistance from his Department which has made possible two field trips.

THE CLASS MAMMALIA.

STRUCTURE AND ZOOLOGICAL POSITION.

The class *Mammalia* includes such diverse creatures as whales, bats and man, as well as most of the common four-footed animals. Unfortunately the word "mammal" has never come into general use, and there is no other word in the English language that is an exact equivalent. Quadruped, which is sometimes used, includes lizards, frogs and other animals which are not members of the class, and does not include whales, man and bats, which are.

A mammal has been very simply defined as a "warm blooded, air-breathing animal that suckles its young." In addition to these characters, land mammals are always covered with hair and never with scales; there is a complete double circulation of the blood and a four-chambered heart; the skull articulates with the vertebral column by means of two rounded surfaces (occipital condyles) instead of one, as in birds and reptiles; there are teeth in both jaws, except in a few species in which they have degenerated; there is a corpus callosum uniting the two hemispheres of the brain; a complete diaphram separates the thorax from the abdomen; and, most important of all, the fertilized ovum is retained in the body of the female and the embryo is nourished from the blood of the mother to a late stage of development by means of a special structure (placenta), which is cast off at birth.*

It will be seen, therefore, that the mammals have the most highly specialized structure of all animals. In the development of the senses, in habits and in mental capacity they stand at the top of the animal kingdom.

In size they vary from a tiny shrew or bat weighing a fraction of an ounce, to the great blue whale, weighing sixty or more tons.

ECONOMIC IMPORTANCE.

A number of species have been domesticated by man and have been made to furnish him with food and clothing. The wide variation in the habits of mammals bring many of the wild species also into intimate relation with man. The members of the class have become adapted to surroundings in a variety of ways. Some live constantly in salt water; some are burrowing animals, spending their lives under ground; others are terrestrial and still others arboreal, while the bats are adapted to aerial locomotion. Their feeding habits are necessarily as varied as their means of locomotion, and some destroy crops or even endanger human life, while others are of great benefit on account of the noxious animals they destroy.

GEOGRAPHICAL DISTRIBUTION.

The distribution of any species of animal is determined by physical conditions. Of these, temperature is the most important. Very rarely do species have a north and south distribution extending through more than twenty or twenty-five degrees of latitude, and very few have a range as great as that. Their distribution is also influenced by humidity, drainage and elevation.

These factors are all relatively constant in Indiana, hence the mammalian fauna is much the same throughout the State.

A scheme for dividing the United States into faunal areas and zones has been proposed by Dr. Merriam† and generally accepted by other zoologists and botanists. According to his map, most of Indiana is in the Carolinian faunal area of the upper austral zone, with a small strip of the lower austral zone coming into the lower Wabash Valley.

---

* The placenta is entirely lacking in the Australian duck-bill and Echidna, and but imperfectly developed in the opossums and other marsupials.

† Life Zones and Crop Zones of the United States. Bull. 10, Div. Biol. Surv., U. S. Dept. Agr.

An examination of the mammalian fauna bears out Dr. Merriam's conclusions, although the lower austral species are not numerous. The species typical of the more southern latitudes are the southern shrew (*Sorex longirostris*), Carolinian short-tailed shrew (*Blarina brevicauda carolinensis*), long-eared bat (*Corynorhinus macrotis*), large-winged bat (*Myotis grisescens*), small shrew (*Blarina parva*), water hare (*Lepus aquaticus*), spotted skunk (*Spilogale putorius*), and water rat (*Oryzomys palustris*), the last being of questionable occurrence.

In the northwestern part of the State a few species that are characteristic of the western prairies, reach the eastern limit of their range. These are the two spermophiles (*Citellus tridecemlineatus* and *C. franklinii*), the pocket gopher (*Geomys bursarius*), coyote or prairie wolf (*Canis latrans*), prairie skunk (*Mephitis mesomelas avia*) and the badger (*Taxidea taxus*), the last being now almost extinct. The prairie mouse (*Peromyscus maniculatus bairdi*), prairie vole (*Microtus ochrogaster*), and prairie rabbit (*Sylvilagus floridanus mearnsi*) are also of prairie origin, although they now extend over nearly or quite all of the State.

Four species, the porcupine (*Erethizon dorsatus*), the fisher (*Mustela pennanti*), the wolverine (*Gulo luscus*) and the star-nosed mole (*Condylura cristata*) are believed to be of northern origin. The first three of these are also extinct.

It will thus be seen that the fauna of the State is not characteristic of any zone or faunal area, but that it is rather characterized as an area where the different faunal types blend. In the absence of mountains or other barriers, it is not possible to fix upon definite boundaries of the life zones.

RELATION TO ENVIRONMENT.

In their relation to the mammalian fauna, physical features other than climate, have a marked influence. The hilly southern portion of this State is better suited for many species of animals than the more level regions in the central and northern parts, and such animals as rabbits, opossums, weasels, minks and skunks are more abundant. Caves, which are numerous in some counties, afford homes for bats, and these animals are abundant in the cave regions. On the other hand, some mammals, especially two or three species of voles or meadow mice, are inhabitants of damp places and are most abundant among the lakes and swamps in the northern part of the State.

PLATE I.—A woodland habitat of the type common when the State was first settled, but now almost gone. University Farm, Mitchell, Indiana.

Classified on the basis of habitat, the sixty-six species of mammals recorded from Indiana may be roughly divided into four groups: (1) Those that live chiefly in the woods; (2) those that live chiefly in the grassy fields and prairies; (3) those with a general range including forest and field; (4) those whose habitat is not closely related with either grass or trees, but whose presence is due to some special reason.

The following 14 species belong to the first group: Five species of tree squirrels (including the flying squirrel), porcupine, raccoon, bear, two species of wildcat or lynx, panther, gray fox, fisher and wolverene. Since much of the forest that once covered more than half of the State has been cleared away, we should expect to find that many of these species are either reduced in number or exterminated. The facts are that seven of the 14 species—porcupine, two lynxes, panther, bear, pine marten and wolverene, are exterminated or nearly so. Of the remaining seven, the flying squirrel and the red squirrel have undoubtedly held their own in point of numbers and may have even increased because they are too small to be much sought after by man, and their natural enemies have decreased. The other three species of squirrel, the raccoon and the gray fox have greatly diminished in numbers, because they have been killed by man and at the same time their available food and habitat have diminished.

The 13 species that live chiefly in grassy regions are as follows: Jumping mouse, pouched gopher, three species of voles or meadow mice, prairie white-footed mouse, two species of spermophiles or ground squirrels, small shrew, star-nosed mole, coyote, badger and bison. Not deducting for pasture and meadow, the total area covered by grass has probably increased rather than decreased, since the first settlement of the State. This would enable these animals to increase in number if food were the only factor affecting them.

However, the bison was the first species to become extinct. A number of factors combined to bring about its extermination. The great size and strength of the individuals and their association in immense herds had made the bison practically immune from danger of its natural enemies; therefore, cunning had been of no value and timidity was at a discount.

Of the other grass-dwelling species, the badger appears to be almost extinct in our State. It is carnivorous and not directly dependent on grass for food, but is a true inhabitant of the prairie. Badgers were never numerous in this State, and their extermination is of little consequence to the fauna.

Plate II.—A woodland habitat with large trees and little underbrush. University Farm, Mitchell, Indiana.

The coyote occupies an anomalous position in that it had almost disappeared from the State thirty years ago, but has again become numerous in many localities during the last decade. The increase in numbers is no doubt an adaptation to the presence of man. Those individuals that were able to "lie low" and escape observation have remained, while others were killed off or driven out. Although the number of coyotes in Indiana at the present time is no doubt less than before the settlement of the State, the species is to be classed with those that are now increasing.

The ten remaining species of this group are all small in size and inconspicuous. They are not numerous in cultivated fields, and numbers of them are killed by man, although they inhabit fence rows and thickets everywhere. Direct evidence as to their former number is lacking, but voles, white-footed mice and ground squirrels have probably increased since the country was first settled because their natural enemies have decreased and their small size and retiring habits enable them to escape coming into serious conflict with man. The other species were never numerous and have neither increased nor decreased to a marked degree.

The third group, those whose habitat embraces both wooded and grassy tracts, includes twenty-three species. Two of this group, the elk and deer, have been exterminated on account of their size, their inability to hide and their food value. The timber wolf is practically extinct, as is also the otter. The former was considered an enemy of man; the latter has been killed for its fur. In thickly settled districts the opossum, rabbit, mink, weasel and two species of skunk have also been partly crowded out and some of them are all but exterminated in certain localities. In other localities where the ground is rough and still wooded most of these species have held their own fairly well. Indeed, there are places in southern Indiana where rabbits are as numerous as they ever were and skunks and weasels have not greatly decreased in number.

The red fox, which also belongs in this group, has decreased in numbers in recent years in thickly settled regions, but there is strong evidence that the numbers of this species greatly increased when the country was first settled, if, indeed, it was not introduced from Europe. It is well adapted by its cunning to live in close proximity to man, and abounds even where the land is nearly all under cultivation. In this it affords a striking contrast to its cousin, the gray fox, which was once abundant, but is now almost extinct.

The woodchuck and chipmunk have certainly increased in numbers. This is due in part to their shy disposition, small economic importance, and the destruction of their natural enemies.

The white-footed mice, two voles, four shrews and mole, which are the remaining species of the group, are all small and inconspicuous. Evidence as to their former abundance is not at hand, but it is very probable that they have increased rather than diminished. It should be noted, however, that very little is known concerning the habits and habitat of the long-tailed shrews (*Sorex*) in this State, and on account of their rarity they should perhaps be included among those that are holding their own.

In the last group of 16 species I have included the beaver, muskrat and water hare, the introduced mice and rats and the bats. The first of these species disappeared early, being killed for the value of its fur and castoreum. Its habit of congregating in large communities about the water aided in its extermination. Repeated breakings of the beaver dams often caused the animals to leave a locality where they were disturbed, even though some of the colony escaped the trappers.

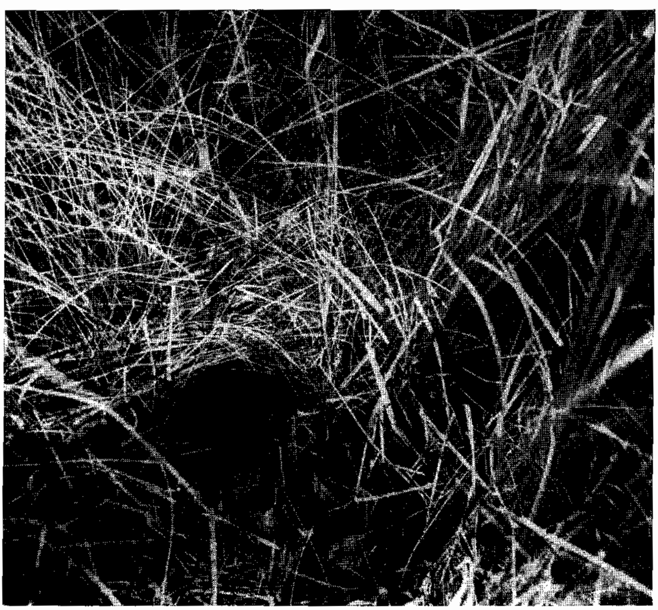
The muskrat has habits similar to those of the beaver, but it is not trapped so persistently, because its fur is less valuable. It reproduces much more rapidly and adapts itself more readily to its surroundings. Therefore, muskrats have been able to survive in every part of the State, and their numbers have been reduced more on account of draining the swamps than because of killing the animals.

Four species of the mouse family have been introduced by man. The black rat came with the earliest settlers and was driven out in the first half of the last century by the larger Norway rat. More recently individuals have been reintroduced but have not become reëstablished. The Norway rat and house mouse have been household pests for centuries and are able to hold their own in the immediate surroundings of man. A red rat has been occasionally introduced with fruit brought from the tropics, but has never become established.

The nine species of bats constitute a peculiar part of the fauna of the State. They make their homes in hollow trees, garrets, deserted buildings and caves. The guides at Wyandotte Cave state that they are less numerous there than formerly, but I have no other evidence as to the present and past numbers of these animals, and there is little reason to believe that they have either increased or decreased in number.

In summarizing the above facts (see table) it must be admitted

A grassy slope, partly filled with brush; the home of *Peromyscus leucopus noveboracensis*, *Zapus hudsonius*, *Synaptomys cooperi stonei* and *Blarina brevicauda*. Near Roselawn, Newton County



An adjacent marsh with the uncovered runway of *Microtus pennsylvanicus* under the coarse marsh grass. Near Roselawn, Newton County.

PLATE III.

that we have very meager evidence concerning the former abundance of many of the species. The small species easily escape notice and many of them are not mentioned by the early naturalists of the State. However, by taking into consideration the facts positively known concerning some of the larger species and such evidence as we may be able to obtain from the present distribution and ecological relations of the other species, the following conclusions may be stated: Fourteen species have been practically exterminated. These have all been animals of large or medium size, or they have been of considerable economic importance. Their extermination has been directly due to the destructive work of man, although this has been accomplished in some instances by a reduction in the available habitat and food supply. Sixteen other species have been greatly reduced in numbers. Some of these will be exterminated in the course of time, while others may become more fully adapted to man and, in the case of the squirrels, they may become semi-domesticated. These sixteen species are all of medium size and most of them have some value for fur or food.

Seventeen species are holding their own fairly well, so far as we can tell from the evidence that is obtainable. Some of these may have been reduced in numbers to some extent, but on the whole they probably occupy about the same position in the fauna of the State that they did a century or two ago. This group is here extended to include several species concerning the numbers of which we have no conclusive evidence. These species are all of small size, or they are very prolific and well adapted to live in close association with man.

The nineteen remaining species have apparently increased in numbers since the coming of the white men. Besides the red fox, which all authorities say was rare during the period of early settlement, the group includes the introduced mouse and rats and most of the species of native mice which, because of their fecundity, small size and inconspicuous habits are better able to cope with man in the struggle for existence than with their smaller foes, the rapacious beasts and birds. Hence, when the carnivorous birds and mammals were lessened in numbers, the small and weak species were given an advantage.

Number.	SPECIES.	Habitat Chiefly Woodland.	Habitat Chiefly Fields.	Habitat Both Forest and Field.	Species Occurring for Some Special Reason.	Exterminated.	Partly Exterminated.	Numbers Stationary.	Numbers Increased.
1	*Didelphis virginiana*			+			+		
2	*Bison bison*		+			+			
3	*Cervus canadensis*			+		+			
4	*Odocoileus virginianus*			+		+			
5	*Sciurus carolinensis*	+					+		
6	*Sciurus carolinensis leucotis*	+					+		
7	*Sciurus niger rufiventer*	+					+		
8	*Sciurus hudsonicus loquax*	+						+	
9	*Tamias striatus*			+					+
10	*Citellus tridecemlineatus*		+						+
11	*Citellus franklinii*		+						+
12	*Marmota monax*			+					+
13	*Sciuropterus volans*	+						+	
14	*Castor canadensis carolinensis*				+	+			
15	*Mus musculus*				+ a				+
16	*Mus norvegicus*				+ a				+
17	*Mus rattus*				+ a	+			
18	*Peromyscus leucopus*			+					+
19	*Peromyscus leucopus noveboracensis*			+					+
20	*Peromyscus maniculatus bairdi*		+						+
21	*Nyctomys decolorus*				+ a	+			
22	*Microtus pinetorum auricularis*			+					+
23	*Microtus pinetorum scalopsoides*			+					+
24	*Microtus pennslyvanicus*		+						+
25	*Microtus ochrogaster*		+						+
26	*Synaptomys cooperi stonei*		+						+
27	*Fiber zibethicus*				+		+		
28	*Zapus hudsonius*		+					+	
29	*Erethizon dorsatus*	+				+			
30	*Geomys bursarius*		+					+	
31	*Sylvilagus floridanus mearnsi*			+			+		
32	*Lepus aquaticus*				+		+		
33	*Felis couguar*	+				+			
34	*Lynx canadensis*	+				+			
35	*Lynx ruffus*	+				+			
36	*Urocyon cinereo-argentatus*	+					+		
37	*Vulpes fulvus*			+					+
38	*Canis latrans*		+						+
39	*Canis occidentalis*			+			+		
40	*Lutra hudsonica lataxina*			+			+		
41	*Mustela pennanti*	+				+			
42	*Lutreola vison*			+			+		
43	*Putorius noveboracencis*			+			+		
44	*Gulo luscus*	+				+			
45	*Taxidea taxus*		+				+		
46	*Mephitus putida*			+			+		
47	*Mephitis mesomelas avia*			+			+		
48	*Spilogale putorius*			+			+		
49	*Procyon lotor*	+					+		
50	*Ursus americanus*	+				+			
51	*Condylura cristata*		+					+	
52	*Scalops aquaticus machrinus*			+					+
53	*Blarina brevicauda*			+					+
54	*Blarina brevicauda carolinensis*			+					+
55	*Blarina parva*		+					+	
56	*Sorex personatus*			+				+	
57	*Sorex longirostris*			+				+	
58	*Corynorhinus macrotis*				+			+	
59	*Myotis grisescens*				+			+	
60	*Myotis subulatus*				+			+	
61	*Myotis lucifugus*				+			+	
62	*Pipistrellus subflavus*				+			+	
63	*Lasionycteris noctivagans*				+			+	
64	*Lasiurus borealis*				+			+	
65	*Lasiurus cinereus*				+			+	
66	*Eptesicus fuscus*				+			+	
	Totals	14	13	23	16	14	16	17	19

a Introduced.

It will be noticed that the bats were placed in the group which have held their own rather than with those which have multiplied. This is because they are so thoroughly adapted to the conditions in which they live that no natural enemies were ever able to prey upon them to a great extent, and they have been neither benefited nor injured by man.

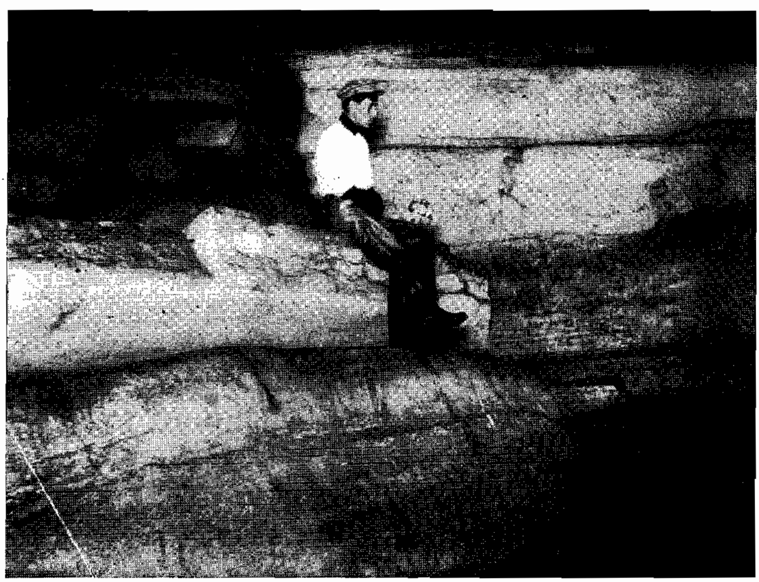
Since the primeval forest has been almost completely cut down, we might expect that the forest dwelling species would be most affected by man. The above table shows that this is the case. Fifty per cent. of the species have entirely disappeared, almost 36 per cent. have diminished in numbers, and the remaining 14 per cent. have, probably, just held their own. Of the grass inhabiting animals one species, or less than 8 per cent., have been exterminated. The same number has been partly exterminated, four species or about 24 per cent., have about held their own, while about 60 per cent. have probably increased in number.

On the assumption that species with generalized habits have the advantage, it would seem that the animals living in both forest and field would hold their own better than any others. Examination shows, however, that several of these species are large and others are fur-bearers. Both qualities are a disadvantage to an animal when it comes into conflict with man. Two species, or 8 2-3 per cent., have been exterminated, and the same number have remained stationary. Thirty-six per cent. have materially decreased and 40 per cent. have increased. Of the introduced species, two have become established and two have not, while no general conclusions can be drawn concerning the others of this category.

For a clearer understanding of ecological relationships, it seems desirable to consider the individual as apart from the species, although it is, of course, impossible for the individual to live in an environment different from that of the species to which it belongs.

Every animal is thrown into contact with two more or less distinct environmental relations, the biological and the physical. The biological environment includes all of those living things which the animal may seek as food or as a mate, and also such creatures as may seek to use it for food or for a mate. The relationship is therefore an active one and the adjustment of the individual to its biological environment is a problem that, to animals of most species, is ever present, ever changing and never solved. When an animal becomes so perfectly adjusted to its biological environment that effort is no longer required to maintain the balance, the animal's mental faculties cease to develop. This has happened to many of

Entrance of Shawnee Cave, near Mitchell.



Fallen rock just within the entrance of Lower Twin Cave near Mitchell. Bats congregate near both of these places in large numbers.

PLATE IV.

the larger animals having a vegetarian diet and has been an important factor in their rapid extermination. For instance, a bison could always find an abundance of grass unless in case of events entirely beyond its control, such as extensive fires or prolonged and deep snows. The strength of the individual, together with the strength of the herd of which it was always a part, rendered each animal practically secure from attacks of all enemies. While there was some fighting for mates among the old males, the habit of associating in herds of great size made this struggle of secondary importance and the only way in which individuals were compelled to adapt themselves to the environment was by migrating to new feeding grounds as pastures were exhausted.

On the other hand, a carnivorous animal is always compelled to seek prey that is often nearly its equal in strength and speed. Here cunning is at a premium, and mental capacity may determine which individuals shall live and which shall perish.

The construction of a den or nest is also, to a large degree, an adaptation to the biological environment. The larger species of grass-eaters trust to speed and strength to escape enemies; their young are born in such a highly developed condition that they are able to walk and run about almost immediately, and no nest or den is ever constructed.

But the young of most other mammals are born in a naked and helpless condition. For their protection most animals construct some kind of a nest, sometimes first making a den or burrow in which to place it. This may be in part, for protection from the physical elements, but is more largely for protection from enemies. Nest-building is almost universal among the smaller rodents that are subjected to attacks from many enemies. However, bats that are equally helpless, spend most of the time on the wing or suspended from the roofs of caves or the sides of hollow trees where they are comparatively free from danger. Consequently they never construct any sort of nest or home, but carry their helpless young about from place to place or leave them clinging to the most convenient resting place.

The effects of home constructing upon an animal are of far-reaching consequence. The instinct and intelligence of the animal are brought into play in selecting the site and material, and the sense of ownership is developed and combative ability maintained in the defense of its home. The ownership of a home limits the range of an animal and gives it a base from which to extend its activities, just as the possession of a home gives a man stability and responsibility. Indeed, it is not too much to assert that the aesthetic and moral senses of man have developed, wholly or largely, as the result of home constructing which is, from the standpoint of evolution, the first step in acquiring property.

It will be seen from the foregoing statements that the biological environment is the chief agency in developing the mental capacity of an animal. It is true that the struggle for existence is with the physical as well as the biological environment, but physical conditions are, to a very large extent, beyond the ability of an animal to modify or control.

Hence the range of the individual, as well as the distribution of the species, is determined principally by physical conditions. Of course the range may be limited by food supply, but no species is found in every place where it might secure food nor does it usually exhaust the supply. Rivers, lakes and smaller bodies of water are often barriers for individuals but not for the species. A mouse or shrew may live along the bank of a small stream and go no farther in one direction than the water, but in time the species will cross it or pass around it.

But there are other barriers that are less obvious. Certain of the meadow mice live in swampy places, and a low hill will ordinarily prove a barrier to one of these creatures although not to the species since they occasionally venture on the higher ground and often inhabit it in wet weather. Some of the ground squirrels live only in dry ground and a marsh proves an effective barrier for them. Other meadow mice live in grassy fields, and their food is principally the tender basal portions of the stems of grass and clover. They could secure plenty of food in a pasture or meadow, but they are rarely found in such places because they make tunnels or runways under dry, fallen grass and are seldom found about farms except along fence rows and in places where the grass is allowed to grow up and remain uncut. Here the grass constitutes a shelter and is to be regarded as having a physical rather than a biological relation to the animal.

Again, there are many animals that live in fields, and a strip of woodland will limit their range. On the other hand, squirrels and other tree dwellers are bounded by areas of prairie or open field. In such cases the species, sooner or later, cross or go around these barriers but this occurs only under unusual conditions, or after the lapse of a long period. To the average individual, living the average life, the limits of activity are much more narrowly circumscribed than they are for the species as a whole.

COLLECTING AND PRESERVING MAMMALS.

It is desirable that a school in which biology is taught, should have a collection of specimens of one or more groups of animals found in the vicinity. Mammals are more easily collected and prepared than birds, and the objections often and justly urged to allowing amateurs to collect birds cannot be urged with regard to mammals. On the other hand, the injurious character of the species of mice makes it desirable that their habits should be learned and many individuals destroyed. Much can be learned about their habits and anatomy while making a collection and preparing specimens.

Excellent directions for preparing specimens of small mammals for study purposes have been published by the United States National Museum at Washington, D. C. These directions, which constitute part N of Bulletin 39, are sent free to schools, teachers or others seriously interested in the study of mammals. The following remarks are condensed from them.

For the study of mammals, the dried and stuffed skins and the cleaned skulls are necessary. The small mammals, such as mice, shrews, ground squirrels, weasels, etc., are most easily collected by trapping. For the smaller species the best trap is the ordinary mouse trap made with a spring fastened on a wooden block and variously known as the "out-o'-sight," "cyclone," "lightning," etc. Most of these are very poorly made, however, and last but a short time if used out of doors where they get wet. A much better (and also more expensive) trap is constructed on the same principle by the Animal Trap Company of Lititz, Pennsylvania, especially for collectors. Rat traps of the same style are suited for catching ground squirrels. The wild mice do not readily enter cage or box traps designed for capturing animals alive.

The fur-bearing animals can be taken in unbaited steel traps set in the entrance of their dens or in paths frequented by them along streams or in the roads. Dry, uncooked rolled oats makes an excellent bait for most small mammals and cheese and nuts are also good.

Mammals spoil more quickly than birds and should be skinned as soon as possible after being caught. In the summer it is necessary to visit traps twice a day, in the evening to replenish bait that insects may have eaten, and in the morning before the hot sun shines on specimens that are caught. In cold weather it is not necessary to visit them more than once a day or once in two days.

Before skinning the animal, three measurements should be taken

(Fig. 1): (1) From the tip of the nose to the tip of the tail (without measuring the hairs) with the animal extended at full length, but not stretched. (2) The tail, from its junction with the body, when pulled at right angles with the body, to the tip. (3) The hind foot from the heel joint to the most distant claw tip. It is desirable that the measurements be given in millimeters and that they be put on the label in the order named above for the sake of convenience in comparing with the measurements of other collectors. Measurements can be made more accurately with a pair of dividers than with a rule or tape alone.

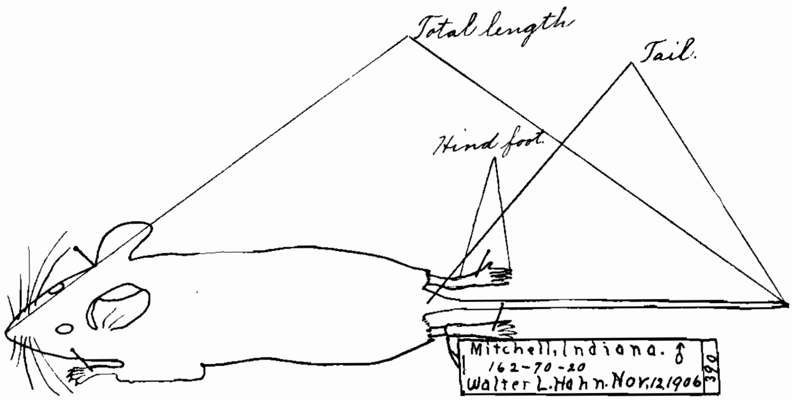


FIG. 1.—Diagram of a mouse, showing measurements to be taken and method of pinning and labeling a skin.

To skin a mammal, lay it on its back and with a pair of small scissors slit the skin along the middle of the belly from the tail to the breast bone. With the fingers, work the skin back from the body and along the sides to the hind legs, and by bending the legs at the knee joint, work the skin off all the way around each of them and sever the leg from the body near the knee. Push the skin back along each leg to the foot and, with a knife and scissors, strip the fleshs and tendons from the bone. In animals no larger than a rat, it will be sufficient to skin the leg down to the ankle joint, but in larger ones the tendons and flesh should be taken out of the foot also. By placing the finger nails, a pair of forceps or sticks about the base of the tail inside the skin, the skin can be pulled off of the tail except in the muskrat and a few other fleshy-tailed animals where it must be laboriously cut off. The bones should always be removed from the tail.

When the tail and hind legs are free, turn the skin back over the body and work it off, as a glove is removed, being careful not to stretch it. The front legs should be skinned in the same way as the hind ones. The ears should be cut off under the skin close to the head and care is necessary in getting all of the skin off around the eyes and mouth without cutting it; a knife or a pair of small scissors must be employed here to get it free. To prevent blood and grease from soiling the fur, cornmeal may be sprinkled plentifully on the body and the inside of the skin, although no harm is done by washing a skin if it is properly dried and the hairs combed and brushed before the drying process is complete.

The skin is now completely removed and is wrong side out. Carefully remove all fat and flesh. Next poison the inside by rubbing over it dry arsenic or a mixture of arsenic and powdered alum; either will preserve the skin from decay and help to keep insects from eating it.

Next turn the skin right side out. Cut five pieces of galvanized wire (No. 23 for a mouse, and for larger animals wire in proportion to their size) of the right length to reach from the tip of the tail and the sole of each foot to the middle of the body. Wrap the tail wire tightly with cotton till it is the size of the tail bone and carefully push it in the skin of the tail to the tip. Put a wire in each of the legs, pushing it down along the bone inside of the skin to the sole of the foot. Wrap the upper part of the leg bone, together with the wire, with cotton till it is the size of the leg before skinning. Next roll together a quantity of cotton the size and shape of the head and body of the animal and with a pair of small forceps, insert it into the skin, pushing it down to the nose, and inserting the ends of the tail and leg wires into the middle of it.

The hair should be smoothed and the body pushed and pinched into symmetry, the mouth closed with a stitch through the lips and the slit in the belly sewed up. When the skin is completed the front legs should be drawn forward parallel to the neck and the hind ones backward parallel to the tail as shown in figure 1. It is a mistake for any one who has had no instruction in taxidermy to attempt to mount a skin with the feet under the body in a natural standing position. Flat skins are just as good for study, require less room, are less easily damaged and usually more artistic than a "mount" made by an amateur. In order to hold their shape they should be pinned on a board and placed to dry where the air circulates freely. Two or three days are usually required to thoroughly dry a small skin and a longer time for larger skins.

The skull is also to be preserved. It may be cut off of the body, dipped in dry arsenic and hung up to dry, or it may be cleaned at once. To clean it, the skull must be boiled till the flesh is tender enough to scrape off. The skulls of small mammals are delicate and the first attempt to clean them is almost certain to result in the breaking of some of the small bones of the palate, if indeed, the entire skull is not destroyed in removing the brain. The latter operation can best be done by using a small wire with one end bent at right angles to the rest and hammered flat. For scraping the flesh from a skull, a small knife will answer and a tooth brush is useful in brushing away loose particles of flesh and cleaning angles after most of the flesh is removed. The forceps which usually accompany a dissecting set will be found useful at many points in the operation. A small amount of washing soda or potash boiled with the skulls makes them easier to clean, but these substances cause the sutures to open and must be used sparingly. Skill can only be acquired by practice and it is surprising to know how much longer it takes to skin and clean the skull of the first animal than it does to accomplish the same work after a little practice.

It is necessary to attach a label to both skin and skull and to give them each the same number in order that their history and identity may not be lost. On the label should be written the locality and date of capture, the sex of the animal, the measurements and the name of the collector, together with a serial number which he gives to each of his specimens (Fig. 1). The date is essential because the color, as well as the length and density of the hair, varies with the season and two or more species have sometimes been described from specimens which differed greatly in appearance because they were taken at different seasons. Among some groups, the sexes differ greatly in appearance and size and hence it is important to know the sex of a specimen. Conventional signs are generally used on a label, the Venus mirror ♀ indicating a female and the sign of Mars ♂ a male. It is well to record in a permanent note book the same data, together with other information concerning the exact place and circumstances of capture or other notes of interest.

If there is no time for skinning mammals, they can be slit open and dropped into alcohol, 80 to 85 per cent., or formalin, 2 to 3 per cent., and treated the same as fishes or other zoological specimens. However, the fluids extract color from the hair and dry specimens are in every way better.

Skeletons of mammals are also of value for study. To prepare them, the internal organs and large masses of flesh are removed and the bones are cleaned in the same way as skulls. Small skeletons are extremely difficult to prepare and those the size of a dog or fox are better for study.

CLASSIFICATION.

The old idea of a species as a group of animals separated from all other groups by characters which are constant and unchanging, has given way to the idea that species are constantly changing and often intergrade. When large collections are brought together from adjoining regions it is often found that the average color, size or other characters of specimens from one locality differ from the average of specimens from another locality, although there may be individuals from either place that bridge the difference. These average characters are now generally considered to be of considerable significance and when a number of them are fairly constant for any circumscribed region, they are recognized as being sufficient to distinguish species or subspecies.

It follows, therefore, that individual specimens cannot always be assigned with any certainty to one species or another. However, the purpose of systematic zoology is not to put every animal into a pigeon-hole, properly labeled with a latin name, but to study variations, their causes and their significance to the biological processes. Yet it does not follow that the study of species has no value. If the amateur is unable to determine certainly to which subspecies an animal belongs, he should not be discouraged or feel that the specimen has no value. Its chief value to him will not be in the name which belongs to it as a stuffed skin, but in the relation which it bore to its environment as a living animal.

It is hoped that the following keys will enable anyone with a little knowledge of biology to identify any mammal found in Indiana with a reasonable degree of accuracy when the skin and skull are before him. The larger museums are usually willing to identify and return to the owner any specimens which are submitted to them, especially if duplicates to be kept by the museum are included. The keys are intended to apply only to species that have been recorded from this State or that are likely to be found within its borders. Some of the points in the key and the definitions of the groups will not hold true for mammals in general.

The arrangement of the key does not follow any natural order of classification and has been planned solely for the purpose of

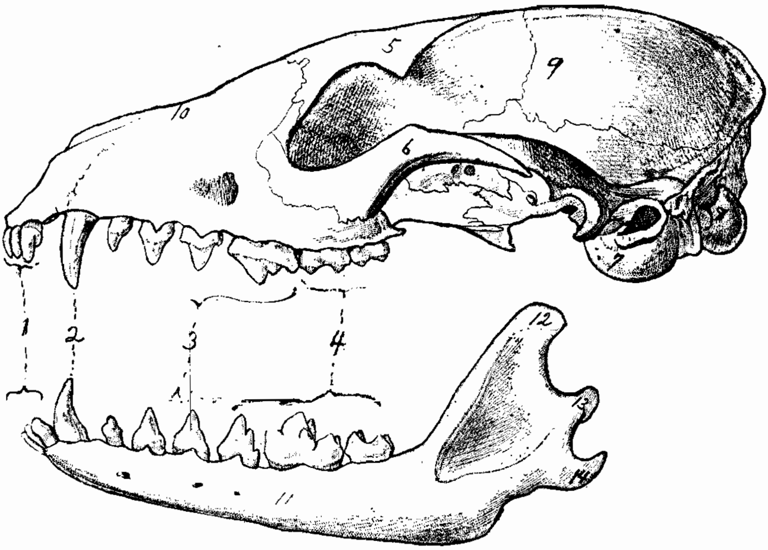


FIG. 2.—The skull of a carnivorous mammal (gray fox). 1, incisor teeth; 2, canine; 3, premolars; 4, molars; 5, postorbital process of skull; 6, zygomatic arch; 7, audital bulla; 8, occipital condyle; 9, braincase; 10, rostrum; 11, mandible; 12, coronoid process; 13, condyloid process; 14, angular process.

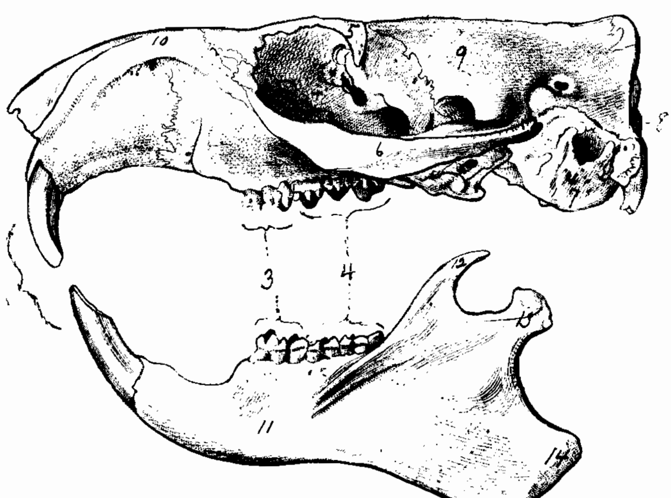


FIG. 3.—Skull of a rodent (the woodchuck). 1, incisors; 3, premolars; 4, molars; 5, postorbital process; 6, zygomatic arch; 7, audital bulla; 8, occipital condyle; 9, braincase; 10, rostrum; 11, mandible; 12, coronoid process; 13, condyloid process; 14, angular process.

enabling the student to identify mammals with the smallest possible labor. Where a genus is represented by more than one species in the State, keys to the species will be found under the genus. External and easily distinguished characters have been used as far as possible, although in some cases skulls and teeth are essential and they are always desirable in establishing the identity of any mammal. (See figures 2 and 3 for parts of the skull.)

KEY TO ORDERS, FAMILIES AND GENERA.

(NOTE.—I = incisor teeth; C = canines; Pm = premolars; M = molars. See figures 2 and 3.)

A. Fore limb modified into a wing with an elastic membrane stretched between the long digits and also between the arm and the body. (Bats.)
Order **CHIROPTERA** and Family VESPERTILIONIDAE, p. 616

B. Ears more than one inch long, partly united in front of the head.
Genus *Corynorhinus*, p. 617

BB. Ears considerably less than one inch long, widely separated in front.

C. Membrane between the hind legs about as thickly furred on top as the body. Genus *Lasiurus*, p. 633

CC. Membrane between hind legs so scantily furred that the skin is distinctly visible.

D. Fur blackish with whitish tips that give it a frosted appearance (teeth on each side, I, $\frac{2}{3}$; C, $\frac{1}{1}$; Pm, $\frac{2}{3}$; M, $\frac{3}{3}$).
Genus *Lasionycteris*, p. 626

DD. Fur without frosting; teeth not as above.

E. Size very small; color yellowish brown (teeth, I, $\frac{2}{2}$; C, $\frac{1}{1}$; Pm, $\frac{2}{2}$; M, $\frac{3}{3}$.) Genus *Pipistrellus*, p. 629

EE. Color darker brown; teeth different.

F. Size large (total length more than four inches) teeth, I, $\frac{2}{3}$; C, $\frac{1}{1}$; Pm, $\frac{1}{2}$; M, $\frac{3}{3}$. Genus *Eptesicus*, p. 631

FF. Size smaller; total length less than 4 inches.

G. Upper incisors 4; common cave species.
Genus *Myotis*, p. 620

GG. Upper incisors 2; rare or perhaps absent from our fauna. Genus *Nycticeius*, Appendix, p. 648

AA. Both pairs of limbs adapted for walking or running; no wings.

B. Inner toe of hind foot widely separated from the rest, like a thumb and without a sharp claw; teats of female opening inside a pouch on the abdomen; upper incisors ten. (Opossum).
Subclass METATHERIA, Order **MARSUPIALIA** and Family DIDELPHIDAE. Genus *Didelphis*, p. 448

BB. Hind feet not as above; no pouch beneath the abdomen; upper incisors less than ten. Subclass EUTHERIA.*

C. Feet all terminating in hoofs (bison and deer).
Order **UNGULATA**, p. 451

D. Horns hollow, permanent and growing throughout life.
Family *Bovidae*, Genus *Bison*, p. 452

*The bats, at the beginning of the key, also belong to the EUTHERIA.

DD. Horns (antlers) solid and shed each year. (Deer, elk, etc.) Family CERVIDAE, p. 454

E. Size large; height at shoulder about five feet; antler four to five feet in length (Wapiti or elk). Genus *Cervus*, p. 454

EE. Size smaller; height at shoulder about three feet; antler one and a half to two feet. (Deer) Genus *Odocoileus*, p. 457

CC. No hoofs; toes with claws.

D. Front teeth chisel shaped and separated from the remainder of the teeth by a wide space, filled by an infolding of the lips. (In the rabbits there are four front teeth in the upper jaw, one pair directly behind the other. All other members of the order have but two incisors above and two below.) (Gnawing animals.) Order **GLIRES**, p. 460

E. Two pairs of upper incisors, the one behind the other. (Hares and rabbits.) Family LEPORIDAE, p. 533

F. Size large; hind foot five inches or longer. Genus *Lepus*, p. 537

FF. Size smaller; hind foot less than four and a half inches; common rabbits. Genus *Sylvilagus*, p. 533

EE. One pair of upper incisors.

F. Tail horizontally flattened, without hairs; size large. (Beavers.) Family CASTORIDAE, Genus *Castor*, p. 487

FF. Tail round or slightly flattened at the sides.

G. Fur mixed with stiff spines or quills. (Porcupines.) Family ERETHIZONTIDAE, Genus *Erethizon*, p. 530

GG. Fur without quills or stiff spines.

H. With external cheek pouches which open outside the mouth; claws very long; tail short and nearly naked; form and habits of moles. (Pocket Gophers.) Family GEOMYIDAE, Genus *Geomys*, p. 524

HH. No external cheek pouches; claws shorter.

I. Four or more grinding teeth in each jaw; tail with long hairs, often bushy. (Squirrels, etc.) Family SCIURIDAE, p. 460

J. Fur very soft and dense; a thickly furred membrane along the side between the fore and hind legs. (Flying squirrels.) Genus *Sciuropterus*, p. 484

JJ. No membrane along the sides.

K. Body short and heavy; skull broad and flat on top. (Woodchucks.) Genus *Marmota*, p. 479

KK. Body slender; head and skull more rounded.

L. Tail bushy; no pouches opening inside cheeks; homes in trees; no stripes on back. (Tree squirrels.)
Genus *Sciurus*, p. 460

LL. Tail not very bushy; pouches opening between teeth and skin of cheek; homes in ground.

M. General color of body rich chestnut brown with stripes of blackish and whitish; four grinding teeth on each side of upper jaw. (Chipmunk.)
Genus *Tamias*, p. 470

MM. General color dull grayish brown; five grinding teeth in the upper jaw. (Spermophiles, often called "gophers.")
Genus *Citellus*, p. 475

II. Never more than three grinding teeth in lower jaw; tail slender and round, with hairs short and lying close to the skin, or tail almost devoid of hairs. (Rats and mice.)

J. Hind feet and tail very long; upper jaw teeth four; (head and body about three inches, tail over four inches and hind foot more than one inch). (Jumping mice.)
Family ZAPODIDAE, Genus *Zapus*, p. 527

JJ. Hind foot and tail proportionately shorter, upper jaw teeth three. Family MURIDAE.

K. Upper incisors with grooves down the front.

L. Form thick set, with short legs, short ears, and tail less than one inch.
Genus *Synaptomys*, p. 521

LL. Proportions about as in the common house mouse, but smaller.
Genus *Reithrodontomys*, Appendix, p. 640

KK. Upper incisors without grooves.

L. Habits aquatic; tail long and flattened at the sides. (Muskrat.)
Genus *Fiber*, p. 517

LL. Not aquatic; tail round.

M. Form stout, with short legs and ears; tail not over half as long as head and body; crowns of molars with loops and triangles. (Meadow mice.)

N. Color rusty reddish on back; molars rootless. (Rare or absent from Indiana.)
Genus *Evotomys*, Appendix, p. 642

NN. Color brownish or grayish; molars rooted. (Common meadow mice.)
Genus *Microtus*, p. 505

MM. Legs and ears of moderate length; tail more than half as long as head and body; crowns of molars with tubercles.

N. Molars with tubercles in two rows (these may be worn off in old animals). (House mice and house and wharf rats.)
Genus *Mus*, p. 491

NN. Tubercles of molars in three rows; native mice of the fields and woods.

O. Size and proportions about as in the house mouse; belly pure white; eyes and ears large. (White-footed mice; common.)
Genus *Peromyscus*, p. 495

OO. Size larger; species of doubtful occurrence or introduced into the state.

P. Color of back bright reddish; belly white; introduced species from the tropics.
Genus *Nyctomys*, p. 503

PP. Found in caves and rocky cliffs; belly pure white; about the size of a house rat.
Genus *Neotoma*, Appendix, p. 641

PPP. Found about water; smaller; belly grayish.
Genus *Oryzomys*, Appendix, p. 640

DD. Tooth row continuous from incisors to last molar, front teeth not chisel-shaped. (In the moles the upper front teeth are always large and somewhat chisel-shaped, but the characters given under the family easily distinguish them.)

E. Size small (total length under ten inches); eyes very small; snout pointed. (Moles and shrews, generally with burrowing habits.) Order INSECTIVORA, p. 597

F. Fore feet very broad and flat; length of adults always over five inches. (Moles.) Family TALPIDAE, p. 608

G. A star of fleshy projections around the nose; teeth, I, $\frac{3}{3}$; C, $\frac{1}{1}$; Pm, $\frac{4}{4}$; M, $\frac{3}{3}$.
Genus *Condylura*, p. 613

GG. No fleshy star about nose; teeth not as above.

H. Tail slender, scantily haired; teeth, I, $\frac{3}{2}$; C, $\frac{1}{0}$; Pm, $\frac{3}{3}$; M, $\frac{3}{3}$. (Common moles.)
Genus *Scalops*, p. 610

HH. Tail thick and fleshy; teeth, I, $\frac{3}{3}$; C, $\frac{1}{1}$; Pm, $\frac{4}{4}$; M, $\frac{3}{3}$. (Of doubtful occurrence in Indiana).
Genus *Parascalops*, Appendix, p. 647

FF. Fore feet not broad (similar to those of a mouse); size not over five inches. (Shrews.)
Family SORICIDAE, p. 597

G. Tail about one-fourth as long as head and body; ears small but easily seen. Genus *Blarina*, p. 597

GG. Tail at least half as long as head and body, external ears scarcely distinguishable.
Genus *Sorex*, p. 604

EE. Size larger (length 12 inches or more*); eyes well developed; snout not especially sharp. (Carnivorous animals.)
Order **FERAE**, p. 539

F. Size very large, with clumsy, thick-set form; tail rudimentary. (Bears.)
Family URSIDAE, and Genus *Ursus*, p. 592

FF. Size medium or small; form slender, tail well developed.

G. Claws retractile into a sheath of the toes; fitted for climbing; muzzle broad and short, (Panthers, wildcats, etc.). Family FELIDAE, p. 539

H. Tail at least one third as long as head and body; teeth 30. Genus *Felis*, p. 540

HH. Tail not over one fifth as long as head and body; teeth only 28. Genus *Lynx*, p. 543

GG. Claws not retractile; snout less blunt.

H. Body thick-set; feet plantigrade; tail with alternate rings of light and dark hairs. (Raccoons.)
Family PROCYONIDAE, Genus *Procyon*, p. 588

HH. Feet not plantigrade; tail not ringed.

I. Hind foot with five toes.
Family MUSTELIDAE, p. 565

J. Toes webbed; habits aquatic. (Otters.)
Genus *Lutra*, p. 565

JJ. Toes not webbed; not aquatic.

K. Colors black and white; highly developed scent glands present which are used for defense. (Skunks.)

L. White of body in one or two broad, connected stripes; form thick-set. (Common skunks.)
Genus *Mephitis*, p. 569

LL. White of body in several narrow, disconnected lines and spots; form more slender. Genus *Spilogale*, p. 575

KK. Colors not black and white; scent glands not used for active defense.

---

*The least weasel, however, measures but 7 inches.

L. Color yellowish gray; claws very long. (Badger.) Genus *Taxidea*, p. 577

LL. Color brown (in some species white in winter).

M. Body stout with legs and tail short; foot plantigrade, as in bears. (Wolverine, not now found in the state.) Genus *Gulo*, p. 579

MM. Form slender and graceful with long tail and slender legs.

N. Size large; length 20 inches or more. (Mink.) Genus *Lutreola*, p. 581

NN. Size smaller; not over 18 inches. (Weasels). Genus *Putorius*, p. 584

II. Hind feet with only four toes; head somewhat pointed. (Wolves, foxes, etc.). Family Canidae, p. 547

J. Size large; length not less than 45 inches; upper incisors divided into lobes. (Wolves and coyotes.) Genus *Canis*, p. 557

JJ. Size smaller, less than 45 inches; upper incisors not lobed. (Foxes.)

K. Hairs of tail soft like those of body; sides rusty red; skull rounded on top. Genus *Vulpes*, p. 551

KK. Tail with a mane of stiff hairs on back; back and sides grayish; skull flat on top. Genus *Urocyon*, p. 547

Order MARSUPIALIA.

MARSUPIALS.

Mammals in which the young are born before development has progressed far. Young placed in a pouch on the abdomen of the mother where they are nourished by milk which she forces out of her teats into their attached mouths by muscular contraction. Brain small and rudimentary. Pelvis with two small separate (marsupial) bones projecting forward from the pubes.

The Marsupials are mammals which, in the process of evolution, stopped before they had reached the complex condition now attained by their relatives. The principal difference is found in the reproductive organs. The organs of the female are all duplicated, almost to the external opening, instead of joining in a common uterus as in other mammals. The fertilized ova develop without the formation of any special structure (placenta) for the attachment of the embryo to the uterus and the young are born in a very rudimentary condition.

The earliest mammals, geologically, of which we have any knowledge are marsupials. The lack of specialization in some members of the order has enabled them to become adapted to changing conditions and they have survived with very few changes since Miocene times. The order is now limited in distribution to America and Australia.

Family DIDELPHIDAE.

OPOSSUMS.

This family includes all of the marsupials of North and South America, to which continents it is limited. It is characterized by the presence of 50 teeth, five toes on each foot, the first toe of the hind foot being widely separated from the rest, and a long scaly. prehensile tail.

Genus Didelphis Linnaeus.

Dental Formula.—I, $\frac{5-5}{4-4}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{3-3}{3-3}$; M, $\frac{4-4}{4-4}=50$.

Generic characters.—A complete marsupium or pouch on the abdomen of the female in which the young are placed immediately after birth; young born at a very early stage when development is less advanced than in most mammals. Tail prehensile, densely haired at the base but nearly naked on the outer two-thirds. Inner toe of hind foot somewhat opposable to other toes. Five digits on both fore and hind feet.

Skull elongated, with a high sagittal crest, pointed rostrum, and numerous teeth.

The genus has a range extending from the northern United States to Middle South America and is represented by a number of species. Only a single form occurs in the eastern United States north of Florida.

1. DIDELPHIS VIRGINIANA Kerr.

OPOSSUM.

Didelphis virginiana Kerr, Animal Kingdom, p. 193, 1792. Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 124, 1894.

Didelphis marsupialis Miller and Rehn, Proc. Bost. Soc. Nat. Hist., p. 7, 1901.

Diagnostic characters.—Easily distinguished from any other animal found in the State by the marsupium of the female, the opposable first toe of the hind foot, the scantily haired, scaly tail, the long pointed snout and the large number of teeth.

Description.—The color is extremely variable, some individuals being nearly white and others almost black. Face white or pale gray with a dark streak running forward from the occiput to the eyes and a ring of black around them. The body fur is of two kinds, a short, dense coat of wooly hairs, and a longer, thinner coat of coarse hairs. The under fur is usually white or slightly yellowish at the base and is tipped with black. The long hairs are usually gray, giving to the entire coat a grizzled effect. Melanistic individuals, having the long hairs black are not rare.

The ears are broad and naked except for a few minute hairs, and are usually blackish in color but sometimes edged or tipped with white. Palms, soles and toes flesh color; upper surface of fore and hind feet black. Base of tail densely furred for about two inches, then naked and black for about two inches; the remainder naked and flesh color, or with a few spots of blackish.

Measurements.—Six specimens taken by the writer at Mitchell averaged 600 mm. (24 inches) in total length; tail 235 mm. (9½ in.); hind foot 55.5 mm. (2 3/16 in.). None of these specimens were fully matured, however, and the adults reach a length of 28 inches with other measurements proportionally increased.

Skull and teeth.—Skull elongated, with a well developed sagittal crest, even in immature animals; braincase small and scarcely elevated above the frontal region; zygomatic arches strong and divergent; palate perforated in the posterior part. Incisors small and weak; canines strong, largest in old males; premolars shaped somewhat like the canines. Posterior molars not appearing till late. The molars do not wear down rapidly but retain the prominent cusps, even in old animals.

Range.—The species is found from Connecticut and the Great Lakes to the Gulf coast and west to the great plains. Slightly different forms occur in Florida and the southwest. In Indiana it occurs throughout the State with the possible exception of some limited areas in the northern portion where it seems to have become extinct, but it is most abundant in the southern part.

Habits.—The opossum is one of the few animals capable of adapting itself to almost any sort of condition. In the long run, with changing climate and fauna and flora, the animal with generalized habits and structure has a much better chance than the one with habits and structure highly specialized for certain peculiar conditions. To this fact is due the existence of the opossum at the present time. The Marsupial type of mammal is the most primitive and the opossum as a race has existed for epochs, while one after another of the more specialized groups of mammals have become decadent or entirely disappeared.

Even now, when he has come into contact with civilized man, the opossum is holding his own very well. In some parts of Indiana the species is not so numerous as it once was, but it is still very generally distributed and even lives in the outskirts of towns and cities.

Its den may be in a deserted woodchuck hole, a hollow log or tree, a natural cavern, a sewer or any other conceivable place that will afford shelter. There, in a rude nest of dried grass, the young are born. The usual number of a litter is from six to ten, but it is said that as many as sixteen are sometimes produced. There are two or three litters in a season.

The young are less than an inch long when born and are blind and naked with imperfectly developed limbs and organs. The mother at once thrusts them into the pouch on her abdomen. They secure hold of the teats and the lips grow about them, so that the young cannot be removed without tearing the mouth. At this stage they are entirely helpless and do not even suckle, the milk being forced into their mouths by the contraction of special muscles about the mammary glands of the mother. They remain in the pouch for some weeks and attain a length of four or five inches before they leave it. For some time longer they remain with the mother and a second litter may be born and placed in the pouch while the first is still running about her back and clinging to her tail.

Most people know something about the peculiar manner in which the young opossums are nurtured, but there are many fables and wrong ideas on the subject. A few years ago the author saw a letter written to the Smithsonian Institution by a Virginia gentleman who claimed to have been a student of natural history for forty years. He asserted that our ideas of the breeding habits of these animals are all wrong and that "the young grow out from the abdomen of the mother like cherries on a stem." The writer also has a letter before him from one of the pioneers of this State, asserting that gestation takes place in the pouch of the mother and that there is some direct connection between this pouch and the internal reproductive organs. It is needless to say that both ideas are preposterous. The early stages of the reproductive process differ in no essential way from those of domestic cattle, rabbits or other mammals.

The opossum is not at all particular as to food. Persimmons and apples are staple articles of diet in the fall, where they can be obtained. Other fruits are also eaten. Insects, crayfish, mollusks, salamanders, frogs, small birds and mice are all eaten with apparently equal relish. Refuse of various kinds, carrion and fresh meat are also eaten.

Mr. E. J. Chansler has given me an account which illustrates both their feeding habits and numbers in Knox County half a century ago. He says: "In 1859 my father killed hogs one day and that evening he killed eight opossums in the dooryard before bed time. They were attracted by the blood and offal."

These animals are not as numerous in southern Indiana now as then, but are in no danger of extermination. In the Kankakee Valley they are said to have increased in numbers in recent years.

Professor Van Gorder states that opossums were plentiful in Noble County previous to the winter of 1854-55. The severe weather of that winter exterminated them and he knows of no further records until 1900. Since that time they have again become plentiful, so much so that they are frequently seen on the car tracks of an interurban line and three were killed by a single car during the winter of 1907-8.

While they occasionally do some damage by killing poultry and useful wild birds, they do more good by destroying harmful insects and mice. The flesh is eaten with great relish by most negroes and many whites, although it is very fat and oily. The skins find a ready sale at from 15 to 25 cents apiece, and are frequently seen made into ladies' furs.

Order UNGULATA.

HOOFED ANIMALS.

Animals which have the feet terminating in rounded hoofs and the heels much elevated above the toes so that only the tips of the latter are placed on the ground in walking. The molar teeth have broad flat crowns and the digestive tube is usually long and complex, being adapted to a vegetable diet.

The ungulates are nearly all animals of medium or large size and are of great economic value. The domestic animals such as swine, sheep, cattle and horses are all included in this group. They are creatures that, in the process of evolution, have found it advantageous to escape their enemies by flight rather than by cunning or by resistance. Hence the bones of the limbs are elongated, giving the animals a longer stride, and the tips of the toes are encased in hoofs which afford protection and a solid footing.

Family BOVIDAE.

CATTLE, SHEEP, ETC.

Animals with hollow horns which are never shed; no canine or upper incisor teeth; two functional hoofs on each foot and usually two lateral hoofs which do not reach the ground; stomach with four divisions.

Genus BISON Hamilton Smith.

Dental Formula.—I, $\frac{0-0}{4-4}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{3-3}{3-3}$; M, $\frac{3-3}{3-3}=32$.

Body covered with crisp woolly hair, longer on the head and shoulders and forming a mane which reaches down on the forehead. Horns and hoofs black; height greatest at the shoulder.

2. BISON BISON (Linnaeus).

AMERICAN BISON; BUFFALO.

Bos bison Linnaeus, Syst. Nat. 10th Ed., I, p. 72, 1758.

Bison bison Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 135, 1894.

Description and habits.—The bison, or buffalo as it is generally but incorrectly called, is too well known from pictures and descriptions to require an elaborate diagnosis here. It has not lived in Indiana in a wild state for nearly a century but must be counted with our indigenous mammals that have disappeared before advancing civilization. Two species formerly existed in immense numbers in North America. The eastern form differs from the woodland bison of western Canada in its paler color, smaller size and shorter horns.

In the early days bison were numerous in Indiana on all of the prairies, meadows and in the more open woods. Their range did not extend much beyond the northern boundaries of the State, but doubtless included all of the northern counties.

Concerning the numbers of bison formerly existing in the Ohio Valley, Mr. Hornaday quotes from several early travelers as follows: "The amazing herds of buffaloes which resort thither [to the salt licks in Kentucky] by their size and number fill the traveler with amazement and terror, especially when he beholds the prodigious roads they have made from all quarters—the vast space of land around these springs, desolated as by a ravaging enemy and the hills reduced to plains by the pawing of their feet. I have heard a hunter assert he saw above one thousand buffaloes at Blue Licks at once." Lewis and Clark estimated that they saw twelve thousand at one time in South Dakota, and Colonel Dodge estimated that he saw half a million during a day's ride on the western plains.

In Indiana they were not so numerous as west of the Mississippi but were doubtless as abundant as in Kentucky. Indeed, there seems to have been a regular migration from the prairies of the West across Indiana, to the salt licks and blue grass meadows of Kentucky. One of their trails crossed the Wabash River nine miles south of Vincennes.

The year in which wild bison were last seen in the State is uncertain. Hornaday places the date of their disappearance at 1810, but this is possibly a few years too early. The Prince of Wied, who spent the winter of 1832-33 at New Harmony, states that they were still abundant on the Illinois prairies a few days' journey from there. Mr. E. J. Chansler informs me that a Mr. Thompson, who made the brick for Governor Harrison's mansion at Vincennes, saw buffalo near there in 1808. Mr. Chansler says also that the father of John G. Bailey came to Vincennes in 1800, when the son was six years old and that the latter could have killed buffalo just east of the town after he became old enough to hunt. This would place the date of their disappearance from the vicinity as late as 1808 or 1810. At that date the upper Wabash Valley and the prairies beyond had scarcely been settled at all and it is reasonable to suppose that bison existed there somewhat later than in the vicinity of the earliest settlements.

However, these magnificent game animals disappeared very shortly after the coming of the white settlers and long before the country became thickly settled. Many of the animals, even in that early day, were wantonly slaughtered for their hides. But the fact that immense herds migrated between the western prairies and the licks of Kentucky and southern Indiana is one reason for thinking that they may have been driven out of this State rather than entirely killed off. Whatever the exact fate of the bisons of Indiana, the almost complete extermination of the race must always be looked upon with regret.

However, from a biological standpoint, nothing but their destruction could have been expected. Although not usually placed very high in the scale among mammalian animals, the bison was in a way, highly specialized. The large size of the animals, their gregarious habits and the herbivorous nature of their food, all combined to render them independent of the biological environment. Wolves and cougars killed an occasional stray calf or sick adult, but they were without formidable enemies. Food was always at hand, and neither skill nor cunning was required to procure it; or if it failed because of drouth or fire, skill and cunning were of no avail. Consequently the habits of the animals became fixed; their mental capacity was not well developed and they were unable to cope with enemies.

Then white men came on the scene and the balance of nature was upset. It is, of course true, that nature has never evolved an animal capable of competing with gunpowder and rifle. However, the gregarious habits and comparative fearlessness of the bison rendered them especially easy victims and made it possible to destroy them by the hundreds and thousands.

Family CERVIDAE.

DEER.

The deer are ungulates with solid, usually branched antlers which are shed and renewed each year; these usually are present in the male only; no incisor teeth in the upper jaw but upper canines often present; stomach with four divisions as in other ruminant animals.

Genus Cervus Linnaeus.

Dental Formula.—I, $\frac{0-0}{4-4}$; C, $\frac{1-1}{0-0}$; Pm, $\frac{3-3}{3-3}$; M, $\frac{3-3}{3-3} = 34$.

Size large, standing four and a half to five feet at the shoulder; antlers, four and a half to five feet long, directed outward and backward but with the tines all directed forward.

This genus is represented by one species, now exterminated or nearly so, in eastern North America, several closely allied species in the west and a few others in Europe and Asia. All are deer of large size.

CERVUS CANADENSIS (Erxleben).

AMERICAN ELK; WAPITI.

Cervus elaphus canadensis Erxleben, Syst. Regn. Animal, Vol. I, p. 305, 1777.

Cervus canadensis Desmarest, Mammalogie, Vol. 2, p. 433, 1822. Butler and Evermann, Proc. Ind. Acad. Sci. for 1893, p. 135, 1894.

Diagnostic characters.—Distinguished from other members of the deer family by its large size and long, branching antlers.

Description.—Color yellowish brown, darker on the under side and legs; buttocks yellowish white. The antlers project backward and outward and their tines point forward and upward. Height of bull elk at shoulder, about five feet. Antlers sometimes five feet in length. The female is smaller and paler colored.

Range.—Formerly abundant in eastern Canada and the United States, as far south, at least, as Tennessee; westwardly it probably extended to the Rocky Mountains; farther west are other closely related species of elk. The eastern form has not a single living representative and but one preserved skin is known to exist. That one is preserved in the Academy of Natural Sciences of Philadelphia.

Records for Indiana are meagre. Dr. John T. Plummer says that the last elk was killed near Richmond in 1811. Evermann and Butler say that it was found in Ripley County subsequent to 1810. E. J. Chansler, on the authority of Mr. Brad Thompson of Bruceville, Knox County, states that an elk was seen near that place in 1830. Mr. Chansler also says that one was killed on Pond Creek, Knox County, by G. T. Everbaugh in 1829. Another man is quoted by Mr. Chansler as saying that an elk was seen in Knox County in 1850. The last record is certainly erroneous or relates to a captive animal.

The records given above for 1829 and 1830 are probably reliable and are the latest ones of which I have any knowledge. Wied says that they were already gone in 1832-3. Many of the local histories I have examined speak of bear, deer and other game in the period from 1820 to 1836, but do not mention elk at all, and they must have been very rare even at this period, although in Pennsylvania the last elk was not killed until 1867 (Rhoads, 1903, p. 30).

Chansler tells me of the abundance of elk horns in Daviess and Knox counties in early years, and Rev. T. H. Ball, in the history of Lake County, states that elk antlers were found in Cedar Lake in that county. In the history of Dearborn and Ohio counties it is stated that Ben Moulton found an elk's head on Laughery Creek so large that when the tips of the antlers were placed on the ground Moulton stood between them without touching the head. There are pieces of elk antler in the State Museum from Jasper and Newton counties. I know of no other records, although in the early days the species was doubtless plentiful in all parts of the State. Usually it prefers wooded and rough country and we may therefore suppose that it was more abundant in the wooded hills of the southern part of the State than in the prairies of the northern portion.

Habits.—The following account is drawn chiefly from the writings of President Roosevelt and Judge John D. Caton. Elk, or wapiti, as they are more correctly called, are the most gregarious of the deer family. During the early summer the mature animals lead a somewhat solitary existence, the cows hiding away to rear their calves and the old bulls living quietly in obscure retreats while their antlers are in velvet. But in late summer they collect in bands. Each old bull has his harem of females which he guards jealously. If another bull approaches they engage in deadly combat, backing off and rushing at each other or locking antlers and struggling with all their might. Sometimes the antlers become locked inextricably and both animals perish. More frequently, one vanquishes the other. As long as he gives fight the weaker bull's danger is not great for the thick skin of the neck is scarcely penetrated by the sharpest thrust of the great antlers, but if he turns to flee and is gored in the flank, a serious wound is inflicted and often causes death.

Frequently a number of small bands group together, each one under the leadership of its master bull. However, each retains his own harem intact and jealously guarded.

There is no semblance of gallantry among these lords of the tribe. A bull will often fight desperately when attacked but he fights for himself only. If his mates and young are endangered when he has a chance to escape, the old bull makes no attempt to defend them, but seeks safety in flight. Nor does he hesitate to drive the females and young from any choice bit of food they may have found, and appropriate it to himself.

Practically all kinds of vegetable food are eaten with equal relish. Weeds, grass and rushes, as well as twigs, bark and leaves, are all acceptable. It is said that in winter they will thrive on food coarser than that on which either deer or domestic cattle can exist.

The mating season is in September. The young are born in May. In the first one or two seasons, but one young is produced. Cows in their prime usually give birth to two, rarely three, calves each year.

The young are spotted, like young deer. The first autumn they lose their spotted coat, becoming uniformly colored but paler than the adults. About eight years are required to reach full maturity, though they breed the second or third year. An adult bull sometimes attains a weight of twelve or fifteen hundred pounds.

The most remarkable thing about the wapiti, and other members of the deer family, is the rapid growth of the antlers. These begin to grow about April and have on the outside, a growth of cutis covered with short hairs and filled with blood vessels. By August the antlers of a bull in his prime may reach a length of five feet each. At this time the velvet becomes dead and is rubbed off by thrashing against trees. During the fall and winter the antlers are bare and in late winter they are shed, coming off at a rounded knob called the "burr," near the base. Males of the second summer have straight unbranched antlers. A tine is added each year until there are six, though some may be deformed or lacking.

Next to the bison, the elk disappeared more rapidly before civilization thany any of our game animals. The causes of extermination are practically the same for both animals. Their great size rendered them noteworthy objects of the chase. Their gregarious habits made it easy to kill large numbers when a herd was located, and the early settlers had no thought of preserving the game which was then so abundant. Added to this was a certain sort of stupidity which often allowed them to stand fearlessly while the entire herd was shot down. They are also less nocturnal than other deer and while preferring rough ground, they do not hide away in dense thickets as the Virginia deer does.

Genus Odocoileus Rafinesque.

Dental Formula.—I, $\frac{0-0}{4-4}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{3-3}{3-3}$; M, $\frac{3-3}{3-3}=32$.

Generic characters.—Antlers, always less than thirty inches in length; the tips curved forward and inward and the tines directed upward; first tine some distance above the base.

This genus is confined to North America. One species with several geographic races is found east of the Mississippi. To the west there are other species.

ODOCOILEUS VIRGINIANUS (Boddaert).

VIRGINIA DEER.

Cervus virginianus Boddaert, Elenchus Animalum, p. 136, 1784.

Cervus dama americanus Erxleben, Syst. Regn. Animal, Vol. I, p. 312, 1777.

Cariacus virginianus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 135, 1894.

Odocoileus americanus Miller and Rehn, Proc. Bost. Soc. Nat. Hist., vol. 30, p. 14, 1901.

Odocoileus virginianus Merriam, Proc. Biol. Soc., Washington, Vol. 12, p. 100, 1898.

Diagnostic characters.—Size comparatively small; antlers curving first outward and back, with the tips turned forward and toward each other; not diverging into equal branches.

Description.—Color of adults reddish brown above in summer; belly, inner side of legs and under part and tip of tail, white; chin with a black band; in winter grayish above. Young, spotted with white. Skull and teeth comparatively small and antlers slender.

Range.—Formerly abundant from the region of the Great Lakes, central New York and New England, to Florida and Louisiana, and from the Atlantic west to Kansas. Slightly different geographic races are found beyond the limits outlined above.

In Indiana deer were once so abundant as to be a nuisance, and the pioneer farmers were often compelled to kill them to protect their crops. It is said that they used to mingle with the domestic cattle that were turned out to graze and learned to come to them on hearing he sound of their bells.

Judge D. D. Banta, in the history of Johnson County, tells us that one of the early settlers, Joab Woodruff, killed 370 deer in the fall of 1822. As late as 1834 a herd was chased from near Franklin, over what is now part of Indianapolis and back into Johnson County, where six were killed.: In the early forties a grand drive for wolves and deer in Warren County resulted in killing 160 deer, while an equal number escaped. (History of Warren County.)

It is difficult to determine the time at which deer disappeared from the different sections of the State, but they were everywhere the last of the large game to be exterminated. Butler states that they were still found in Ripley County "only a few years ago" (written in 1893). According to W. J. Ward, a drove of three were seen and two of them killed in the Eel River bottoms in the latter 50's. In Lagrange County the last one was killed in 1859 (Theo F. Upson). Dr. Haymond, in 1869, doubts whether there is a single deer in Franklin County. In Warrick County the last wild deer was killed in 1874 (Bob White). In the History of Allen County, edited by T. B. Helm, it is stated that some are still (1880) to be found in a large marsh in Jackson township in that county. In Wabash County they were still abundant in 1854 (County history, by T. B. Helm). In Steuben County they have not been seen since about 1865. In Noble County they disappeared between 1853 and 1867 (Van Gorder). The swamps of the Kankakee Valley and the cypress swamps in Knox County were the last retreats of the deer in this State. According to Butler (1894) one was killed in Jasper County in 1890 and one was seen in Newton County in 1891. The author spent a month collecting in the Kankakee Valley in 1905 and could learn of no records for that part of the State more recent than those given above.

Chansler states, on the authority of Mr. N. B. Edwards, that the last wild deer were seen near Red Cloud in Knox County in 1893. The writer was told by several Knox County citizens, whose names he does not now remember, that deer were seen in the cypress swamps in the southeastern part of that county as recently as 1906. However, these were probably animals that had escaped from a private deer park owned by Mr. Thomas Johnson near Decker. They had disappeared over most of the State much earlier. Several accounts say that they were diminishing in numbers, though still common, in the period from 1830 to 1840. By the latter date they were doubtless becoming rare in many places and were exterminated in most of the counties previous to 1860.

Habits.—The ability of deer to exist in places where bison and elk have long ago been exterminated by man, is due chiefly to their retiring habits. Where deer are hunted much they hide away in the most inaccessible mountain retreats, the densest thickets or the most impenetrable swamps. In such places they rest during the day and are active only at night.

Where they are afforded adequate protection from hunters, as in New York, New England and some other States, they become more tame and rapidly increase in numbers. In Maine it is said that they have again become numerous where they were once all but exterminated. Reasonable protection, together with setting aside forest and swamp land for permanent reservations, would have produced the same result in Indiana.

The mating season is in the fall, from late October to about the first of December. The males at this time lose their timidity and come out in the open. At this season they do not hesitate to attack a man on slight provocation.

The young are born in late April, May or June. Usually there are two, and the mother seeks the most secluded retreat for their birth-place. For several weeks they are quite weak and do not travel far, but by the middle of summer they become strong and active. The first coat is spotted. The second summer the males or "spike bucks" are equipped with straight, unbranched antlers which grow rapidly and are shed at the end of the season like those of the wapiti. The second year there are two prongs and another is added each year until maturity.

The Virginia deer can subsist in winter on such coarse feed as twigs and dead leaves, or on beechnuts and acorns which they dig out of the snow. In summer, when food is plentiful, they prefer the succulent grasses of the lowlands, and also frequent ponds, where they eat the aquatic vegetation.

Order GLIRES.

GNAWING ANIMALS.

Characters of the order.—Lower incisors, 2; upper incisors, 2 or 4, chisel shaped and adapted for gnawing, growing throughout life from persistent pulps; canines lacking; a fold of skin turned inward at the sides of the jaws and separating the mouth into two divisions.

The animals belonging to this order are all of small size. Dr. Coues says of them: "Though a feeble folk, comparatively insignificant in size and strength, they hold their own in legions against a host of natural enemies, rapacious beasts and birds, by their fecundity, their wariness and cunning, their timidity and agility, and their secretiveness, each after the means by which it is provided for exercising its instinct of self-preservation, among which insignificance itself is no small factor."

Family SCIURIDAE.

SQUIRRELS.

Upper incisors two; molars three on each side of upper and lower jaws; premolars one or two on each side above and two below; frontal bone with a post orbital process. Tail long and hairy, very often bushy. Toes four on the front foot and five on the hind foot.

Squirrels are medium sized rodents with generally arboreal or fossorial habits. They are found in all parts of the world except Australia. The family contains many genera and there are more species belonging to it than to any other family of mammals excepting rats and mice (*Muridae*).

Genus Sciurus Linnaeus.

Sciurus Linnaeus, Syst. Nat., ed. 10, Vol. I, p. 63, 1758.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{1-1 \text{ or } 2-2}{1-1}$; M, $\frac{3-3}{3-3} = 20$ or 22.

Generic characters.—Tail long and bushy. Ears well developed, pointed, hairy. Feet adapted for climbing.

The distribution of the genus is nearly the same as that of the family. The species are very numerous, especially in the tropics. The forms found in Indiana may be distinguished by the following key:

Size small; length from nose to tip of tail under 375 mm. (15 in.); hind foot under 50 mm. (2 in.). (Subgenus *Tamiasciurus.*) *Sciurus hudsonicus loquax,* p. 468.

Size large; total length over 450 mm. (18 in.); belly and ears always more or less rusty; upper cheek teeth, 4 on each side. (Subgenus *Parasciurus.*) *Sciurus niger rufiventer,* p. 466.

Belly and ears whitish; upper cheek teeth, 5 on each side. (Subgenus *Neosciurus.*) Back always somewhat rusty; hind foot about 60 mm. (2⅜ in.). *Sciurus carolinensis,* p. 461.

Back gray in winter; body heavier; hind foot about 70 mm. (2¾ in.). *S. c. leucotis,* p. 464.

SCIURUS CAROLINENSIS Gmelin.

SOUTHERN GRAY SQUIRREL.

Sciurus carolinensis Gmel., Syst. Nat., Vol. I, p. 148, 1788.

Sciurus carolinensis carolinensis Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 130, 1894.

Bangs, Proc. Biol. Soc., Wash., Vol. 10, p. 153, 1896.

Diagnostic characters.—Size smaller than either the northern gray squirrel or the fox squirrel, but much larger than the red squirrel; back grayish and belly white, both having a rusty tinge.

Description.—The southern form of the gray squirrel differs from the closely related northern subspecies chiefly in its smaller size and in the rusty tinge of the fur in winter; in the northern form the back and ears are clear gray in winter. The dimorphic black phase is seldom found in this smaller southern race.

Measurements.—The skin of a single individual from Bloomington measures: head and body, 250 mm. (10 in.); hind foot, 62 mm. (2½ in.).

Skull and teeth.—Skull slightly smaller than that of the fox squirrel, with a narrow, compressed rostrum, long nasals and broad braincase. There are two premolars above (5 cheek teeth on each side in the upper jaw) while the fox squirrels have but one premolar in each side of the upper jaw.

Range.—The two subspecies of the gray squirrel are not sharply marked off in Indiana. I should be inclined to call most of those from the southern half of the State, *carolinensis.* At Bloomington and Mitchell, the characteristic rusty tinge is generally retained in winter, although individuals are sometimes seen in which the back is nearly clear gray. I have seen but few winter specimens from farther north than Indianapolis. McAtee (Proc. Biol. Soc., Wash., Vol. 20, p. 3) records *leucotis* from Bloomington but on the other hand Bangs assigns specimens from Denver, Miami County, to the southern form. The gray winter coat and the larger size, places those from the two northern rows of counties at least, in the subspecies *leucotis,* althought they cannot be regarded typical. Throughout the central part of the State there is a blending of the two forms. Some individuals from the same locality have the characteristics of one variety and some of the other, while other individuals cannot be definitely assigned to either race.

The southern form ranges from central Indiana and Iowa east to the atlantic and south to the Gulf States. Different varieties occur in Florida and Louisiana.

Habits.—The gray squirrel is characteristically a dweller of the deep forest. The giant white oaks, tulip poplars, red maples and shellbark hickories which covered the hills of southern Indiana in the early days were its delight. Yet, where it is protected and fed, it becomes a contented inhabitant of city parks and shade trees.

It is diffcult for the present generation to realize how numerous these animals were in the early days. Judge Banta, in the history of Johnson County, states that in 1821 four families living in White River township, did not succeed in saving a single bushel of corn from the squirrels. In a four acre field of shocked corn, only a single ear was overlooked by the squirrels. In another four-acre field every ear was taken within two days after the corn had ripened.

The historian of Bartholomew County gives an account of a great squirrel hunt which took place in that county in 1834. There was strong rivalry between Sand Creek and Wayne townships as to which had the best squirrel hunters. Finally it was agreed that each township should select fifty men to compete in a three days' squirrel hunt, to be terminated by a great barbecue for which the losing side was to pay. The total number of squirrels killed is not recorded, but an idea of the destruction of the animals may be obtained from the statement that the individual championship was awarded for killing 900 squirrels in three days. The second largest number was 783.

In the early days the fox squirrels were much less numerous than the gray species. Now the latter are exterminated in many places and those remaining are generally limited to the larger tracts of woodland while the fox squirrels are still common in most of the open groves.

The gray squirrel has also been called the migratory squirrel on account of the habit the species formerly had of making long marches or migrations at irregular intervals. At such times they gathered in droves of thousands and began to move in one direction. Audubon thus describes one of these migrations: "It was in 1819 when we were descending the Ohio River in a flatboat, chiefly with the intention of seeking for birds then unknown to us. About one hundred miles below Cincinnati, as we were floating down the stream, we observed a large number of squirrels swimming across the river and we continued to see them at various places until we had nearly reached Smithland, about one hundred miles above the mouth of the Ohio. At times they were strewn, as it were, over the surface of the water, and some of them being fatigued, sought a few moments rest on our long steering oar which hung in the water in a slanting direction over the stern of our boat."

In Wabash County there was a great northward migration of the squirrels in 1834, when they swam the Wabash River in countless numbers. Mr. E. J. Chansler states on the authority of several old settlers, that the squirrels also migrated in Knox County in 1834, and again in 1836 and 1837.

On the occasion of these migrations the pioneer farmers resorted to various means to get rid of the pests and save their corn. The children were stationed in the fields with bells, tin pans and horse fiddles to frighten them away. Hundreds were drowned while crossing streams and many were shot by the unerring marksmen of those days. A local historian tells of one man who shot 26 without moving from his tracks.

The species is very prolific and even this wholesale slaughter would scarcely have held the number in check had it not been accompanied by clearing the forest and so reducing the available habitat of the squirrels. Two litters are usually reared each year. The first is born just at the end of winter, usually during the first two weeks of March, in southern Indiana. The parents mate again shortly afterward and the second litter is born any time from July to September. I have seen the young, only just large enough to leave the nest, on the seventh of the latter month. Very young squirrels may also be found at times throughout the summer, but it is probable that they are the offspring of the last litter of the previous year.

Economic status.—Under present conditions, gray squirrels rarely do much damage to fields of corn and, as far as I know, are never injurious in any other way. They are pretty and interesting animals and every effort should be made to give them protection and preserve the species from extermination. When kept in groves or city parks they should be provided with rain-proof boxes, as they are very liable to pulmonary diseases during the early spring months. In the Smithsonian grounds at Washington, D. C., not less than six, of a colony of 15 or 20, died during the spring of 1905, and in each case the cause of death was pronounced by the government veterinarians to be pulmonary diseases.

SCIURUS CAROLINENSIS LEUCOTIS Gapper.

NORTHERN GRAY SQUIRREL.

Sciurus leucotis Gapper, Zool. Journ., Vol. 5, p. 206, 1830.

Sciurus carolinensis leucotis Miller and Rehn, Syst. Results of the Study of N. Amer. Land Mam. to 1900, p. 31, 1901.

Sciurus carolinensis hypophaeus Merriam, Science, N. Ser., Vol. 7, p. 351, 1886.

Diagnostic characters.—Size larger than the southern gray squirrel, the average length being about 19 inches as against 17 for the southern; the hind foot of the northern form is 2½ inches while that of the southern is 2⅜ inches. Ears and back clear gray in winter without a rusty tinge.

Description.—Except for the characters given above, the subspecies *leucotis* resembles the typical *carolinensis.*

Measurements.—Five specimens from the Kankakee Valley south of Hebron average: Total length, 473 mm. (19 in.); tail, 223 mm. (9 in.); hind foot 62.5 mm. (2½ in.). Typical specimens from southeastern Canada are somewhat larger.

Range.—The principal facts known concerning the range of the two forms in Indiana are stated under the account of *carolinensis.* In the Kankakee Valley in Porter and Jasper counties I have found that the gray squirrel usually keeps in the denser swamps and is seen less frequently than is the fox squirrel, although equally abundant.

Van Gorder thinks the species is extinct in Noble County and Upson states that he has not seen the black phase in Lagrange County since 1879 and that the gray squirrels are also nearly extinct. It should be remarked that most species of animals are regarded as less numerous than they really are because they are not frequently seen.

Remarks.—One of the chief points of interest in connection with this subspecies is the status of the dimorphic black phase. Where the two forms occur, the black phase is always considered a distinct species in the popular mind. The early American naturalists held the same view, but Baird correctly placed the two color varieties in the same species in his account of the mammals of North America, published as a volume of the Pacific Railroad reports in 1857.

Almost thirty years later Merriam described a subspecies from Elk River, Minnesota, as *Sciurus carolinensis hypophaeus,* the principal characters being a dusky belly associated with the typical gray coat of *S. c. leucotis.* While collecting along the Kankakee in Porter County in 1905, the writer obtained a series of squirrel skins which show gradations from the light grizzled back and white belly of *leucotis* to the grizzled back and dark belly of *hypophaeus,* and the almost complete black of the dark phase. Some of the specimens have the ordinary gray back and at the other extreme the squirrels appear to be entirely black unless closely examined, when paler rings can be distinguished on some of the hairs.

These and similar facts obtained by other collectors clearly indicate that both the dark bellied and black varieties are forms which may be produced by the common gray squirrel at any time or place for causes as yet wholly unknown. Since they probably do not breed true they cannot be considered as true species or subspecies.

It is of interest to know that the black phase was formerly more abundant in some parts of southern Indiana than they now are. Dr. Haymond wrote in 1869: "The black squirrels were common—forming about one-third of the total number of squirrels in southeastern Indiana at the period of its first settlement. Now they have completely disappeared."

At New Harmony, however, Wied states that Lesueur saw but one black squirrel in many years. The writer has not seen or heard of a black squirrel in the southern part of the State in recent years. In other states, also, it has been found that the black squirrels are the first to disappear. This is no doubt due, in part, to the fact that they are more conspicuous and are therefor killed off the more quickly. It is possible, also, that they are, in a way, abnormal and lack the vitality necessary to continue their kind under adverse circumstances. In southern Porter and northern Jasper counties in 1905 the black or partially black squirrels were nearly as numerous as the gray.

SCIURUS NIGER RUFIVENTER (Geoffrey).

FOX SQUIRREL.

Sciurus rufiventer Geoff., Cat. Mus. Hist. Nat. de Paris, p. 176, 1803. Allen, Bull. Am. Mus. Nat. Hist., Vol 16, p. 167, 1902.

Sciurus niger ludovicianus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 131.

Sciurus niger rufiventer Osgood, Proc. Biol. Soc., Wash., Vol. 20, p. 44, 1907.

Diagnostic characters.—Size larger than any of the gray squirrels; hair of back banded with gray and rusty yellowish; tail very long and bushy; under parts bright, rusty yellow.

Detailed description.—The rusty or "foxy" color of this species separates it readily from the gray squirrels and it is never confused with them. The muzzle is usually bordered with the yellowish color which also encircles the eyes. The hairs of the back are colored with alternate bands of blackish and rusty. Hairs of belly are blackish at base but rusty yellow on the outer third and this color also predominates on the under side of the tail. The exact shade of the yellowish color is extremely variable in different individuals as is also the proportion of yellow and black. Hence the great differences in the appearances of the animals.

Measurements.—The average of five specimens from northwestern Indiana is: total length, 547 mm. (21⅞ in.); tail, 245 mm. (9⅞ in.); hind foot, 67 mm. (2 11/16 in.).

Skull and teeth.—The skull is long with a narrow braincase and relatively broad rostrum. It differs from the skull of the gray squirrel also in that it lacks the small first premolar, there being but four cheek teeth on each side of the upper jaw.

Range.—Fox squirrels belonging to four or more subspecies are found throughout the region from the western border of the great plains to the Atlantic. The subspecies, as now recognized, has a range extending from South Dakota and Wisconsin to the Alleghenies and south to Mississippi. However, the squirrels from the western part of this range differ from their eastern relatives as much as these do from some of the other forms.

In Indiana the fox squirrel is found throughout the State wherever sufficient timber remains to afford shelter.

Remarks.—The fox squirrel does not have a black phase, and melanistic individuals are rare if they ever occur, although the southern form *Sciurus niger* is black with white ears and nose.

However, white or partially albinistic individuals are not uncommon. Bangs* mentions a "curious series representing every degree of albinism," from Denver, Miami County, Indiana. I have records of albinistic individuals from Kouts, Porter County, and Rising Sun, Ohio County, and there is a skin in the Indiana University collection at Bloomington.

Habits.—The fox squirrel seems better able to adapt itself to man's proximity than its gray cousin. The actual number in the State has no doubt decreased as the land has been subjected to tillage, and the numbers are probably still decreasing, but this is due to the vanishing forests rather than to actual extermination. However, they are not disappearing as rapidly as the gray squirrels. In the early days the latter species outnumbered the fox squirrels. Indeed, Dr. Haymond says they first appeared in Franklin County about 1837, but his statement is open to question, as Dr. Plummer records it without comment at Richmond in 1844, and the Prince of Wied says that it was common at New Harmony in 1832, although less abundant than the gray species.

It is difficult to say just what has enabled the squirrel of this species to cope better with man than its smaller relative. Its food is similar for the most part, as is its method of obtaining it. The fox squirrel often lives in the open groves about farm buildings, whereas the other species does not often voluntarily take up its residence outside of large tracts of tall timber. In the winter of 1906-7 but one fox squirrel was known to live on the 180-acre tract of large trees on University Farm near Mitchell. Large numbers of gray squirrels inhabited this tract. But in the open wood lots of the surrounding farms fox squirrels were abundant, while the other species was rare.

According to some statements, fox squirrels sometimes joined their gray kindred in the great migrations of the early days. They were in the minority, however, and the early writers always mean the gray species when they speak of the migratory squirrel. At the present time the fox squirrel seems to wander the most, although it is not known to take long journeys. In their wanderings from one wood to another they are often chased up a solitary tree in a field and become victims of the farmer's dog or gun. When hard pressed by a dog they do not hesitate to enter a sinkhole or underground burrow.

Like the gray squirrels, this species stores up quantities of

* Proc. Biol. Soc. Washington. Vol. 10. p. 146.

acorns and nuts in hollow trees and depends partially on these stores for the winter supply of food. In the summer they feed to a large extent on tender roots, bulbs and berries. I have found their stomachs nearly full of blackberries. They begin quite early to eat the unripe nuts and acorns and their lips are sometimes much stained by the juices of acorns as early as August 20.

So far as I am aware, the breeding habits of this species do not differ greatly from those of the gray squirrel. Two litters are produced a year.

SCIURUS HUDSONICUS LOQUAX Bangs.

RED SQUIRREL; PINE SQUIRREL; CHICKAREE.

Sciurus hudsonicus loquax Bangs, Proc. Biol. Soc. Washington, Vol. 10, p. 161.

Sciurus hudsonicus Evermann and Butler, Proc. Ind. Acad. Sci., for 1893, p. 130.

Diagnostic characters.—Size much smaller than the other tree squirrels; sides with a black stripe in summer; back with a broad rusty band down the middle; and ears with tufts of long hair in winter.

Description.—In winter the back is a bright, deep rusty red in the middle and grayer or more olivaceous on the sides; the hairs all ringed with black. The belly is white with the dark plumbeous at the base of the hairs, sometimes showing through. The central part of the tail is the same color as the middle of the back. Outside of this reddish color there is a band of black followed by a band of lighter red at the tips of the hairs. In summer the red band in the middle of the back is not so distinct and there is a distinct blackish line along the flanks. The ears in winter have a distinct tuft of long hairs which are not present in summer.

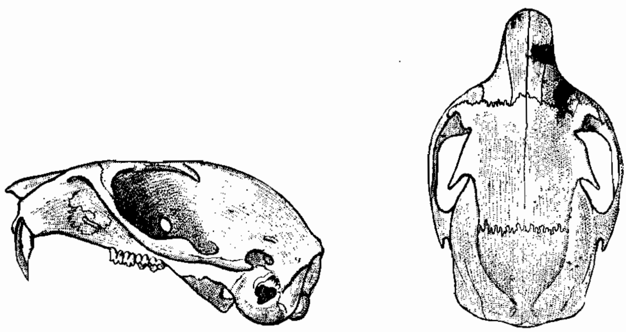
Measurements.—An adult female from Porter County measured in total length, 322 mm. (13 in.); tail, 141 mm. (5 11/16 in.); hind foot, 43 mm. (1 12/16 in.).

Skull and teeth.—The skull (fig. 4) is readily distinguished from that of the other tree squirrels by its small size. Compared with that of the ground squirrels it has a short, broad rostrum and braincase. There are two premolars on each side of the upper jaw (five cheek teeth) but the first one is always small and occasionally it is lacking.

Range.—This subspecies of the red squirrel has a range extending from northwestern Indiana to southern New England and south in the mountains to the Carolinas. Other forms are found in northern New England, Labrador, Minnesota and to the west.

In Indiana its range includes the northern part of the State only, and there are localities within its range where it is wholly unknown. I was unable to hear of it near Roselawn in northern Newton County. In southern Porter County, 30 miles east of Roselawn, it was abundant in a country that does not differ in the character of the soil, drainage or timber.

Other localities are Laporte, South Bend, Kewanna, Ray, Winona Lake, Marion and Miami, Fulton, Wabash, Randolph, Lagrange, Huntington and Delaware counties, Dr. Haymond reported in 1869 that one had been seen in Franklin County, but there is no other record as far south.



a b

FIG. 4.—Skull of *Sciurus hudsonicus loquax*: a, lateral view; b, dorsal view. After Baird.

Habits.—In this State the red squirrels seem to prefer the open groves near barns and farm residences. In South Bend they have taken up their residence in the catalpa trees that border one of the streets well within city limits. Here they are known to be guilty of robbing birds' nests. There is a colony of red squirrels in the grounds of the Winona Assembly at Winona Lake.

The writer's personal acquaintance with this species in its native haunts is somewhat limited. It is an active, energetic animal, apparently spending most of its time in searching for, storing up and eating food. Much of its time is spent on the ground, where it gathers acorns and nuts and buries them under the leaves and soil. Some supplies are stored in hollow trees also, although the snow is no hindrance to its finding and securing buried treasure.

In summer it usually has a home built of sticks in the branches of the trees and sometimes this is built tightly and firmly enough to afford a winter home also. However, a hollow tree is generally utilized for this, and sometimes the creatures have a hole under a stump or rock to which they also resort.

Stone and Cram say of the red squirrel that "he has more petty vices and fewer virtues than any other beast that roams the woods. He is quarrelsome, noisy and forever prying into the affairs of others. In winter he makes a regular business of robbing his neighbors of the stores of provisions they have gathered, though he always has more than his share hidden away at home and zealously guarded; and in summer he robs birds' nests high and low.

"Yet one cannot help liking him, for a keen sense of humor and never-failing good spirits tip the balance against all sorts of evil deeds. Even in northern New England the cold is never fierce enough to curb his jollity any more than the blistering heat of July. * * *

"Few people realize what thoroughly practical, thrifty and ingenious little animals they are, for, unlike most thieves, they are not in any way shiftless or lazy, but are steady, hard workers the year round. There is no idle season for them.

"Other squirrels live a careless, gypsy sort of life through warm weather, commencing the labor of harvesting only when the nuts are ripe. But as early as July, while the young squirrels have still to be watched over and looked after, the industrious red squirrels begin cutting off the green cones of the white pine, and work early and late burying them, half a dozen in a place, under pine needles, to be dug up in the winter and early spring and opened for the seeds they contain.

"By the time the business of gathering the pine cones is over for the season, the nuts and acorns are beginning to ripen, and there are fall apples to be picked and stored in the hollow trees, for the red squirrel is firm in exacting the tithe of the farmers and looks after the collecting of it himself. In the matter of corn, however, he prefers to wait until the farmer has gathered it into his bin, when the squirrel can generally get it without much loss of time."

Genus TAMIAS Illiger.

Tamias Illiger, Prodromus Syst. Mam. et avium, p. 83, 1811.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{1-1}{1-1}$; M, $\frac{3-3}{3-3} = 20$.

Generic characters.—Size small for a squirrel; tail slender and not very bushy; back striped with five lines of blackish and two of whitish on a ground color of brown; but four cheek teeth on each side of the upper jaw; cheeks with pouches that open between the teeth and lips.

The six or seven forms belonging to this genus are all geographical races of a single species limited to North America east of the Rocky Mountains. These animals are commonly known as ground squirrels, but that name is also applied to a number of related genera, differing chiefly in number of teeth. The name chipmunk is generally restricted to the squirrels of this genus and is, therefore, the more desirable name to adopt.

TAMIAS STRIATUS (Linnaeus).

CHIPMUNK; GROUND SQUIRREL.

Sciurus striatus Linn., Syst. Nat., ed. 10, Vol. 1, p. 64, 1758.
Tamias striatus Baird, 11th Rep. Smiths. Inst., p. 55, 1857.
Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, pp. 129.
Sciurus striatus lysteri McAtee, Proc. Biol. Soc. Wash., Vol. 20, p. 3, 1907.

Diagnostic characters.—Easily distinguished by its general brown color with five stripes of black and two of light color on the back.

Description.—The chipmunk is too well known to require an elaborate description. The head is brown with a blackish stripe running from the side of the nose through the eye and back to the ear. This is bordered above by a white stripe and that is followed by another narrow, indistinct stripe of blackish. Under the eye there is also a white stripe running from the base of the ear to the cheek. There is another dark but indistinct stripe below this.

The back has a median blackish stripe running from the occiput to the rump. On each side of this are two pairs of alternating pale and dark stripes, the lower light stripe being nearly white, while the median pair are grizzled brown. The rump is bright rufous chestnut and the side and shoulder grizzled yellowish brown with some black tipped hairs; tail grizzled black and gray above and chestnut below.

Measurements.—Specimens from northern Indiana measure 239 mm. 9 9/16 in.) in total length; tail, 95 mm. (3 12/16 in.); hind foot, 30 mm. (1 3/16 in.).

Skull and teeth.—The skull (fig. 5) is slender and tapers gradually from the zygomatic arches to the tip of the nasals, the outlines being much less square than in *Sciurus hudsonicus,* which has a skull of about the same length but broader. The upper cheek teeth are but four in number.

Range.—Chipmunks are found throughout North America east of the Rocky Mountains, except in the boreal regions. The typical *striatus* occupies most of the eastern United States except in New England, northern New York and Michigan and in the mountains. To the north a subspecies, *lysteri,* is found. McAtee* has listed the Indiana form as *lysteri,* but in this he erred, as this northern subspecies has a much paler color, a larger average size and larger hind foot than the specimens from this State.

The chipmunk is found all over Indiana where there are moderately open woods or dry pastures, overgrown with bushes or filled with stumps and rocks.

Habits.—Everyone who has lived in the country, in the southern third of the State at least, is familiar with some of the habits of

a b

FIG. 5.—Skull of *Tamias striatus*: a, lateral view; b, dorsal view. After Baird.

these little animals. There they may be seen, ever watchful and alert, about almost any heap of stones, logs, or the old-fashioned rail fences that have not yet disappeared. If they are approached too closely they dart away for a short distance, taking care not to expose themselves in the open and probably uttering a shrill protest as they go. If pursued they are apt to dart into some burrow or other hiding place at a point where there seems the least probability of escape.

If a burrow is not within reach they can run up a tree without difficulty, but their claws are not as sharp as those of a tree squirrel and they can be easily shaken down.

Their nest is nearly always placed underground, and generally, but not always, the entrance is concealed under a stone, stump or the base of a hollow tree. There is usually very little dirt about the entrance of their burrows, and it is supposed that they carry

* Mam. Monroe Co., Proc. Biol. Soc. Wash., Vol. 20, p. 5.

it away in their cheek pouches, though I know of no one who has ever seen them at it.

For a rodent, the chipmunk has a remarkable vocal ability. His name chipmunk or chipping-squirrel was given to him because of the chipping song he sings as he sits in the bright autumn sunshine. I have heard this chipping at intervals of two or three seconds for fifteen or twenty minutes, with scarcely a note missed. What its purpose may be, I cannot conceive.

A second noise is the rapid chatter he makes in defiance as he dashes away from danger along a fence or wall. But the most startling sound that I have ever known to proceed from any rodent's throat, is the shrill whistle of this little animal. Its exact nature is indescribable, but it resembles the whistle of a bird more than any mammal note that I know of. I have been fooled by it myself, and I once knew two very good ornithologists to search all over a hillside for some unknown bird, only to discover that the call that had lured them was not that of some feathered creature, but the ventriloquistic whistle of one of these little squirrels.

The food of the chipmunks is quite varied. In the oak woods they store up quantities of acorns in the autumn, and these form the staple article of food for several months. All kinds of nuts are eaten when they can be secured, and one of the favorite dwelling places of the animals is in an old pasture where clumps of hazel bushes are interspersed with stone piles or stumps. In the spring they sometimes do considerable damage by digging up sprouting corn from the furrows. In the autumn some corn is taken from the shocks. They also levy tribute on the wheatfields, separating the chaff from the grains and filling their cheek pouches with the latter to be carried to the den and stored for time of need. I have taken 145 grains of wheat from the pouches of an animal killed beside a shock of wheat. Many kinds of wild seeds and fruits are no doubt eaten. In a swampy district in Maryland, I found them storing up seeds of the sweet gum, which is there abundant. One that I caught had nearly 40 of these seeds in his pouches.

The capacity of the cheek pouches is surprisingly large. They open between the lips and the molars and extend along the cheeks and neck beneath the outer skin. They are simply folds of skin that have grown back from the lining of the lips and are not furred inside. They can be stretched to hold a considerable quantity of grain or seeds, as in the two instances mentioned above.

As a rule, the chipmunk does not eat much food at the place where he finds it growing, for he knows his enemies are legion, and therefore gathers it hastily and carries it to his burrow and stores it there to be eaten at leisure. A quantity is stored up for winter use, for these animals, unlike the woodchuck, do not sleep soundly all through the cold season. They can still be seen scampering about during the warm days in early December, and I have little doubt that they come out sometimes during the warm days of mid-winter, although I have never seen them during the last half of December, nor in January and February.

I am not able to say just how they spend the winter months. It is pretty generally believed that they awaken now and then and eat some of the food they have stored up.

Certainly they have need of awakening sometimes, for the sites of their winter homes are not always well chosen. In the autumn of 1906 I noticed that one of these animals was making its home under the roots of a small black gum tree standing on the edge of a sinkhole. It was frequently seen carrying acorns into this den during the late autumn and undoubtedly selected the place for its winter sleep. In January a heavy rain flooded the sinkhole and the water stood above the level of the chipmunk's hole for several weeks. I did not see the animal either then or afterwards, and never learned whether it escaped or was drowned during its winter sleep.

This species, like many others with similar habits, has undoubtedly thrived as the land has been cleared and tilled by man. Although sometimes found in the woods, it is not fond of the dense forests and was not abundant when white men first came to the State. With their coming many of its chief enemies disappeared or were reduced in numbers.

It is most abundant at the present time in the fields that are partially overgrown with bushes and covered with stones. However, it is not averse to living in close proximity to man, and I have known a chipmunk to make its home under the front veranda of a house occupied by a quiet couple who did not molest their little neighbor. At Indiana University a colony has lived for years in the foundation of Owen Hall, all unconscious that some of their pickled or skinned relatives were within, and that animals by the hundreds were being dissected in the zoological laboratories just over their heads.

Economic status.—In some instances chipmunks do much damage by digging up the sprouting corn from the rows. In such cases the squirrels should be poisoned, trapped or shot. A better way is to keep the fields free from heaps of stone, brush or rubbish of any kind. The animals have also been known to rob the nests of birds. On the whole, however, they do little damage, as most of their food consists of wild seeds and fruits. They are fond of the seeds of the giant ragweed or horseweed, and doubtless do some good by destroying weed seeds. They also eat some insects, though not enough to be of much use in that way.

Genus CITELLUS Oken.

Citellus Oken., Lehrbuch der Zoologie, Vol. II, p. 842, 1816. Allen, Bull. Amer. Mus. Nat. Hist., Vol. 16, p. 375, 1902.

Spermophilus Cuvier, Dents des mammiferes, p. 160, 1825. Baird, Mam. N. Amer., p. 304.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{2-2}{1-1}$; M, $\frac{3-3}{3-3}=22$.

Generic characters.—Size about that of the chipmunks (*Tamias*) but form generally more slender; tail often scantily haired, slender and rounded; cheek pouches present as in *Tamias;* ears usually short and round; color of the different species various, but never with dark and pale stripes alternating on a chestnut-colored back as in the preceding genus; upper jaw with five cheek teeth on each side.

The genus *Citellus* (usually called *Spermophilus*) as formerly understood contained a great number of species and had a range including most of the north temperate zone. Recently this genus has been divided into several genera, but there is lack of agreement as to what species should be included in each. As now understood, the genus still includes a number of species in America, Asia and Europe.

Two species only are found east of the Mississippi River, and one of these does not extend farther east than north-central Indiana, while the other is found as far east as Ohio. They may be distinguished as follows:

Whitish stripes and rows of dots on the back, in a ground color of brown; length not over 12 inches. *tridecemlineatus.*

Back without any stripes; length about 15 inches. *franklinii*

CITELLUS TRIDECEMLINEATUS (Mitchill).

STRIPED SPERMOPHILE; THIRTEEN-LINED GROUND SQUIRREL.
Also known as the Striped Gopher.

Sciurus tridecemlineatus Mitchill, Medical Repository, New Ser., Vol. VI, p. 248, 1821.

Spermophilus tridecemlineatus Audubon and Bachman, Quad. N. Am., Vol. I, p. 294, 1849. Evermann and Butler, Proc. Ind.

Acad. Sci. for 1893, p. 128. Stone and Cram, Amer. Animals, p. 161, 1903.

Citellus [*tridecemlineatus*] Allen, Bull. Amer. Mus. Nat. Hist., Vol. XVI, p. 375, 1902.

Diagnostic characters.—Back striped with six lines of buffy white and seven wider stripes of brown; stripes on the lower part of the sides not all very distinct, however.

Description.—The ground color of the back is a light chocolate brown when viewed at a little distance, the hairs being banded with chestnut and black. A rather faint row of light spots runs from the back of the head to the base of the tail, through the middle of a brown stripe. On each side of this, the pale stripes alternate with the brown, the latter being all marked with a row of pale dots excepting the outer one, which is usually indistinct and without the row of pale spots. The solid stripes are of nearly uniform width, the light ones being about two millimeters wide and the brown ones six millimeters. On the back of the neck the light spots become joined in a solid stripe. The pale spots vary in distinctness and size. Between them there is often an indistinct spot that is darker than the rest of the brown.

The forehead is tinged with yellowish brown. The lips are pale buff. The ears, lower cheeks, throat, belly and feet vary from pale buff to light yellowish brown. The tail above is chestnut in the middle, this being bordered with a black line which is followed by an outer fringe of buff. Below, the middle is lighter and the black line is indistinct.

The fore feet have very long, comparatively straight claws. The external ear is a mere rim, two or three mm. in height. There are large cheek pouches opening between the teeth and the lips.

Measurements.—Average of three individuals from Porter County: Total length, 275 mm. (11 in.); tail, 101 mm. (4 in.); hind foot, 34 mm (3/8 in.).

Skull and teeth.—The skull resembles that of the chipmunk in form and size. The braincase is usually a little broader in the present species and the skull more convex above. The spermophiles all have five cheek teeth, however, instead of four as in the chipmunks. In the chipmunks the incisors are usually yellow or brown, while in the present species they are white.

Range.—This little ground squirrel has a range extending from Saskatchewan to Oklahoma and from the western border of the plains to northwestern Ohio. In Indiana it is found only in the prairie portion, not extending much south or east of the Wabash

River. It has, however, been recorded from Butler County, Ohio, about 30 miles north of Cincinnati.

Evermann and Butler give the following records: Terre Haute, Lafayette, and Benton, White, Carroll, Newton and Lagrange counties. In addition I can record the species from Fowler, Oxford, Mountayr, Lake County (Ball), Hebron, South Bend, Wolcottville, Lacrosse, Hudson and Winona Lake.

Habits.—This species belongs to a large group of the squirrel family known as the spermophiles, and often incorrectly called gophers. They are typical inhabitants of the great plains and mountains of western America, but only two species are found east of the Mississippi. In many ways they are intermediate between the prairie dogs and woodchucks on the one hand and the chipmunks and tree squirrels on the other. They always make their homes underground and seldom climb trees.

Railway embankments are favorite dwelling places of these animals, at least in northern Indiana, where much of the land is swampy. There is little doubt that they have extended their range, locally, by following railways through swampy districts that are not suited for their habitation and thence spreading out into the drier areas.

Their habits seem to differ greatly in different localities. At Mountayr, in Newton County, I found them living in the pastures and along the fences. The holes leading to their nests were less than two inches in diameter and there was not a particle of loose earth about them. I was at a loss to know what had made the holes until I trapped a spermophile at one of them. The farmer on whose land I caught a number had never seen them, and did not know that such animals were in the neighborhood nor did I ever see them alive in this locality.

Near South Bend, Wolcottville and other places, I have known them to dig holes considerably larger at the mouth and leave the dirt where they threw it out after the manner of woodchucks. In some localities they do not appear to be as shy and may often be seen sitting up on their haunches on the lookout for danger.

Economic status.—In some places where the striped spermophile is abundant it becomes a serious pest. In this State it has never done a great deal of harm to crops. At Mountayr I found them living in a field of ripened oats, but the owner did not think the damage done by the animals was appreciable. Other farmers have told me that they do little harm. One spermophile was examined whose cheek pouches were filled with seeds of the Canada thistle which he was thus helping to destroy. They also eat some insects, especially crickets and grasshoppers.

However, experience in some of the other States has shown that it is not desirable to allow them to become too numerous. Where they injure crops at all they should be destroyed. They are really taken in "out o' sight" rat traps baited with dry oatmeal or a grain of corn. They can often be drowned out by pouring a bucket or two of water into their holes.

CITELLUS FRANKLINII (Sabine).

THE FRANKLIN SPERMOPHILE; GRAY GROUND SQUIRREL; PRAIRIE SQUIRREL.

Also called Gray Gopher.

Arctomys franklinii Sabine, Trans. Linn. Soc., Vol. 13, p. 587, 1822.

Spermophilus franklinii Baird, Mam. N. Amer., p. 314. Miller and Rehn, Proc. Bost. Soc. Nat. Hist., Vol. 30, p. 49. Evermann and Butler, Proc. Ind. Acad. Nat. Sci. for 1893, p. 129. Stone and Cram, Amer. Animals, p. 162.

Citellus [*franklinii*] Allen, Bull. Amer. Mus. Nat. Hist., Vol. 16, p. 375, 1902.

Diagnostic characters.—Color, dull grayish brown; size somewhat larger than the striped spermophile.

Description.—This spermophile is nearly equal to the gray squirrel in size, but the tail is shorter and not so bushy. The color is brownish gray above, with small, indistinct spots of lighter gray and blackish. The neck and head are hoary and the throat whitish; rest of under parts somewhat tinged with buffy; tail gray; ears small but somewhat larger than those of the striped spermophile.

Measurements.—An adult female from Mountayr, Newton County, measured 375 mm. (15 in.) in total length; tail, 120 mm. (4 4/5 in.); hind foot, 49 mm. (2 in.).

Skull and teeth.—As compared with *C. tridecemlineatus,* the skull (fig. 6) is heavier, flatter on top and more angular. Like that species it has five cheek teeth.

Range.—From Indiana to Kansas and north to Saskatchewan. In Indiana it probably does not occur in more than five or six counties. The only records I have are Remington and Monticello, given by Messrs. Evermann and Butler, and Mountayr and Hebron.

Habits.—At Mountayr I found this species living about a stone pile in a field of oats, and they also had holes, similar to woodchuck holes, but smaller, about a rod from the stone-pile. In this neighborhood the species was known as the gray squirrel. I was unable to learn of more than the one colony anywhere near.

The animals were not afraid of traps and three were caught in a single trap, without bait, in two days. They were all females, and one taken August 18 appeared to be nursing. The cheek pouches of one contained several crickets and one of the others had been garnering oats. The farmer on whose land they were taken did not think that they had injured his crops appreciably.

Mr. W. S. Blatchley reports digging one of these spermophiles out of a mound near Boone Grove, Porter County, on October 6. At that time it had already begun to hibernate.

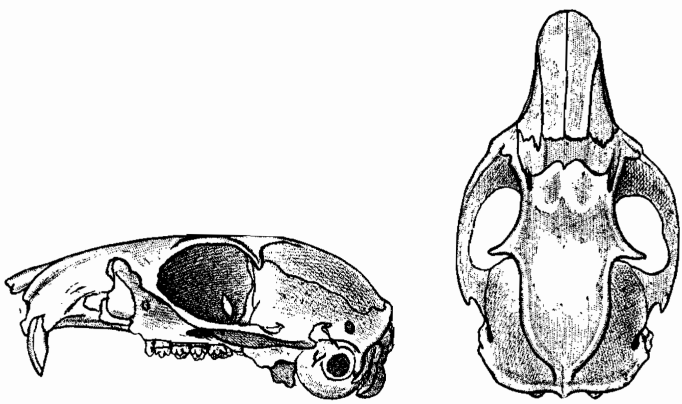

a b

FIG. 6.—Skull of *Citellus franklinii*: a, lateral view; b, dorsal view. After Baird.

Economic status.—The Franklin spermophile is not sufficiently numerous in this State to be of much economic importance. In some of the States farther west it sometimes does considerable damage to grain. It eats some insects, but is not beneficial to any marked degree. There is no reason why its flesh should not make good food, though I cannot vouch for its flavor.

Genus MARMOTA Zimmermann.

Marmota Zimmermann, Specimen zoologicae geographicae, p. 509, 1777. Allen, Bull. Am. Mus. Nat. Hist., Vol. 16, p. 17, 1902.

Arctomys Schreber, Saugethiere, Vol. 4, pls. 207-211, 1780.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{2-2}{1-1}$; M, $\frac{3-3}{3-3}=22$.

Generic characters.—Form heavy and thickset; tail short; ears small; color grizzled brownish or grayish with no distinct stripes;

skull broad, depressed and strong, with straight post-orbital processes; first premolar nearly as large as the second.

The range of this genus includes most of the north temperate zone. The species are not numerous, however, and only one is found in the eastern United States.

MARMOTA MONAX (Linnaeus).

WOODCHUCK; GROUND HOG.

Mus monax Linnaeus, Syst. Nat., ed. 10, p. 60, 1758.

Arctomys monax Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 128, 1894.

Marmotta monax Allen, Bull. Amer. Mus. Nat. Hist., Vol. 16, p. 17, 1902.

Diagnostic characters.—The woodchuck cannot be confused with any other Indiana mammal. Its grizzled, yellowish gray color, heavy body, broad, blunt head and short tail readily distinguish it from all the mammals of the region.

Description.—The predominating color of the head is dark brown, this color being grizzled with paler tipped hairs. The edges of the ears and some spots about the eyes are also paler; a whitish line borders the mouth. The hairs of the back and sides are ringed with silvery gray, blackish and reddish brown. Belly generally rather light reddish brown, often somewhat grizzled. The hairs of the belly are usually scanty so that the skin is visible. The feet are black or dark brown. Tail short and rather scantily haired, the hairs usually having less of the silvery gray band of color and hence the tail is darker than the back. There is a great variation in color, some animals being nearly black and others much more red or gray. I have also heard of albinos, but have never seen any.

Measurements.—The size varies greatly. Woodchucks usually appear very much smaller in the spring than in late summer, when they are fat and strong. An adult female from the Kankakee Valley, the largest specimen of which I have any measurements, though probably not the maximum size of the species, had a total length of 615 mm. (24½ in.); tail, 145 mm. (5 13/16 in.); hind foot, 93 mm. (3 12/16 in.).

Skull and teeth.—The skull (figs. 3 and 7) is characterized by its very broad flat top, or dorsal, surface and angular outlines. The incisors are long and broad; the lower jaws are very imperfectly fused together and readily come apart in the cleaned skull. Not infrequently in the living animal they become slightly dislocated, the upper incisors do not meet the lower ones exactly and both continue to grow indefinitely, sometimes penetrating the flesh and even the bones of the skull. The molar teeth have prominent, W-shaped crowns which do not wear smooth, even in old age.

Range.—The woodchuck's habitat extends from New England and North Dakota to Georgia and Louisiana. Other species are found to the north and west. In Indiana it is found in every county.

Habits.—The woodchuck, or ground hog, as he is more often called in southern Indiana, is noted for his long winter's sleep. Retiring to his burrow when the first hard frosts come, he shuts

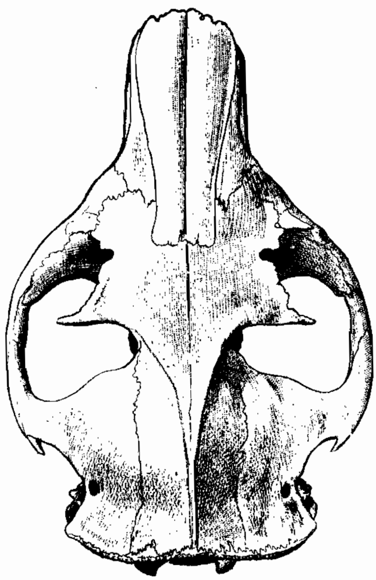


FIG. 7.—Skull of *Marmota monax*. After Baird.

himself off from the world with a goodly pile of earth and sleeps in blissful ignorance of winter and its cold. The popular idea that he comes out on a certain day is nothing more than a superstition, just as it is a superstition that leads people to believe that the coming of spring can be forecasted by the cloudiness of the sky on the second of February.

If the winter nap of our sleepy friend does not have a regularity that would seem to make an alarm clock a necessary part of the equipment of his burrow, its length can nevertheless be foretold with some degree of accuracy. In southern Indiana the animals usually retire about the middle of October. I have seen them on the 14th of that month after the severe early frost of 1906; but I have never seen them as late as November, although it is possible that a few may venture out in the sunshine of that month. I do not know that they ever appear as early as February 2, which is popularly styled "ground-hog day." Before the end of February, however, they usually begin to clean out and enlarge their burrows or dig new ones.

After they once venture out, snow and cold do not drive them back to winter quarters, and their tracks may often be seen in the deep snow that sometimes falls in March. At such times they subsist largely on tender twigs and young trees. This food could be obtained by them throughout the winter, as well as by the rabbits, who find it ample for their winter diet. The hibernation of the woodchuck, then, can not be looked upon as an adaptation necessary for the animal's existence. It is rather a physiological peculiarity which may possess advantages, but which does not have selective value.

Even during the summer the greater part of the time is spent in sleep. Except during the breeding season these animals are usually active only for brief periods two or three times a day. The rest of their existence is spent within their burrow, presumably in sleep. It is easy to see how a creature with such a vegetative existence could acquire the habit of prolonged sleep after it has stored up a large quantity of fat, though it is not so easy to see why some of the leaner animals do not waken in December or January, and I have never known such a thing to occur.

It is said that a hibernating woodchuck cannot be dug out unless by accident or by excavating a large area about his den, because he plugs the passage into which he crawls with dirt so tightly that it cannot be found. When pursued into his den during the season of activity, he also fills the passages so that he cannot be readily found, and at such times he can also extend his burrow very rapidly.

The food of the woodchuck is quite varied. Tender clover and ripe apples are favorite articles of diet. But many kinds of grasses twigs, leaves, stems and vegetables are eaten at times. I once captured one of these animals in a sassafras tree and, on examination, found its stomach gorged with sassafras leaves.

The animals that live in the fields seldom forage far from home. The den is located in a place convenient to feeding grounds. The owner comes out early in the morning, stopping near the door of his home to rise up on his haunches and survey the horizon for possible danger. If the coast is clear he wanders off, usually following a path of his own making and nibbling clover or grass on the way. He does not forget to rise up on his haunches and look for danger, even while feeding. In the spring, while lean and hungry, he may stay out for an indefinite length of time. Later in the summer he usually returns in an hour or two, and perhaps does not come out again till late afternoon. At this time he sometimes goes for a visit to his neighbor across the field, but most often he stays near home, although he may prolong his supper till after nightfall. Sometimes he comes out for a midday lunch also.

If discovered away from his burrow he knows but one thing to do—get back to safety at once. Under such circumstances he does not hesitate to run directly toward a person and his rush is so impetuous that one is apt to be knocked down if he remains in the animal's path. If cornered the woodchuck at once shows fight, and his long, powerful incisors make him a formidable antagonist for any inexperienced dog.

At the present time men, dogs, and possibly foxes, are the only enemies the adult woodchuck has to fear. For this reason the species has increased in abundance in recent years, where formerly their numbers were held in check by such carnivorous animals as wolves, coyotes, bears, panthers and lynxes. The writer can remember when, somewhat more than twenty years ago, an older brother killed a woodchuck and all the boys and some of the men in the neighborhood were ignorant as to the identity of the animal. At the present time the same farm in southeastern Indiana harbors from 25 to 50 "ground pigs," as they are popularly called, and their appearance is doubtless familiar to every country boy in the State.

Economic status.—The woodchuck has no good qualities and many evil ones. The animal is a voracious eater during the seasons that crops are growing. Besides eating a great quantity of clover, grass, some grain, a little fruit, and occasionally garden vegetables, they make paths through the meadows and grain fields, and tread down more than they eat. Where there are few on a farm, the loss is not very noticeable, but where they become abundant they do much damage. In some localities they have become such pests that bounties are offered by the county. Porter County paid out $700 in such bounties during the five years ending with 1905. At ten cents apiece this means an average destruction of 1,400 woodchucks per year. The numbers were not appreciably diminished, however, and the money might have been expended with much better results. An ounce of bisulphide of carbon soaked into cotton or an old rag and thrown as far as possible down the hole of a woodchuck will usually asphyxiate the inhabitants. The fumes of this chemical are heavy and go downward, so that it is not necessary to cover the hole if care is taken to throw the substance as far down as possible.

Poison can sometimes be put in a ripe apple, which should then be left along the paths used by the animal at a little distance from the den. This, of course, can only be done where there is no danger of man or domestic animals eating the poisoned fruit.

In the early spring when the animals are still weak from the winter's fasting they can often be caught by setting a steel trap well down inside the hole and partially covering it with dirt. There is a chance, however, that the animal will bite off the foot just below the jaws of the trap and thus free itself. In late summer it requires a very strong trap to hold a full grown woodchuck, as they are then very strong and their first effort, when entrapped, is to pull free, and in this attempt they are often successful.

The flesh of these animals is said to be tender and well flavored. The woodchuck is a dainty feeder, usually eating nothing but juicy fruits and tender grass and clover, and there is no well-founded reason for thinking him unclean. There is, however, a strong antipathy among many people to eating most kinds of animals with whose flesh they are unfamiliar. If a taste for the meat of these animals could be cultivated, it would help to solve the problem of getting rid of a serious pest.

Genus SCIUROPTERUS Cuvier.

Sciuropterus Cuvier, Dents du mamiferes, p. 255, 1825.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{2-2}{1-1}$; M, $\frac{3-3}{3-3}=22$.

Generic characters.—A membrane extends along the sides of the body from wrist of fore-limb to ankle of hind leg. The body is covered with very dense, long, soft fur, pure white underneath, varying from gray to brown on the back and without distinct spots or markings of any kind. Tail very broad and flat. Skull much depressed posteriorly. Fore-limb with a supplementary bone articulating with the outer side of the wrist and helping to expand the membrane.

The genus is represented by several species in North America as well as Europe and Asia. Only one species is found in Indiana

SCIUROPTERUS VOLANS (Linnaeus).

FLYING SQUIRREL.

[*Mus*] *volans* Linn., Syst. Nat., ed. 10, Vol. I, p. 63, 1758.

Sciuropterus volans Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 131, 1894.

Diagnostic characters.—Distinguished by the membrane which extends from the fore leg along the side to the hind leg.

Description.—Fur very dense and soft. Color, brownish drab above, with the under parts pure creamy white from chin to tail, the hairs being white at the base as well as the tip, a somewhat unusual condition among mammals. The cheeks are whitish and there is an indistinct dark ring around the eye. The fore feet are white; hind feet brown above, excepting the toes.

The ears are small and rounded. The fur of the tail is dense and long, standing out at the sides, thus making the tail very broad and flat. The membrane which extends along the flanks is merely a double fold of skin produced from the sides and belly. In skinning the animal it is apt to split open from the inside.

Measurements.—An adult male from Mitchell measured 230 mm. (9¾ in.) in total length; tail, 97 mm. (4 in.); hind food, 28 mm. (1⅛ in.).

Skull and teeth.—The skull is distinguished from that of other squirrels found in Indiana by its small size and rounded form. The braincase is depressed at the back; postorbital processes very short. Rostrum short and sharply marked off from the broad interorbital region. Cheek teeth five in number, the first one small and so closely applied to the second as to be easily mistaken for a part of it.

Range.—This species of flying squirrel has a range from New England to Georgia and west to the plains. Other species are found in the west, south and north. In Indiana it doubtless occurs in every county.

Habits.—Flying squirrels are almost as numerous in some localities as gray squirrels, but they are seldom seen because of their nocturnal habits. During the warm nights that come in late February, March and April their shrill, bird-like calls may be heard in almost any woodland by him who knows how to listen.

During the late summer they may sometimes be seen in the evening twilight, sailing from some lofty point to the base of a tree not far away. They cannot be truly said to fly, for they do not propel themselves while in air, but gather impetus in leaping from a solid body. The membranes along the flank act as a parachute to bear them up, and the broad tail also aids in supporting them in air and doubtless serves as a rudder, enabling them to alight with more certainty. It is worthy of note that some Asiatic flying squirrels that have slender, round tails have the membrane extended back of the hind limb and joined to the base of the tail.

The young are born about the first of April. They are usually from two to four in number and are brought forth in a deserted woodpecker's hole or knot hole in a tree. If taken while young they become very tame and make pretty and interesting pets. Prof. F. H. King* writes of some that he had: "I have never known wild animals that became so perfectly familiar and confiding as these young squirrels did; and they seemed to get far more enjoyment from playing upon my person than in any other place, running in and out of my pockets and between my coat and vest. After the frolic was over they always esteemed it a great favor if I would allow them to crawl into my vest in front and go to sleep there where they felt the warmth of my body. When forced to go to sleep by themselves, the attitude taken was amusing. The nose was placed upon the table or other object it happened to be upon, and then it would walk forward over it, rolling itself up until the nose almost protruded between the hind legs; the tail was then wrapped in a horizontal coil about the feet, and the result was an exquisite little ball of life in soft fur which it seemed almost sacrilegious to touch."

Even the adult animals reared in the wild state are fond of living near human habitations. Mr. E. J. Chansler writes me: "Some twenty years ago we lived in a little cabin by a creek. While eating supper about dusk, we would hear a racket in the board loft, and presently the flying squirrels would sail down and light on the table and eat with us. They kept this up for quite a while." A colony has lived for a long time on the campus of Indiana University, apparently as oblivious of the people about them as most of the students are of the presence of the squirrels. They also live near the cabin on the University's property at Mitchell.

During the winter season they are quite gregarious and numbers may often be found together. Prof. U. O. Cox reports finding fifteen in a hollow snag in Randolph County on a Thanksgiving day. (Evermann and Butler.) When asleep in a hollow tree they usually come out if the tree trunk is rapped sharply. Sometimes the entrance to their home is at the ground and I have caught them

* Quoted in American Animals.

in a trap placed on the ground beside a hole in the base of a hollow tree.

Economic status.—The food of the flying squirrels consists chiefly of acorns and nuts. I doubt that they ever injure standing grain or crops of any kind, although they may sometimes steal from granaries and corn cribs. They are said to eat some fruit, a few insects, and, occasionally, carrion.

Family CASTORIDAE.

BEAVERS.

Size large for a rodent; habits aquatic; tail broad, flat, and almost devoid of hair.

Genus CASTOR Linnaeus.

Castor Linnaeus, Syst. Nat., ed. 10, Vol. I, p. 58, 1758.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{1-1}{1-1}$; M, $\frac{3-3}{3-3}=20$.

Generic characters.—Size the largest of any North American rodent; tail broad and horizontally flattened; skull very strong and without postorbital processes.

The genus formerly had a range extending from Mexico to the Arctic zone and throughout Europe and more or less of Asia. There were but few species, however, and these are now very generally exterminated except in the thinly settled regions. A single species with several geographic races is found in eastern North America.

CASTOR CANADENSIS CAROLINENSIS Rhoads.

CAROLINA BEAVER.

Castor canadensis carolinensis Rhoads, Trans. Amer. Philos. Soc., Vol. 19, p. 420, 1898.

Castor fiber Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 128.

Diagnostic characters.—Those of the genus. The southern form, *carolinensis* is said to be distinguished from the northern beaver by its lighter color, larger size and much broader tail. No specimens from Indiana are to be had, but it is assumed for geographic reasons that the southern form is the one that formerly occurred in this State.

Description.—Rhoads says of the color of the two races: "The upper winter fur of *canadensis* is blackish brown, the hairs tipped with chestnut. rump and thighs dark chestnut. In *carolinensis* the upper colors are hazel brown and the rump and thighs bright cinnamon rufous, the under parts broccoli brown, making it a much duller and paler colored animal than the Canadian beaver."

The general appearance of beavers is well known. The form is short and thick-set, the hind feet webbed and with but four toes, the second toe having two claws. The tail is broad and flat, devoid of hair but covered with scales.

Skull and teeth.—The skull is extremely large and strong, with large flat molar teeth and strong processes for the attachment of the muscles used in mastication.

Range.—The Carolina beaver formerly ranged throughout the eastern United States, except New England, the Allegheny Mountains and possibly the Canadian border, in which places the Canadian beaver replaced it.

In Indiana it was once found throughout the State, but disappeared almost as soon as the bison and elk. The Prince of Wied states that it was exterminated at New Harmony previous to 1832, and Dr. Plummer wrote in 1844 that beaver dams were still to be seen about Richmond, but he knew of no one who had ever seen beavers there. However, Mr. E. J. Chansler tells me that a beaver was taken near Vincennes in 1840 by Mr. F. Dubois. Evermann and Butler say that a beaver was taken near New Harmony "not many years ago" (1888). They also say that a beaver was seen in the Wabash River near Lafayette in 1889. I place little credence in these last two records, for the consensus of opinion is that the species was exterminated all over the State not later than 1840.

Habits.—Most natural histories contain good accounts of the habits of beavers, and this account will, therefore, be less extensive than these interesting animals might otherwise deserve. Macfarlane states that in the Northwest territories of Canada the beavers mate in January or February and from four to eight young are born three months later, the usual number of young for a mature female being four, five or six. They are small and quite naked and helpless at first, but grow rapidly and in a few weeks begin to eat succulent plants. The females do not breed until about three years old. The males fight desperately for mates during the breeding season, but apparently remain faithful to the mates they choose and assist in rearing the young.

These animals have instincts specialized to a high degree and are commonly supposed to be very intelligent, although it has not been shown that their intelligence extends very far in the way of ability to meet new situations. They dam streams in order to form ponds of suitable depth, and in these ponds they construct houses of sticks and mud. The sticks are obtained by cutting down trees near the water and are sometimes six inches or more in diameter. They are cut with the teeth and it has often been asserted that the lowest and deepest cut is on the side toward the water, so that the tree will fall in the direction that will save work in carrying it. This point is disputed, however, and it is probable that if the trees fall toward the water it is because they lean that way and not because the beavers exercise extraordinary wisdom in cutting them.

The food of beavers is bark which they obtain by cutting trees and which they store up for the winter. They also eat tender aquatic plants. In storing sticks of wood for winter food they do appear to show considerable intelligence, for it is said that they usually place their supply so that it will not be carried away by a flood. The dam and the banks of the pond are also carefully guarded and strengthened to prevent breaking in time of high water.

The cause of the early extermination of this species is to be found, in part, in the extraordinary persecution to which they are subjected. The coat of the beaver has always been one of the most valuable of furs, and Macfarlane states that the Hudson's Bay Company exported an average of more than 118,000 beaver skins from Canada each year from 1853 to 1877, while as late as 1903 they sold over 49,000 skins. In addition to the fur, beavers yield a product called castoreum, which is used in perfumery and other drugs. It is secreted by glands associated with the reproductive organs.

The habits of the animals in associating together in colonies, the presence of which are indicated by dams and ponds, has also aided in the extermination of the species by making it easier for trappers to locate the animals. Compared with the muskrat and many other rodents, the rate of reproduction is slow, since the animals do not breed until three years old.

Where they are protected they soon increase, however, and according to Mr. Macfarlane the Hudson's Bay Company has done a valuable service in limiting the catch and preventing extermination in the Northwest territories of Canada. It seems altogether possible that the animals might be successfully reared in confinement if given a good range and plenty of cottonwood, birch, ash and other trees suitable for food and for making dams and houses.

Family MURIDAE.

RATS AND MICE.

Size ranging from some of the smallest of mammals to the muskrat, which weighs several pounds. There is a single incisor on each side of the upper and lower jaw; no canines or premolars; molars three on each side of the upper and lower jaws.

The family is of world wide distribution and includes over 100 genera and more species than any other family of mammals. The tropical species, which are very numerous, are still imperfectly known and many new species and genera will yet be found.

The American rats and mice belong to four subfamilies which can generally be very easily distinguished. To the *Murinae* belong the introduced mice and rats which are all well-known household pests. They are characterized principally by the long, scaly, nearly hairless tails, and by having the tubercles or projections on the crowns of the molar teeth of the upper jaw arranged in three rows.

The second group, *Cricetinae,* includes many old world species and all of the white-footed mice, harvest mice, grasshopper mice and others of North America. They have also moderately long tails, slender limbs and bodies and many of them have white bellies, large ears and prominent eyes. The tubercles of the upper molars are arranged in two rows.

The third group, *Microtinae,* includes the meadow mice or voles and the muskrat. With the exception of the muskrat they all have short tails, short legs, small eyes and ears and plump, thick bodies. The crowns of the molars are without projecting tubercles, but are flat and are arranged in a series of loops and triangles which project from the middle line on both the inner and outer side of the teeth.

The fourth group, *Neotominae,* includes the native cave rats and wood rats, of which only two or three species are found east of the Mississippi and none have certainly been recorded from Indiana. They resemble the honse rat in external form, but the belly is pure white, the tail is more thickly covered with hair and the teeth bear considerable resemblance to those of the *Microtinae.* They were formerly placed in the subfamily *Cricetinae,* to which they are related, but more recently they have been regarded as forming a separate subfamily.

Genus Mus Linnaeus.

Mus Linnaeus, Syst. Nat., ed. 10, p. 59, 1758.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{0-0}{0-0}$; M, $\frac{3-3}{3-3}$ = 16.

Generic characters.—Front teeth without grooves; molar teeth with tubercles of the crowns in three rows (these not evident in the teeth of old animals, where the crowns are worn smooth); tail long, scaly and scantily haired.

Three species are found in this State, all of which have been introduced. The genus has a cosmopolitan distribution and is represented by a very great number of species, chiefly in the tropical regions of the old world.

The Indiana species may be distinguished by the following key:

Size small, under 200 mm. (8 in.). *M. musculus.*
Size large, 300 mm. (12 in.) or more.
  Color bluish black; tail as long or longer than the head and body; form slender. *M. rattus.*
  Color brownish; tail shorter than head and body; form rather stout. *M. norvegicus.*

MUS MUSCULUS Linnaeus.

HOUSE MOUSE.

Mus musculus Linnaeus, Syst. Nat., ed. 10, p. 62, 1758.
Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 127, 1894.

Diagnostic characters.—Size small (6 to 7 in.); color "mouse gray," often with a tinge of yellow on the belly, but never with bright brown back and white belly; eyes and ears of moderate size; tail scantily haired and scaly; skull small and delicate as compared with the white-footed mouse.

Range.—The house mouse probably came from Asia, but it is now a household pest throughout the civilized world. It reached America with the first colonists, and doubtless has lived in Indiana almost from the time of the first permanent white settlements.

Habits.—Not only are the house mice found in almost every house and barn in the State, but they have also taken up their abode in the fields. When the farmer takes up his shocks of grain or fodder several species of mice are apt to scamper away, and among them some house mice are very often seen. I have also found them living in the open grassy fields in half a dozen counties. They no doubt go back and forth more or less between field and barn and spend their time wherever they can most easily obtain food.

Their depredations in granary and pantry are too well known to require discussion. They can squeeze through a hole surprisingly small and often get into a room that is supposed to be mouse-proof. If nutritious food is not at hand they seem to be able to live for a time on almost any substance that they can swallow. A friend once told me that he had very carefully put away everything that it seemed possible for mice to eat for several weeks in the hope that they would leave his house. In this he was disappointed, and he then began setting traps. Several mice were caught, and on examination it was found that their stomachs were filled with paper. This had apparently been sufficiently nutritious to keep them alive for some time.

No satisfactory means of getting rid of mice has ever been discovered. Like the rain, they come alike to "just and unjust," the rich and the poor. However, it is possible to exclude them from the rooms of a well built house, and good floors, closely fitting doors and screen wire placed over ventilators, hot air shafts or other necessary openings will go farther than anything else to prevent damage by mice and rats.

MUS NORVEGICUS Erxleben.

COMMON OR NORWAY RAT.

Mus norvegieus Erxl., Syst. regni animal, Vol. 1, p. 381, 1777. Miller and Rehn, Proc. Bost. Soc. Nat. Hist, Vol. 30, p. 65.

Mus decumanus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 127.

Diagnostic characters.—Body heavy, covered with coarse, brownish-gray fur. Tail scarcely as long as the head and body together, covered with prominent scales which are interspersed with few hairs. Further description of this animal seems unnecessary.

Range.—Originally coming from Asia, this pest has been carried by man to all parts of the world. It is said to have been introduced into America about 1775. In this state, according to Dr. Haymond, it first reached Brookville in the summer of 1827. Dr. Plummer gives the date of its arrival at Richmond as 1835, and Mr. Chansler states that it reached Vincennes about 1840. In all of these places the black rat, which had preceded it, was driven out in from two to five years.

Habits.—Most people are all too familiar with some of the habits of the brown rat. It lives principally about barns, under houses and about wharfs and sewers. It digs great holes under buildings and cannot easily be captured in such places.

The rate of increase is very rapid. The period of gestation is short, and the female produces from four to twelve young three or four times a year. Females begin to breed when only four or five months old, and the potential number of descendents from a single pair of parents within twelve months may be computed at 700 or more, although the actual number is always much less.

In addition to destroying a large amount of valuable commodities, rats are known to spread disease. It is not improbable that they may sometimes spread tuberculosis, and infection of the bubonic plague has been directly traced to these rodents.

Methods of Destruction.—Rats may sometimes be captured by setting steel traps in their holes or paths and covering them with loose dirt, but the animals often escape by sacrificing a foot. Wire cage traps are sometimes effective and may capture several in a night. They are shrewd animals, however, and those that live to maturity become adepts in avoiding traps. The newer styles, which consist of a wood or metal base, to which is attached a loop of stiff wire driven by a coiled spring, are the most effective. Dry oatmeal, cheese, sausage (especially "wiener wurst") or buttered toast, make excellent baits.

The United States Department of Agriculture has issued a bulletin dealing with methods of destroying rats from which the following facts are taken:

One of the most effective means of destruction is the use of barium carbonate or barytes. This is a mineral poison without taste or smell and, in small quantities, is harmless to larger animals. Its action is slow and the rodents usually leave a building to seek water and their bodies do not, therefore, decay about the premises and produce the offensive odors which make other poisons so objectionable.

It may be made into a dough, using one-fifth barytes and four-fifths cornmeal, or one-eighth barytes and seven-eighths oatmeal; or it may be spread on bread and butter or moistened toast. The poisoned bait should be dropped into the rat runs in small quantities. If it is not at once effective it should be tried again with another bait.

Strychnine and arsenic are also effective poisons, and the dry powder can be put into sausage, cheese or raw meat; or it may be dissolved in boiling water, with sugar added to kill the bitter taste, and the sirup may then be mixed with oatmeal or poured on bread, or wheat or corn can be soaked in it over night. The objection to strychnine is that it is so virulent that rats die on the premises and their bodies being usually in places where they cannot be easily reached, they decay and produce a very disagreeable odor. Arsenic is not always effective in killing rats. Phosphorus, which is sometimes used, is also ineffective unless made very strong, and it then become dangerous to property because it may ignite and start a fire.

Ferrets and dogs trained to catch rats are often very effective in ridding premises of the pests, but for the person who has no time to train and assist them, they are not usually of great value.

However, the most effective method of dealing with rats is to construct houses, barns and outbuildings so that the rodents can not get into them. The use of concrete for walls and floors, if the walls are put down deeply, will usually keep them out. It is necessary to use a fairly thick layer of concrete and to lay all drains and water pipes in concrete. Ventilators or other openings should be covered with wire netting. The exercise of care in making buildings rat proof at the time of construction will more than repay the additional cost in actual saving of money, to say nothing of the annoyance it obviates.

MUS RATTUS Linnaeus.

BLACK RAT.

Mus rattus Linn., Syst. Nat., ed. 10, p. 61, 1758. Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 127, 1894.

Diagnostic characters.—More slender than the preceding species; tail longer than the head and body together; color bluish black with little or no brown fur.

Range.—This was the common rat of Europe in the early historic times. It was introduced into America at the time of the earliest settlements and thrived for about two centuries, when the larger brown rat appeared and drove it out. This species probably reached Indiana soon after the first permanent settlements were made and it disappeared within a few years after the Norway rat appeared. Mr. Chansler says that it was last seen near Vincennes about 1845. Evermann and Butler say that Dr. Haymond included it in his Franklin County list in 1869, but I understand that he includes it as an exterminated species. Dr. Plummer also says that it disappeared within a few years after the coming of its larger relative.

Recently the species has been found in the State again. An individual,* now in the State Museum at Indianapolis, was taken at New Albany, December 6, 1904. It doubtless reached this place in a shipment of goods from some southern port.

Habits.—The habits of this species are similar to those of the common rat. That is probably the reason the two species cannot exist together and the larger drives out the smaller. This species is said to be less of a nuisance, however, because it is smaller and less aggressive. The black and white rats, often kept as pets and for psychological and bacteriological experiments, are probably derived from this species.

Genus PEROMYSCUS Gloger.

Peromyscus Gloger, Gemein. Hand und Hilfsbuch d. Naturgeschichte, Vol. I, p. 95, 1842 (*Hesperomys* of Baird. *Calomys* of Evermann and Butler.). Osgood, North American Fauna No. 28, 1909.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{0-0}{0-0}$; M, $\frac{3-3}{3-3} = 16$.

Generic characters.—Size and form similar to the house mouse (*Mus*) from which the genus is distinguished by having two rows of tubercles on the molar teeth instead of three and by the white under parts of the body. No other mice recorded from Indiana are apt to be confused with those of the genus *Peromyscus*, although there are genera in the south and west which resemble it. Of these the little harvest mouse (*Reithrodontomys*) may yet be found in the State. It is distinguished by its small size and grooved upper incisors.

The range of this genus is limited to North America and the extreme northern corner of South America. The species are among the most plastic of any mammals known, varying with every change of climate and physical surroundings. More than 150 species and subspecies are known. Three forms are recorded from Indiana and a fourth may sometime be found in the southern part of the State. They may be distinguished by the following key:

Color of both young and adults, bright golden or fulvous.
nuttalli, appendix.

Color of young, dull bluish gray; of adults, fawn color, grayish or brownish.

* This may possibly be a roof rat, *Mus alexandrinus* Geoffroy, often classed as a variety of the black rat. The specimen is stuffed out of proportion and I have had no chance to examine the skull, but it seems to agree perfectly with the black rat in color. The roof rat is common in parts of the southern states and might easily have been carried up the river on a boat.

Adults fawn color, with a very dark dorsal stripe; tail about two inches; skull small. *bairdi*, p. 502.

Adults in fall and winter, bright rusty brown, with a broad median stripe of blackish. *leucopus*, p. 496.

Adults similar, but with the brown more obscured by dusky tipped hairs and the dorsal stripe less distinct. *noveboracensis*, p. 497.

PEROMYSCUS LEUCOPUS (Rafinesque).

WHITE-FOOTED MOUSE; DEER MOUSE; WOOD MOUSE.

Musculus leucopus Rafinesque, Amer. Month. Mag., Vol. III, p. 446, Oct. 1818.

Hesperomys leucopus Baird, Mam. N. Amer., p. 459, 1857.

Calomys americanus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 127.

Peromyscus leucopus Thomas, Ann. and Mag. Nat. Hist., 6th Series, Vol. 16, p. 192, 1895. Osgood, N. Am. Fauna No. 28, p. 113, 1909.

Diagnostic characters.—Somewhat larger than the house mouse and easily distinguished from it by the white under parts, large ears and great protruding eyes; it is less easily distinguished from the other species of white-footed mice.

Description.—Color dark, the middle of the back being very slightly darker than the sides and face; underparts white with a somewhat slaty basal region on the hairs; tail not very densely haired; ears dusky, with a margin of whitish; hairs of ears short.

Measurements.—Osgood gives the following measurements for a specimen from Hickman, Ky.: Total length, 168 mm. (6¾ in.); tail, 73 mm. (3 in.); hind foot, 19 mm. (¾ in.).

Skull and teeth.—As compared with the house mouse, the skull is much larger. Rostrum long and narrow, with its lateral margins nearly parallel; dorsal profile arched; interorbital region constricted; upper incisors narrow. The molars have the tubercles of the crowns arranged in two rows. In old individuals these are apt to be worn down smooth. The skull is slightly smaller than that of the next subspecies.

Range.—As defined by Osgood the range of typical *leucopus* is from southwestern Indiana to Louisiana and from eastern Virginia to Oklahoma. He does not give any positive records from Indiana, but mentions New Harmony specimens as being "doubtful" in position. His selection of a type locality just within the edge of the range of a form which he re-defines, is unusual, and it remains to be seen whether other mammalogists will accept his conclusions.

Inasmuch as the type locality, whether we accept Hickman, Kentucky, which is designated by this author, or the one that has been currently accepted, the pine barrens of Kentucky, is much nearer our boundaries than that of the subspecies, it seems best to include the species in our list.

Habits.—The habits resemble those of the subspecies following.

PEROMYSCUS LEUCOPUS NOVEBORACENSIS (Fischer).

NORTHERN WHITE-FOOTED MOUSE.

Mus sylvaticus noveboracensis Fisher, Synopsis Mammalium, p. 318, 1829.

Peromyscus leucopus noveboracensis Miller, Proc. Bost. Soc. Nat. Hist., Vol. 28, p. 22, 1897. Osgood, N. Am. Fauna No. 28, p. 117, 1909.

Diagnostic characters.—Similar to *P. leucopus,* but slightly larger, less brown in winter and with the dark dorsal stripe lacking or poorly defined.

Description.—Of about fifty mice of this species now before me, from a number of localities in the State and representing all ages and seasons, the brightest colored individual is one taken at Mitchell on October 21, 1906. The color all over the upper part of this specimen is bright, deep fulvous. On the top of the head, neck and back, there are a number of long, coarse black hairs that overlie the others and give a darker tinge, but there is no distinct stripe. Hairs of throat and lips pure white; those of belly, chest and legs, white at the tips and plumbeous at the base, the dark color showing through somewhat.

All other specimens taken in the winter coat have either a fairly distinct dark band down the middle of the back or a suffusion of blackish all over the back. In March and April most individuals are noticeably darker and the darkening continues until in midsummer the predominating tint is dark bluish gray with a suffusion of brownish on the legs and flanks. At this season the color of the dorsal surface closely resembles that of some house mice. This change of color is due, in part, to the wearing away of the brownish tips of the hairs and perhaps in part to a fading of the color. The under surface also becomes grayer in the worn summer pelage, because of the wearing off of the white tips of the hairs.

The young are at first plumbeous all over excepting the belly, the hairs of which are always tipped with white. The flanks first become covered with brownish hairs and this color spreads to the thighs, shoulders and cheeks. At this stage, which is reached shortly before adult size is attained, the animals often have a very sharply defined stripe of plumbeous on the back, bordered on each side by brownish. The bright fulvous color is not usually attained till the approach of winter.

Measurements.—Ten specimens from Mitchell average: Total length, 157.6 mm. (6 5/16 in.); tail, 70.3 mm. (2 12/16 in.); hind foot, 19.1 mm. (11/16 in.). The same measurements for ten specimens from the Kankakee valley are 171.2, 80.3, 20. Average of ten from Knox County, 167, 74, 20; five from Bascom, 159, 75, 19.2.

Skull and teeth.—The skull and teeth are essentially like those of the preceding form.

Range.—The northern white-footed mouse is found from Nova Scotia to Minnesota and south to Virginia and Kentucky. Throughout most of this large area it is the most abundant mammal. In this State it occurs in every county unless specimens from the southern part be considered as belonging to typical *leucopus.*

Habits.—Although the white-footed mouse is one of our most abundant mammals, many people know very little about its habits. One reason is that these mice are nocturnal and do not often show themselves during the day. Often the species is not distinguished from the house mouse in spite of the striking difference in color and proportions.

It also resembles the house mouse in being able to adapt itself to a variety of conditions. The species is equally at home in woods or fields. In the woods the creatures usually make their homes under a decaying log, in a hollow log or in the base of a tree. They also use underground tunnels, and when we see a small, clean-cut hole going down through the moss near the base of a maple or oak, we may feel pretty sure that a white-footed mouse has a home safely hidden among the tangled roots beneath.

In the open fields these mice are not abundant. But they do not at once desert their old habitat when a piece of woodland is cleared. The roots of the stumps are still considered good places in which to make their homes, and if the field becomes overgrown with weeds and bushes, these mice consider it their own especial property and there they thrive and multiply.

The old-fashioned rail fences also make good harboring places for these mice, and rock-piles are regularly tenanted by them. Houses and barns are sometimes entered, especially if situated in the edge of a wood, but this species does not thrive in such close relationship to man as the house mouse does, and has never become a household pest.

Sometimes they enter caves. A colony of these mice has existed in Marengo Cave since its discovery in 1883, but they remain near the entrance, and there is no evidence to show that they have ever become isolated in the cave. Their nocturnal habits would fit them well for taking up a subterranean life, but it is doubtful whether there is ever a food supply in any cave sufficiently constant for the animals to become permanently established.

The adaptability of the white-footed mice is of great advantage to them, and their ability to live in all sorts of places accounts for the fact that they are everywhere one of the most abundant of our small mammals. Under natural conditions their food consists principally of the seeds of various trees, shrubs and other plants. The seeds of the wild plum are almost invariably garnered by them in old pasture fields, and the giant ragweed seeds are also an important item in their diet in such places. In the woods, nuts, acorns and the seeds of the tulip poplar are among the most important articles of food.

Where they come in touch with cultivated crops they are not slow in learning to take a share for themselves. Corn shocks left long in the field, at least if it is near woods or brushy pasture, are sure to be inhabited by some of the mice, and they have a grotesque appearance as they bound away from the uplifted shock with their great eyes protruding, their large ears standing straight, and the tail sticking out stiffly behind.

The white-footed mice make pretty and interesting pets if captured while young. The following observations on the habits of this species, made at Mitchell, are quoted from the author's paper on the vertebrates of the Indiana University Farm. (Proc. U. S. National Museum, Vol. 35, p. 573.)

"A number of white-footed mice were kept in captivity at different times, but they could not be kept together. On one occasion six were caught under corn shocks and were divided equally between two cages. Next morning each cage contained two partially eaten carcasses, while of the survivors in each cage, one died within a few hours and the other a day later.

"A male taken when half grown became so tame that it would eat from my hand. It remained under cover of its box during the day, but toward sunset would leave its retreat and begin to run about the cage looking for food and clambering about, often hanging downward from the roof of the cage. It would not allow me to pick it up, but would voluntarily come to my hand and nibble it or take food from it. Various kinds of food were given it; cheese and dry oatmeal were favorites. Among wild fruits none were eaten so greedily as the berries of the buck-bush (*Symphoricarpos symphoricarpos*). These berries are here the most important single article of diet for these mice in winter and also are eaten extensively by other mammals as well as by birds. Acorns were also readily eaten. Seeds of the redbud (*Cercis*), the wahoo (*Euonymus*), and the bittersweet (*Celastrus*) were eaten only when the articles of food above mentioned were lacking. Seeds of the scarlet sumac (*Rhus glabra*) were rejected entirely.

"A female with three young ate her offspring soon after being put in the cage, but the old one lived for several months. At one time, during my absence, she was without food, but ate the pasteboard box which served her for a home; she must have subsisted on this for at least a week.

"Two were taken about an old pond shortly after a period of exceptionally heavy rainfall. At this time salamander eggs had been deposited in abundance around the edges of ponds and the receding water left many of them stranded on the bank. The stomachs of both of the white-footed mice taken at this place contained some gelatinous matter which I could not positively identify, but which resembled the coating of salamander eggs more closely than any other substance apt to be found in such a place."

The nest is often made in a woodpile, although it is also placed under ground at times. It is composed of bark, small twigs, dry grass or leaves and lined with some kind of soft material. In construction it is very compact and resembles a bird's nest. Not infrequently an old bird's nest is used as a basis, and the mouse merely remodels and covers it.

The young are usually four or five in number, though sometimes as few as two or as many as six. They are naked and helpless when born, but grow rapidly and mature in about three months. Several litters are born each year, though I am unable to say how many.

After all our studies, we really know very little about the life history of our smaller mammals. How long do they live, provided they do not meet a violent death? If any die of old age, how are their last days spent? How are the offspring trained in the matters of food getting and nest building? These are some of the questions still unanswered for most of the smaller species. I have but a single observation on the life cycle of *Peromyscus*. On March 15 at Mitchell I saw a white-footed mouse come out of a woodpile in the bright light of midday and walk slowly and painfully toward a hollow tree which was sometimes inhabited by these animals. I picked it up and it made no attempt either to escape or to bite, but cowered in my hand. It was evidently ill, and I put it in a cage, where it died within an hour. Dissection showed that it was an old male with worn teeth and that its stomach was gorged with food and congested with blood. There was no apparent source of poisoning, and I judge that the animal was attacked by some intestinal disease which acted rapidly and caused death, as it sometimes does in human beings. Epidemics are known to spread among various animals, but there was no evidence of an epidemic among the mice about here where I caught a number during the same month, and the cause of the death was apparently an individual malady.

The habits of these mice are affected in some parts of northern Indiana by the extensive swamps which cover a part of the region. Artificial drainage is rapidly altering conditions, but parts of the Kankakee valley were formerly overflowed to the width of from one to three miles during the spring floods. The white-footed mice inhabit these flooded forests and take refuge in the trees during high water. Their food supply is probably derived from stores which the squirrels have laid up in the hollow trees, with the addition of seeds which find lodgment among the branches, and is perhaps helped out also by tender twigs, buds and bark.

When high water continues for several weeks the supply of food must be very limited indeed, since the animals are restricted to a single tree or to several whose branches touch, because they can not leap from limb to limb like the squirrels. A hunter once told me that while he was eating his lunch, sitting on the trunk of a fallen tree surrounded on either side by a mile or more of water, a mouse came down a tree against which the fallen top rested, and after a number of panicky retreats, at last ventured to come up and nibble at some bread crumbs near the lunch box, which sat on the forks of the tree close to the hunter's legs. The animal was so nearly starved that its customary timidity was forgotten, and it no doubt considered the ample lunch which the hunter left for it as a fair reward for its boldness. Doubtless many mice die of starvation at such times, and some are probably drowned by the floods.

Economic status.—The white-footed mouse can not be considered beneficial from any standpoint, although it does eat a few insects. When it gets into fields of corn or small grain its destructiveness is equalled only by that of the house mouse and rat.

The most effective way of combating these mice is to keep fields and fencerows clean and free from brush and rock-heaps. They seldom live in the clean, smooth pastures or meadows and never live in the cultivated fields unless they can find harboring places of some sort where they can make their homes. They are easily captured in ordinary mouse traps baited with cheese or dry oatmeal and set near the holes leading to their nests.

PEROMYSCUS MANICULATUS BAIRDI (Hoy and Kennicott).

PRAIRIE WHITE-FOOTED MOUSE.

Mus bairdi Hoy and Kennicott in Kennicott, U. S. Patent Office Report for 1856, pp. 92-95, Pl. XI, 1857.

Hesperomys michiganensis Baird, Mam. N. Amer., p. 476, 1857.

Calomys michiganensis Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 139.

Peromyscus michiganensis Allen, Bull. Am. Mus. Nat. Hist., Vol. VIII, p. 238, 1896.

Peromyscus maniculatus bairdi Osgood, N. Am. Fauna No. 28, p. 79, 1909.

Diagnostic characters.—Smaller and bluer (less brownish) than *P. leucopus* and with smaller ears and feet.

Description.—The color differences between *michiganensis* and *leucopus* are not easily described, but they are none the less evident. The duller color seems to be due, in part, to the greater number of plumbeous tipped hairs, in part to the fact that the other color is fawn rather than russet. The dark stripe along the middle of the back is also more plumbeous and this color is continued along the dorsal side of the tail. The tail is more thickly haired than in the common deer mouse and the dark color of the dorsal third is very sharply marked off from the white ventral two-thirds. The hind foot is shorter and more slender, an important character in distinguishing *michiganensis* from young leucopus, as the foot of a young mouse is proportionally larger than that of an adult, and the foot attains the maximum size before the animal is fully adult.

Measurements.—An adult female from Newton County measured 135 mm. (5 6/16 in.) in total length; tail, 60 mm. (2 6/16 in.); hind foot, 15 mm. (10/16 in.). The corresponding measurements of an Ohio County specimen were 137 mm. (5 7/16 in.); 57 mm (2 4/16 in.); 17 mm. (11/16 in.).

Skull and teeth.—The skull is both shorter and more slender than in *P. leucopus,* the incisive foramina are relatively wider, being expanded posteriorly and the audital bullae are relatively wider. The teeth are narrower and the posterior upper molar is relatively smaller; coronoid process of the lower jaw is relatively stronger.

Range.—The range of this species includes part of Ohio, most of Indiana, Illinois and Wisconsin. The limits of its range are not well known. In their list of 1893 Evermann and Butler were unable to give any records of this species for the State, but put it in the list of whose which probably occurred. Since then it has been recorded by the writer from Newton County and by McAtee from Bloomington. I have also taken it at Bascom, Ohio County, and Chansler has taken two specimens at Bicknell, Knox County. Osgood also records it from Denver, Miami County. I know of no other records from the State, but these widely separated localities show that the species is of general occurrence and failure to report it from elsewhere is no doubt due, in part, to the fact that it is often confused with the young of *Peromyscus leucopus,* which it closely resembles.

Habits.—I have never obtained this species anywhere except in the thick bluegrass. Dr. Hoy stated many years ago that it was found only in the oak openings, but he seems to have held an erroneous idea concerning the identity of some of the mice which he collected, and the specimens from the prairies were not dissimilar to those from the open woods as he supposed. Indeed, the species is undoubtedly of prairie origin and it is doubtful whether it occurred in southern Indiana previous to the clearing of the forests.

Very little is known concerning the habits of this species. In general its habits are not dissimilar to those of *P. leucopus* when the latter species lives under the same conditions, as it sometimes does. The prairie white-footed mouse is a more delicate creature and it doubtless has a somewhat more restricted field of activity.

Genus Nyctomys Saussure.

Nyctomys Saussure, Revue et Magasin de Zoologie, 2d Ser., Vol. 12, p. 106, 1860.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{0-0}{0-0}$; M, $\frac{3-3}{3-3}=16$.

Generic characters.—Size somewhat larger than the white-footed mouse, smaller than the house rat; body slender; tail very long; back bright reddish; under parts white.

This genus is indigenous to Mexico, Central America and northern South America, where it is represented by some half a dozen species. Its inclusion in the Indiana fauna is made necessary by reason of its having been twice introduced into the State.

? NYCTOMYS DECOLORUS (True).

"RED RAT."

Sitomys (*Rhipidomys*) *decolorus* True, Proc. U. S. Nat. Museum, Vol. 16, p. 689, 1894.

Description.—Color rich reddish brown above; white on the underparts; tail very similar to the back in color both above and below; a dark ring around the eye; skull with strong supraorbital ridges.

I have no specimen before me as I write and this description is drawn from some hasty notes taken on a specimen in the State Musem at Indianapolis, supplemented by a reference to Dr. True's original description of the species *decolorus.* This specimen was captured in Indianapolis, May 1, 1903. Later in the same year an example of the same species was taken in Bluffton, Indiana, and sent to the National Museum at Washington, where it is retained in the collections as No. 122627. Concerning its identity Dr. M. W. Lyon, Jr., wrote me as follows: "The red rat belongs to the genus *Nyctomys* and may possibly represent the species *decolorus* True. * * * I am not at all sure. There are very few specimens of the genus in Washington, and none of them are authoritatively named excepting the type of *decolorus* which is a young thing and not much good, and a specimen of *sumichrasti.*"

The species *sumichrasti* inhabits the state of Vera Cruz, Mexico, while *decolorus* is from Honduras. How these rats reached Indiana is a mystery. The one from Bluffton was caught in a grocery store and it seems probable that both may have reached here in a shipment of tropical fruit or other merchandise.

The fact that two of these animals should reach the State alive seems to indicate that some care is necessary to prevent the introduction of species of rats and mice which may become established and become a pest. This species is tropical and is not likely to be introduced in numbers sufficiently large to permit acclimatization. However, our experience with the house mouse, house rat, English sparrow and a horde of insect pests is such that we can not afford to take any chances, and strange rodents should be killed off with even greater care than our native kinds. Species of animals transferred from one locality to another often find a niche not occupied by the native fauna, and with the absence of natural enemies they may multiply very rapidly and become a serious pest.

Genus MICROTUS Schrank.

Microtus Schrank, Fauna Boica, Vol. I, 1st Abth., p. 72, 1798. Miller, N. Am. Fauna, No. 12, p. 9.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{0-0}{0-0}$; M, $\frac{3-3}{3-3}=16$.

Generic characters.—Form thickset, with short, heavy legs, the hind pair of which are generally flexed at the ankle joint so that the body is carried close to the ground; head broad and blunt; eyes small, ears concealed by fur; tail always shorter than the body without the head, often much shorter.

The skull is broad, flattened dorsally, and strongly built. The upper incisors are never grooved; lower incisors long, the roots extending along the lower jaw almost to the angle, passing outside the last molar and inside the other two; molars with the enamel folded into loops which extend across the tooth, or triangles which have their bases along the middle line; molars with the bases the same shape of the crowns and not divided into prongs or roots.

The range of the genus includes most of the north temperate zone in both hemispheres. The mice of this genus are known as voles or meadow-mice. About 75 forms are known from North America and of these, four are found in Indiana. The Indiana species belong to three subgenera. They may be distinguished by the following key:

A. Tail short (less than 1 inch); color brownish with dense soft, velvety fur; mammae four; skull flat. (Subgenus *Pitymys*).

B. Ear conspicuous above the fur; color dark rich brown; tail nearly one inch. *auricularis.*

BB. Ear small; color dull brown; tail paler underneath than above. *scalopsoides.*

AA. Tail about an inch and a quarter or longer; fur coarse and grizzled; mammae more than four.

B. Color dark brown, grizzled with black; tail about an inch and three-quarters; mammae eight. (Subgenus *Microtus.*) *pennsylvanicus.*

BB. Color black and white or yellowish in a sort of pepper-and-salt mixture; tail less than one and a half inches; mammae six. (Subgenus *Pedomys*). *ochrogaster*

MICROTUS PENNSYLVANICUS (Ord.).

COMMON VOLE; MEADOW MOUSE.

Mus pennsylvanicus Ord., Guthrie's Geog., 2d Amer. Ed., Vol. II, p. 292, 1815.

Arvicola pennsylvanicus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 127.

Microtus pennsylvanicus Bailey, N. A. Fauna, No. 17, p. 16, 1900.

Diagnostic characters.—This species is distinguished from the other voles found in Indiana by its long tail. It is also of a darker brown color than any other species except *pinetorum.* The latter species has soft, dense fur and tail less than one inch in length.

Description.—The color of the back is dull dark chestnut, duller in winter than summer; under surface silvery gray with more or less of a brown tinge in some individuals; tail and feet about the color of the back or a little paler. The ear is distinctly visible above the fur, but low and rounded as compared with the white-footed and house mice; eyes small and bead-like; fur long and coarse.

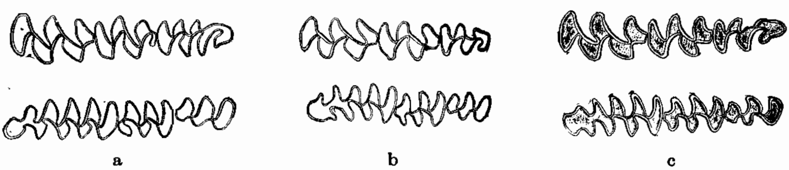


FIG. 8.—Crowns of the molar teeth of *Microtus*: a, Microtus pennsylvanicus; b, Microtus pinetorum; c, Microtus ochrogaster. After Bailey. North American Fauna No. 17, Bureau of the Biol. Surv., U. S. Dept. of Agri.

Measurements.—Ten specimens average: total length, 160 mm. (6 6/16 in.); tail, 42.3 mm. (1 12/16 in.); hind foot, 19.8 mm. (12/16 in.); greatest length of skull, 28 mm.

Skull and teeth.—The skull (fig. 9) is long and rather slender, but with widely spreading zygomatic arches; incisor teeth long, slender, light yellowish brown, projecting well beyond the skull proper. First lower molar (fig. 8a) with an anterior, foliated loop, a posterior transverse loop, and five closed triangles between them.

Range.—From the Atlantic coast to Dakota and from Canada south to the Carolinas. Its range, therefore, includes all of this State, but it can not be found in every locality. Evermann and Butler record it from Franklin, Carroll, Wayne, Vigo and Randolph counties. Other records are, Roselawn, Mountayr, Hebron, South Bend, Wolcottville, Bloomington and Bascom.

Habits.—In this State *Microtus pennsylvanicus* is seldom found at a distance from the marshes and streams and the common vole of most localities is *M. ochrogaster* or *Synaptomys c. stonei.* East of the Alleghenies the distribution is partially reversed and *Synaptomys* is always found in the bogs and swamps while the common meadow mouse, as it is there called, is found in the drier fields as well as the marshy places.

Along the Kankakee River, near Roselawn, I trapped industriously on a grassy sand hill above high water level and caught several species of small mammals, but no voles. Next I went down into an adjoining marsh that is covered with a growth of coarse

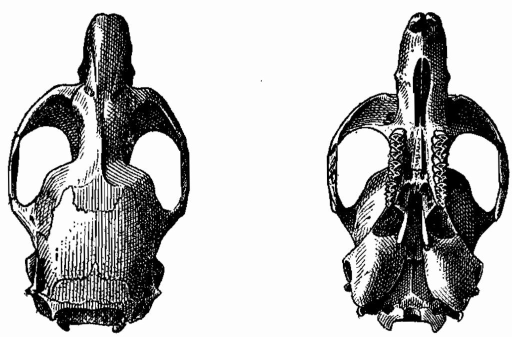


FIG. 9.—Skull of *Microtus pennsylvanicus*: a, dorsal view; b, ventral view. After Bailey. N. Am. Fauna No. 17, Bureau of the Biol. Sur., U. S. Dept. of Agri.

grass in summer, but is flooded with stagnant water during the spring. The grasses there grow up rank and fall down, become coated with a film of mud, and form a dense mat year after year. Under this mat of dead and decaying grass I found runways and caught the Pennsylvania vole in abundance. How do they get along in time of flood? Some retreat to the higher ground, no doubt, but some must be cut off by the water, for they go out into the marsh half a mile from higher ground; and half a mile is a long distance for these clumsy, slow moving little creatures. Are they able to swim out? Do they float down stream till washed ashore accidentally? Do they climb trees, or what becomes of them? These are questions I am not able to answer.

We do know that these mice can swim short distances and do not hesitate to take to water. I have found their runways elsewhere in boggy places, running along under the dry grass for some distance, then going through underground tunnels filled with water, and perhaps leading to a nest under some upraised hummock. I have never found the mice at home in such a place, but there is strong evidence that they do at times occupy nests that can be reached only by swimming through tunnels that are filled with water.

In the southern part of the State, where there are fewer marshes, they often live along the grassy banks that line the smaller streams. They are sometimes found under corn and wheat shocks also, being therefore independent of the swamps; but they are not the most common mice in such situations.

Their food is principally grass blades. In winter when green grass is scarce they can subsist on the dried blades that they find under the snow, although tender green blades are not entirely lacking even then. The grass is cut away in a path just large enough for the animal to pass through comfortably and care is taken that it shall be where the long stems have fallen over so that they form a roof for the runway. These paths are extended nightly and often ramify and reunite in a bewildering maze of endless passages. However, the animals do not depend altogether on elongations of these pathways for their food. Often they find a bunch of particularly juicy grass and there they sit and eat their fill. Usually they are not "clean eaters," but leave sections of the grass blades, either because they are too tough or because it does not seem to the creatures profitable to pick up dropped food when there is so much at hand.

These mice will also eat grains and seeds, as their occasional presence under corn and wheat shocks testifies. However, I have examined the stomachs of a number of individuals, principally in August when both seeds and grass are plentiful, and have found that about 80 per cent of the contents was grass.

Butler and Quick state that this species breeds from February to December and that they never saw more than four young at a time. The only two pregnant females that I have taken contained two and four fetuses respectively. However it is known that six or more young are sometimes produced in a litter. The nest is made of dry grass and is often, though not always, placed underground.

Economic status.—This species is less injurious to farmers in Indiana than either of the other voles or the common white-footed mouse. Its habits of staying about marshy places renders it comparatively harmless both to meadows and to grains and vegetables. However, I know of no way in which it is useful unless it be in destroying a few weed seeds and an occasional insect. When it enters grain fields it may do considerable damage and it is always to be considered a pest that should be suppressed rather than a species to be protected.

MICROTUS OCHROGASTER (Wagner).

PRAIRIE VOLE.

Arvicola ochrogaster Wagner, Suppl. to Schreber's Säugethiere, Vol. III, p. 592, 1843.

Arvicola austerus Le Conte, Proc. Acad. Nat. Sci. Phil., Vol. VI, p. 405, 1853. Baird, Mammals N. Am., p. 539, 1857. Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 121.

Microtus austerus Bailey, N. A. Fauna, No. 17, p. 73, 1900.

Microtus ochrogaster Osgood, Proc. Biol. Soc., Wash., Vol. XX, p. 48, 1907.

Diagnostic characters.—Distinguished from other Indiana voles by the "salt and pepper" color of the fur of the back and the "ochery yellow" tinge which overlies the hair of both back and belly; size medium; tail one to one and a half inches.

Description.—Fur of back plumbeous at base, the long coarse hairs being dark throughout their entire length while the shorter fur is banded with black and gray or buffy. Sometimes the pale band is decidedly brownish and the animal resembles *M. pennsylvanicus* slightly. The sides are paler and the hairs of the belly lack the black bands, but are plumbeous at the base and gray or fulvous at the tips. There is considerable variation in the color and certain specimens from Laporte in the collection of the Field Museum have less of the yellow tinge than most of those from southern Indiana. I am unable to state, however, that these differences are more than individual variations. The tail is slender, the same color as the back above and very nearly white below. Feet pale; a yellowish ring about the eye in most individuals.

Measurements.—Ten specimens from Mitchell average as follows: Total length, 143.6 mm (5 12/16 in.); tail, 35.7 mm. (1 7/16 in.); hind foot, 19.7 mm. (13/16 in.).

Skull and teeth.—The skull (fig. 10) is long, narrow and rounded as compared with other species of *Microtus*. The molars (fig. 8c) have wide spreading, re-entrant angles. The first lower molar has three closed and two open triangles besides a transverse loop at each end; the second has the anterior triangles confluent, followed by two closed triangles and a transverse loop; the third has three transverse loops.

Range.—The prairie vole has a range extending from Oklahoma and Nebraska to Ohio. Its range thus covers the whole of Indiana, though it does not seem to occur everywhere in the northern part of the State. Localities are Laporte, Putnam County, Vigo County, Bloomington, Mitchell, Wheatland, Bicknell, southwestern Knox County, Bascom, Franklin County.

Habits.—This species is the most common vole of the upland fields in southern Indiana. Its habits there are similar to those of its cousin, *Microtus pennsylvanicus,* of the lowlands. I have

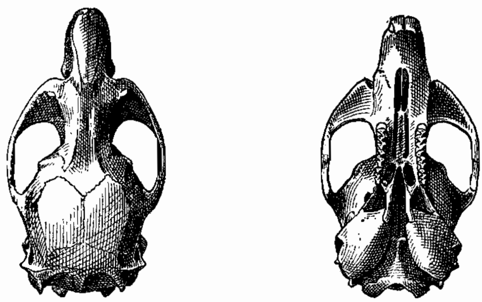


FIG. 10.—Skull of *Microtus ochrogaster*: a, dorsal view; b, ventral view. After Bailey. N. Am. Fauna No. 17, Bureau of the Biol. Sur., U. S. Dept. of Agri.

seldom seen it far from fence rows, old pastures or meadows where the grass grows thick and tall and forms the roof and walls of the runways made by these mice. It is active and feeds principally in the day time, although it also runs about more or less during the night.

From its runways it sometimes extends its activities to fields of grain. It is very fond of wheat when it is just ripening and has an ingenious method of getting at the heads. The stalks are not stiff enough for the mice to climb and interference with other heads prevents the wheat from falling over when the stalk is cut at its base. Therefore, the mice raise themselves on their haunches and cut the stalks as high as they can reach and when the cut end falls to the ground they cut off another section three or four inches long and repeat the process until the head is in reach. This work has been attributed to *M. pennsylvanicus,* and that species may be guilty also, but I have caught the prairie vole near freshly cut stems when none of the other species were to be found in the locality. Wild seeds and berries are eaten also, but the principal food of this species is grass.

The nest is of dry grass and is placed under ground or under a protecting log or rock. One that I found was in a little depression under a discarded railroad tie lying on the side of an embankment. At the time of discovery, about 4 p. m. on April 11, the mother was not at home, and I carefully replaced the tie over the nest containing three hairless and blind young. Early the next morning the old mouse was again absent but about ten o'clock I found her nursing her offspring. She began to run with the young still clinging to her teats, but the whole family was captured. They were confined in a roomy wire cage with plenty of dry grass and cotton for a nest and fresh grass, bread and water for food. Nevertheless, the next morning the cage contained only the mother; she had eaten her children. The old mouse lived only two days longer. She showed a surprising ability to climb, not only going up the sides of the cage, but creeping, fly-like, across its wire top with her claws hooked in the meshes of the wire and her body hanging downward.

The breeding habits are very much like those of *Microtus pennsylvanicus.* I have caught young almost four inches in length on April 2d; they must have been born about the first of March. Pregnant females have also been found in September and the breeding season evidently includes all of the summer months, though I am positive that they do not, as a rule, breed between October and February. Sometimes they mate as soon as the litter of young is born. The period of gestation is short, probably not over three weeks. I have never found more than four young in any litter. Two and three at a birth are quite usual. Miller states that the number of mammae is four, but he evidently erred, for Bailey gives the number as six, and all that I have examined when the mammae were in condition to be distinctly seen, had six. This would seem to indicate that more than four young are sometimes produced at a time.

Economic status.—In the southern part of the State, at least, this species is more destructive to crops than the preceding one, but less so than the following; the white-footed mouse or the house mouse. Its work is confined chiefly to places that can be easily reached from fields or fence rows that are overgrown with grass, weeds and bushes. Therefore, a very effective way of ridding a farm of the mice is to keep it free from rank grass, weeds or bushes. They are easily caught in traps set in their runways and baited with dry oatmeal, nuts, cheese or even bread or grain. Occasionally they damage orchards by stripping the bark from the young trees in winter. However, the prairie vole is not the worst offender in this respect.

MICROTUS PINETORUM AURICULARIS Bailey.

BLUE-GRASS VOLE.

Microtus pinetorum auricularis Bailey, Proc. Biol. Soc. Washington, Vol. XII, p. 90, 1898. N. Am. Fauna, No. 17, p. 65, 1900.

Arvicola pinetorum Evermann and Butler (part), Proc. Ind. Acad. Sci. for 1893, p. 127.

Diagnostic characters.—Distinguished from all the other mice of this family except *Synaptomys* by its short tail (less than one inch). From *Synaptomys* it is distinguished by being brown in color instead of gray, and in having slender upper incisors without grooves down the front.

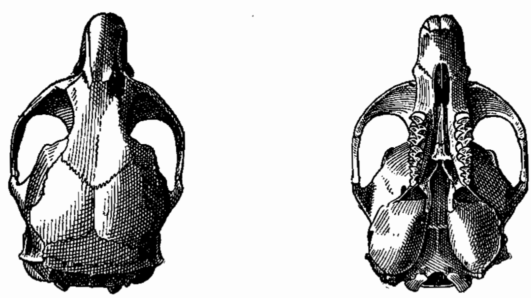
Description.—The chief difficulty in identifying this mouse is in separating it from the next subspecies to which it is closely related and the two forms are therefore compared here, the characters being taken principally from Bailey. Upper parts dull brownish chestnut in *scalopsoides,* not always darker, but always richer and more intense in *auricularis;* tail indistinctly bicolor in *scalopsoides,* being sooty above and grayish below; scarcely darker above than below in *auricularis.* Feet brownish gray in *scalopsoides;* dull brown in *auricularis.* Ears scarcely visible above the fur in *scalopsoides;* distinctly projecting in *auricularis.* Average measurements of *scalopsoides* from the type locality (Long Island, New York), total length, 125 mm.; tail, 20 mm.; hind foot, 16.3 mm.; of *auricularis* from the type locality (Washington, Mississippi), total length, 119 mm.; tail, 22 mm.; hind foot, 17 mm. The skull is also slightly larger and the tooth row longer in *scalopsoides.*

The fur of these mice is soft and velvety and there are no coarse hairs. Their eyes are also smaller than those of the two preceding species, and they are better adapted to the underground life, which they seem to prefer. There are but two pairs of mammae, both in the inguinal region.

Specimens from Bascom, Mitchell and Bicknell have been assigned to the subspecies *auricularis* rather than *scalopsoides,* because their colors are darker and richer and the ears more prominent than on specimens from Maryland, which are assumed to be fairly typical of *scalopsoides.* Bailey in his revision of the genus has assigned some Brookville specimens to each form.

Measurements.—Full grown specimens from Mitchell vary 17 mm. in total length and 2 mm. in length of hind foot. The average of five specimens from this locality is: Total length, 119.2 mm. (4 13/16 in.); tail 18.6 mm. (12/16 in.); hind foot, 15.8 mm. (10/16 in.). Five from Bascom are slightly larger. Cranial measurements of four from Mitchell: Greatest length of skull, 25.8 mm. (1 in.); basilar length, 21.2 mm. (14/16 in.); palatilar length, 12.8 mm. (½ in.); greatest width of braincase, 12.2 mm. (½ in.); depth of braincase over audital bullae, 15.5 mm. (7/16 in.); maxillary tooth row, 6 mm. (¼ in.).

Skull and teeth.—As compared with other species of *Microtus* the skulls of *pinetorum* (fig. 11) and its subspecies are flat and



a b

FIG. 11.—Skull of *Microtus pinetorum*: a, dorsal view; b, ventral view. After Bailey. N. Am. Fauna No. 17, Bureau of the Biol. Sur., U. S. Dept. of Agrri.

wide, with a quadranguar braincase, wide interorbital space and short rostrum. The molars are narrow, the loops and triangles are essentially as in *Microtus ochrogaster,* although they differ in proportions, the most apparent difference being in the posterior upper one. (See fig. 8b.)

Range.—The bluegrass vole occupies the region between the Allegheny Mountains and the Mississippi River south of the Ohio River, and extending north of the latter into southern Indiana and Illinois. Other subspecies are found to the north and east. Indiana records are Brookville, Bascom, Mitchell and Bicknell.

Habits.—As mentioned above, this species lives underground most of the time. Unlike all of the other voles which live almost exclusively in the grass, this one is more abundant in the woods, although found in fields also. Since it lives under ground and is not dependent on the overhanging grass for its protection, it is found in cultivated fields, gardens, orchards, lawns and meadows. In such places it rarely comes to the surface and is difficult to trap, because it closes up an opening made into its burrow instead of coming out to get the bait placed for it.

The tunnels which it makes, like those of the mole, are marked by lines of upheaved earth. How it makes them I do not know, for it has neither the powerful, shovel-like feet nor the pointed nose which so admirably fit the mole for its work. No doubt it sometimes uses tunnels already made by the moles or by the short tailed shrews. However, if it uses the runways of the shrews it does so at the risk of its life, for these fierce little animals run down and kill the mice and devour them greedily.

The mice get even with the order Insectivora, in a measure, by doing immeasurable mischief for which the moles and shrews get the blame. The latter animals are chiefly insectivorous and do good by eating cut-worms, grubs, beetles, flies or any other insects they can get. On the other hand the mice eat roots, bulbs, seeds and bark and are sometimes a serious pest on the farm; but the moles get the blame for eating newly planted corn and garden vegetables which they have not touched.

Young orchards are often badly damaged by these mice, which not only cut or peel the slender roots of the trees, but also strip the bark from the bases of the trunks. I know of a young orchard in which the trees were protected in winter by a heap of coarse manure and stalks about the base. When it was removed in the spring half of the trees were partially or wholly girdled and many of them died. The farmer attributed this to the ferments in the manure, but this was so coarse that I am sure it did no harm, and firmly believe the mice had been working on the trees, their tooth marks being so fine that they were overlooked. It is known certainly that this species has been guilty of similar work elsewhere.

Aside from cultivated plants, the mice of this subgenus live principally on roots. Butler and Quick found them storing up the tuberous roots of the wild violet in underground heaps of a gallon or more. Like the other voles, they are also fond of the stems and leaves of tender green plants. Where their tunnels are in the fields, there is often an opening here and there, with the grass blades near it clipped close to the ground. Sometimes in walking quietly through the woods you may hear a dead leaf rustle as though moved by the wind. If you look quickly and keenly toward it you may distinguish a brown head, set with two tiny, bead-like eyes, disappearing into a hole under the leaves. If you examine the place closely you will probably find the entrance to the labyrinthian tunnels of these mice and very likely you can also find where the animal has been cutting the stem of a green violet or some other tender plant.

The nest is always placed under ground or under an old stump or log and is made of fine, dry grass, root fibers or leaves. All the breeding females that I have seen had two, three or four young, and as they have but four teats the latter number would seem to be the maximum for the species.

Economic status.—This is the most destructive of our native mice and it is the greater pest because it is not often seen and is almost unknown to the farmer. Most often it is the species guilty of throwing up the dirt into the bases of wheat and corn shocks, and coming up through a small, obscure hole to eat the grain. It may not be the only offender in this respect, but it is quite agile in escaping into its runway while the other voles and the white-footed mice often run away on top of the ground.

The injury which this species does in orchards has already been referred to. I have also known them to eat sweet potatoes and white potatoes from the rows, and to follow along corn rows and eat the sprouting grains.

Since they live in cultivated fields and under ground, they can not be driven away by keeping down weeds and grass, although they are not as abundant in a clean field as in one overgrown with weeds and bushes. They can be trapped if some care is taken to find openings which they themselves have made from their tunnels. If the latter are dug open, a trap placed in them is apt to be pushed aside or covered with dirt. Strychnine or arsenic make good poisons, and grain soaked in a sweetened solution of either of these poisons and dropped into holes made in the roof of their tunnels is very effective. Where there are stumps or logs or brush heaps that can be overturned quickly, the mice can often be caught by hand, and clearing a field of such shelters is not without its effect in lessening their numbers.

MICROTUS PINETORUM SCALOPSOIDES (Audubon and Bachman).

MOLE MOUSE.

Arvicola scalopsoides Audubon & Bachman, Proc. Acad. Nat. Sci. of Phil., Vol. I, p. 97, 1841.

Arvicola pinetorum Evermann & Butler (part), Proc. Ind. Acad. Sci. for 1893, p. 127.

Microtus pinetorum scalopsoides Bailey, N. A. Fauna, No. 17, p. 64, 1900.

(For diagnosis, description and measurements see the preceding species.)

Range.—This subspecies extends from southern New York to Illinois, with a more northern range than the preceding. Indiana localities are: Terre Haute, Brookville, Randolph County, Wabash County. The last two records are from Evermann and Butler, and are assigned to this subspecies for geographic reasons. I have never taken these mice in the northern part of the State, and have no measurements of my own.

Remarks.—Admitting two subspecies of this group of mice to the Indiana fauna is made necessary by Bailey who, in his revision of the genus, records the two forms from Brookville. Such a procedure may be necessary to the systematist who wishes to assign all of his specimens to one form or another, and at the same time be consistent in observing the characters which define the forms; but it is wholly at variance with the true conception of species and subspecies. If subspecies are to be considered as all derived from an ancestral form by a process of variation, the variations becoming fixed by climatic or other direct influences, or geographic isolation, it is unthinkable that two of these subspecies should be found in the same locality. It is conceivable, of course, that where they intergrade there should be a neutral zone in which some individuals should be like one and some like the other subspecies, but these are all neutrals or else the forms do not intergrade and hence are not subspecies. The Linnaean system of nomenclature is inadequate to express such relations.

It should be stated that the same differences which Bailey recognized in Brookville specimens are to be seen in those collected at Mitchell. Number 150, author's collection, is small and of a rich glossy brown color as found in *auricularis*. Number 259 is decidedly larger and duller as in *scalopsoides,* and there are other specimens showing the same differences.

Habits.—The habits are not known to differ materially from the other form.

Genus Fiber Cuvier.

Fiber Cuvier, Lefons d'anat. comp., Vol. I, tabl. 1, 1800.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{0-0}{0-0}$; M, $\frac{3-3}{3-3}=16$.

Generic characters.—Distinguished from all other members of the family by the large size and long tail, which is laterally flattened. The skull and teeth resemble those of some of the larger species of *Microtus,* but the molars are rooted.

The genus is limited to North America, and extends from northern Mexico to Labrador and Alaska. About ten species and subspecies are now recognized. Only one of these occurs in Indiana.

FIBER ZIBETHICUS (Linnaeus).

MUSKRAT.

[*Castor*] *zibethicus* Linn., Syst. Nat. Ed. 12, Vol. I, p. 79, 1766.

[*Fiber*] *zibethicus* Cuvier, Règne Animal, Vol. I, p. 192, 1817.

Fiber zibethicus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 126.

Diagnostic characters.—Those of the genus.

Description.—Fur of two kinds, an overfur of long, moderately coarse hairs, and a dense underfur of wooly hairs. The color is dark glossy brown above, with the sides tinged with yellowish and belly dirty, yellowish white; upper lip yellowish. Hind feet very broad, with the toes joined together by a web; ankle joint so constructed that the feet can be turned edgewise during the forward stroke of the foot in swimming.

The whole structure is a very perfect adaptation to aquatic life. The tail acts as a rudder in the water; the feet make very effective propellers; and the fur is a water-proof covering through which no moisture penetrates.

Measurements.—An adult female from the Kankakee near Hebron measured 640 mm. (25 10/16 in.) in total length; tail, 290 mm. (11 10/16 in.); hind foot, 75 mm. (3 in.).

Skull and teeth.—The skull resembles that of the species of *Microtus* in general appearance but, of course, is much larger, The braincase is quadrangular as in *M. pinetorum,* but is not so flat and the rostrum is proportionally longer. The roots of the lower incisors are outside the roots of the molars.

Range.—The typical form is found from southern Canada to southern Virginia and the Gulf States and west to at least the Rocky Mountains. It is found in this State wherever there are suitable bodies of water.

Habits.—It seems to me the word "versatile" is appropriate in describing the habits of this animal. With habits in the primeval state essentially like those of the beaver, the muskrat has thrived and multiplied with the settlement of the country, whereas the beaver disappeared early before advancing civilization.

Although the valuable fur of the beaver aroused the greed of man to a greater extent than the more humble coat of the muskrat, the latter animal has been trapped, shot and otherwise persecuted almost incessantly. Nevertheless he has profited by the destruction of his natural enemies and he has taken advantage of artificial ponds and canals to extend his habitat. He has even been able to maintain a somewhat precarious existence along the streams within the limits of the larger cities. In his quest for food, he sometimes follows cellar drains and reaches the winter supply of vegetables, thereby putting himself on a par with his despicable cousin, the house rat. But it must be said that such offenses are infrequent.

Where they have an extensive tract of water and are not too much disturbed, the muskrats build houses similar to those of the beaver. Mr. Butler has given the following description of one which was built on a marshy peninsula projecting into a stream near Brookville. "The house was composed chiefly of swamp grass, sedge, coarse weeds and mud, while fresh water algae, small pieces of drift, a few pieces of shingle and two staves were found among the more common material. The greater part of the mud was in the lower part of the house, and I think it was mostly brought in attached to the roots of grass. The ground in the neighborhood of the house was cleared of all vegetation, even of roots, for some distance. The house was nicely thatched with weeds and sedge.

"The ground plan was oval in outline, four feet six inches wide and six feet three inches long. On the land side the house was two feet six inches high, and on the water side three feet four inches. The whole presented the appearance, in miniature, of an oblong hay rick. The inside was quite irregular. Measurements at the bottom of the chamber showed the greatest length to be 22 inches, the least 12 inches, with an average width of 16 inches. The greatest height, measuring from the surface of the stream, was one foot. Six inches from the bottom, a shelf was found running from the left of the entrance and above the top of the water. This shelf was 12 inches long and eight inches wide, and ranged from six to eight inches in height. It was arched over very neatly with drift and coarse weeds. At a point farthest from the center of the chamber, immediately over the shelf, was a passage leading upward toward the side of the house. While it did not penetrate the wall, it passed through the more compact portion and enabled the inmates to obtain air. Entrace was had through a covered way, from and beneath the water to the center of the house, where it terminated in a mass of fine grass and mud, through which there was a funnel-shaped opening to the interior.

"This house was completely destroyed, and within a week the muskrats had erected a new one on the site of the old, similar to it but nearly twice as large, using the material of the old and clearing off the vegetation from a much larger space."

Where the muskrats live in thickly populated localities or along small streams they do not build houses, but make burrows beneath the water and there is also a vertical hole in the bank that leads down to the nest and supplies air to the inmate. The burrows sometimes extend back for many feet and the nest is generally placed about the high-water level of the stream.

Usually there is a place not far from the nest where the animals are in the habit of climbing the bank to search for food and where they return to the water. Trappers take advantage of these smoothly worn "slides" to set their traps. For, while it can not be said that the muskrat shows much ingenuity in avoiding traps, the uninitiated is very apt to meet with failure the first time he attempts to catch one. The animals do not often stumble blindly into a trap set on the bank, and if one does get caught in a steel trap so located, his first act is to brace himself with all his might and pull to get free. If the trap is weak and the animal full grown he may succeed. If not, he usually continues struggling and biting until he has either broken his foot off or else he bites it off below the jaws of the trap, where it is numbed by their pressure, and pulls out the stump and so escapes.

Accordingly experienced trappers place a steel trap in the water at the bottom of a "slide," where the unwary "rats" get in readily, and the chain is fastened by a stake set in deep water, so that the animal cannot get on the bank, and it is soon drowned by the weight of the trap. The "rats" are also speared in the houses during the winter.

Trapping muskrats for fur has been an important source of revenue to many men, especially in the marshes along the Kankakee River. A trapper who went to the Kankakee country in 1865 told me that at that time muskrat houses stood so thickly in some places that it was possible to open three or four of their houses from an anchored boat. Mr. I. N. Lamb states that in 1871, after the Kankakee valley burned off, he sometimes caught more than eighty muskrats in a single night in his line of 100 steel traps. In the history of Lake County it is stated that the annual catch in that county alone, varied between 20,000 and 40,000 during all of the period from 1834 to 1884. In the Northwest territories of Canada, according to Macfarlane, more than 768,000 skins were taken by the Hudson's Bay Company in 1873, while in 1903 the number had reached 1,482,670.

In spite of this tremendous slaughter the species holds its own fairly well except where the habitat is reduced by drainage or where disease becomes prevalent, as it sometimes does. As recently as 1904 one trapper I know claims to have caught 300 "rats" in 30 days, trapping in the Kankakee in Newton and Lake counties. The same season another trapper took 700 of the animals during the fall and winter in Porter and Jasper counties. The average price of the skins is about 15 cents, the price varying in different years, and being higher for late winter than for fall skins.

The food of muskrats is quite varied. During the summer it consists principally of marsh grasses and other aquatic plants. When these become scarce in winter, the animals turn to any vegetable food at hand, and gardens and cornfields near their homes may suffer in consequence. At such times they also resort to animal food, and the fresh water mussels are often eaten. The shells can be cut with the powerful incisors of the rodents, and it is said that they have also learned to carry mussels out of the water and lay them on the bank, where they die and are then opened easily with the paws.

Butler states that the number of young is usually from four to six, but Macfarlane says that from eight to twenty are produced at a time in Canada. The adult females usually produce three litters a year, the young being brought forth between March and September in grass-lined nests in the tunnels that lead into the banks of the streams.

Economic status.—As shown above, the muskrat may be a source of income to a considerable number of people. If the figures given above for Lake County are correct, the residents of that county made four or five thousand dollars annually from the muskrat hides in the fifty years preceding 1884.

The injury which these animals do to crops is negligible, since their aquatic habits usually keep them from cultivated fields. However, they sometimes do considerable damage to ditches, ponds and railway embankments near the water by digging into the banks. These holes are enlarged by action of the water, especially if there is a current, and they may cause the embankment to break. Mr. Butler states that a trench of gravel through the bank or a dressing of gravel or cinders on the surface of the embankment will keep the animals from digging into them, and keeping them free from vegetation also keep the rodents away. They are sometimes supposed to destroy fish, but this is seldom or never the case.

If they become troublesome, they are easily caught in traps by the method previously described. It is also easy to poison them with apple, turnip or cabbage poisoned with strychnine and dropped near their dens.

Genus SYNAPTOMYS Baird.

Synaptomys Baird, Mamm. N. America, p. 558, 1857.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{0-0}{0-0}$; M, $\frac{3-3}{3-3}=16$.

Generic characters.—Form like that of *Microtus,* the tail being shorter than in most species of that genus. Upper incisor broad, with distinct grooves down their anterior faces; lower incisors with the roots inside the molars; molars rootless (without prongs);

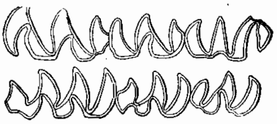


FIG. 12.—Enamel pattern of molar teeth of Synaptomys: a, upper molars; b, lower molars. After Miller. N. Am. Fauna No. 12, Bureau of the Biol. Sur., U. S. Dept. of Agri.

the posterior upper one with four transverse loops differs markedly from the corresponding tooth in any species of *Microtus.* (See fig. 12.)

The genus is limited to North America north of the gulf states. About ten species and subspecies are known, only one of which is found in our State.

SYNAPTOMYS COOPERI STONEI (Rhoads).

THE STONE LEMMING MOUSE.

Synaptomys stonei Rhoads, Amer. Nat., Vol. 27, p. 53, 1893.

Synaptomys cooperi Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 126.

Synaptomys cooperi stonei Rhoads, Proc. Acad. Nat. Sci. Phil. 1897, pp. 305, 392. Hahn, Proc. U. S. Nat. Mus., Vol. 32, p. 460, 1907.

Diagnostic characters.—Color above, brownish gray; form squat and heavy; tail less than one inch; upper incisors grooved.

Description.—The shade of color varies considerably. In individuals in summer pelage the color is decidedly rusty, the short fur of the back being all tipped with ferruginous, which the long overfur partly conceals. The winter specimens usually are paler, the tips of the short fur being cinnamon or fulvous. The sides are paler and the belly is pale slate color, with the plumbeous bases of the hairs showing through more or less. Throat and underlip of some individuals white, of others slate.

The status of the various names that have been given to different forms of *Synaptomys,* and the relationships of these forms has not been satisfactorily determined. The history of some of these names, together with reasons for adopting *stonei* as the name for the Indiana form of the lemming mouse, has been given by the author (Proc. U. S. Nat. Mus., Vol. 32, pp. 460-461), and he has seen no reason to change his conclusions. Since that time he has collected lemming mice on the Missouri River in South Dakota, which are apparently the form *gossi* and differ markedly from the Indiana specimens in being much larger and clumsier, with larger and heavier skull.

Measurements.—Ten specimens from Mitchell averaged 113.2 mm. (4 8/16 in.) in total length; tail, 18.5 mm. (12/16 in.); hind foot, 17.2 mm. (11/16 in.); ear from crown, 9 mm. (6/16 in.). Three from Wolcottville, Lagrange County, average, total length, 114.3 mm.; tail, 20 mm.; hind foot, 16.3 mm.

Skull and teeth.—The skull of the Indiana *Synaptomys* is intermediate in size between that of the typical species (*cooperi*) from the east and that of the species *gossi* from the plains region. The general features of the skull are given under the diagnosis of the genus. Average measurements of ten skulls from Mitchell are: Greatest length, 26 mm.; palatilar length, 12 mm.; greatest width of braincase, 12 mm.; depth of braincase over bullae, 9.6 mm; length of molar tooth row, 6.8 mm.

Range.—From southern New Jersey to Indiana; the limits of the range are not known. In this state it seems to be of common occurence in all sections. Records are: Roselawn, Hebron, Wolcottville, Nashville, Brookville, Bascom, Bloomington, Mitchell.

Habits.—East of the Alleghenies the lemming mice are found only in sphagnum bogs and swamps. In Indiana I have but a single specimen recorded from a swamp. That one was taken in a tamarack swamp near the Lagrange-Noble County line east of Wolcotville.

At other places they seem to be confined to areas covered with dense blue grass. Their habits there are similar to those of the prairie vole and the two species are often found together; whether they live in harmony I do not know. Butler and Quick say of it that it prefers open woods pastures where there is little undergrowth. They state that it is the most active of our mice and is off like a flash if disturbed when under cover.

These authors are mistaken in saying that the nest is always placed under cover. I have found a conical nest ten inches in diameter and five inches high placed on the ground with no covering except a very thin veil of dry grass blades. It was inconspicuous, however, for it was made of moss and grass and placed in a hummocky place among some sumach bushes. The lining was of fine, dry grass.

Inside were four little mice about two and one-half inches long, with open eyes and body fully covered with hair. I took them to the house, made a warm nest for them and began to feed them milk with a pipette. They seemed to thrive for two days, then all died suddenly. An old mouse, apparently their mother, was caught at the site of the nest. She would have given birth to five more young in a week or ten days. The usual number of young at a birth seems to be four, but three and five are not infrequent.

These mice live on grass more exclusively than any other species that I know. However, they sometimes eat seeds and roots, and like some species of *Microtus*, sometimes store up supplies in the winter. Butler and Quick state that they sometimes store up large quantities of the roots of the wild artichoke (*Helianthus*).

Economic status.—No doubt this species, like all other members of the family, sometimes does damage to grain and vegetables. But of this I have no direct evidence, for I have never caught the species in cultivated fields nor do I know that it has ever been taken in such places.

Family GEOMYIDAE.

POCKET GOPHERS.

Form adapted for underground life, with short, strong legs, front feet armed with powerful claws, hind feet also strong, tail short, ears and eyes small, and incisors long and strong. The skin of the cheeks is folded inward, forming pouches which reach from the mouth to the shoulder inside of the outer skin, the opening of these pouches being outside of the mouth.

The family is limited to North America, where it is represented by several genera and a number of species. A single genus is found east of the Mississippi.

Genus Geomys Rafinesque.

POCKET GOPHERS.

Geomys Rafinesque, Am. Month. Mag., Vol. II, No. 1, p. 45, 1817.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{1-1}{1-1}$; M, $\frac{3-3}{3-3} = 20$.

Generic characters.—Upper incisors, with two grooves, a small one near the inner or midle edge of the front and a deeper one near the middle. Premolar in each jaw with a constriction which makes the enamel pattern the shape of a flattened figure 8. Other molars simple and without any marked constrictions or folds. Skull with a triangular braincase and prominent processes (mastoid processes of the squamosal and bulla) for the attachment of the muscles used in mastication; region between the eyes constricted; rostrum long and subcylindrical.

Form short and stout; eyes and ears small; tail short; nearly naked and extremely sensitive to touch. Claws of fore feet extraordinarily long and strong. Large pouches opening beside the mouth into the cheeks.

The genus contains about 15 species and subspecies in the plains region of the United States and Canada, and with two or three isolated forms in Georgia and neighboring States. But one species is found in the central states east of the Mississippi.

GEOMYS BURSARIUS (Shaw).

EASTERN POCKET GOPHER.

Mus bursarius Shaw, Trans. Linn. Soc. of London, Vol. 5, pp. 227-228 and Pl. 5, 1800.

Geomys bursarius Merriam, N. Am. Fauna, No. 8, p. 120, 1895. Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 126, *Diagnostic characters.*—The generic characters distinguish the species from all other mammals found in the State.

Description.—The color is described by Merriam as "dark liver brown or chestnut above and below, somewhat paler on the belly; fore feet white; hind feet soiled white; hairs of tail usually brown on basal part and white on terminal part." The form is indicated by the generic description.

Measurements.—Dr. Merriam gives the following measurements as the average of 68 specimens: Total length, 274 mm. (11 in.); tail, 76 mm. (3 in.); hind foot, 33 mm. (1 5/16 in.). No measurements of Indiana specimens are at hand.

The skull and teeth are sufficiently characterized under the description of the genus.

Range.—From the Canadian border in North Dakota to southeastern Missouri and east to northwestern Indiana. Indiana marks the eastern limit of its range, and it is not generally distributed in this State. I have never collected it in Indiana nor do I know of any specimens from this State in collections, but there is no doubt of its occurrence in Lake and Newton counties. The only definite records I have are Shelby, Lake County, and Lake Village, Newton County.

Habits.—The gophers are burrowing animals and spend all of their time underground excepting in late summer and autumn, when they are said to sometimes wander about in search of new locations. The mole thrusts its pointed nose into the earth and heaves upward, at the same time thrusting his broad front feet forward and pushing to one side. In this way he lifts the dirt upward all along his path, and is saved the trouble of carrying it. But the gopher laboriously breaks the dirt loose with his powerful incisors and claws and, when he has accumulated a heap, places himself behind it, making a scoop of his forelimbs, and pushes it along the already completed part of his tunnel to an opening and there heaves it up to the surface. The work is very rapid, however. These gopher hills sometimes contain a bushel or more of earth and they are the only indications we have of the presence of the animals; they leave no mark along their pathway as the moles do.

In his work of excavating, the gopher moves back and forth in his tunnel like a shuttle engine, without turning around. The tail serves as an organ of touch in the backward progression, being rather short and fleshy, and is carried straight behind the animal.

In some text-books of zoology we find it stated that the pouches are filled with earth which is thus carried out to the surface and emptied. According to the observations of Merriam and Schaeffer, this statement is erroneous, and the dirt is always moved by placing the fore legs behind it and pushing with the hind legs.

The cheek pouches differ from those of the ground squirrels in opening outside of the mouth and in being lined with fur on the inside. Their only use is for carrying food to the store houses, which always contain a larger supply than the animal can possibly use. The pouches can be turned wrong side out without injury, and it is said that they are sometimes thus everted when the animals are frightened by a snake.

Dr. Merriam thus describes the way in which the pouches are filled and emptied: "A piece of potato, root or other food is seized between the incisor teeth, and is immediately transferred to the fore paws which are held in a horizontal position, the tips of the claws curving toward one another. If the food requires reduction in size, the trimming is done while held in this position. The piece is then passed rapidly across the face with a sort of wiping motion which forces it into the open mouth of the pouch. Sometimes a single rapid stroke with one hand is sufficient; at other times both hands are used, particularly if the piece is large. In such cases the long claws of the one hand are used to draw down the opening, while the food is poked in with the other. It is obviously impossible for the animal to pass food from the mouth to the pouches without the aid of its fore claws.

"The most remarkable thing connected with the use of the pouches is the way in which they are emptied. The fore feet are brought back simultaneously along the sides of the head until they reach a point opposite the hinder end of the pouches; they are then pressed firmly against the head and carried rapidly forward. In this way the contents of the pouches are promptly dumped in front of the animal. Sometimes several strokes are necessary. I am not prepared to say that the animal can not empty the pouches by means of the delicate investing muscles, but I have never seen them emptied in any other way than that here described."

The food consists almost wholly of roots of various kinds. In their native state, the gophers live almost wholly on the roots of the prairie grasses and other prairie plants. With the introduction of cultivated plants into their range they have found many of them more desirable food. Potatoes and garden vegetables are often eaten. Roots of fruit and other trees are sometimes cut off to such an extent as to almost destroy an orchard. But the food which they consider peculiarly fitted for themselves is the large, succulent roots of the alfalfa.

Pocket gophers apparently breed but once a year, the young being born in March and April. There are usually three or four in a litter, but there may be as many as six. They are born in a nest of fine grass placed in a lateral passage of the main burrow, and do not reach maturity till the end of the summer, when they begin to shift for themselves.

Economic status.—In this State the pocket gophers are too rare to do much harm. But in many localities farther west they have caused serious losses to farmers, gardeners and fruit growers. They can be caught in small steel traps placed in the bottom of their tunnels, or in special gopher traps. The animals always close every hole through which light enters and a small opening near the trap takes the place of bait. They can also be poisoned with strychnine placed in potato or dried fruit and dropped through a small opening into the tunnel.

Family ZAPODIDAE.

JUMPING MICE.

Dipodidae Flower and Lydekker, Introduction to the Study of Mammals, pp. 479-480, 1891. Miller and Rehn, Proc. Bost. Soc. Nat. Hist., Vol. 30, p. 166.

Zapodidae Lyon, Proc. U. S. Nat. Mus., Vol. 23, pp. 659-668.

Hind feet much elongated; metatarsal bones five in number and separate (not united into a cannon bone); no cheek pouches; tail very long.

The family is not easily confused with any other American rodents. The kangaroo rats, which resemble the jumping mice in form and inhabit southwestern North America, are distinguished by the presence of external cheek pouches like those of the pocket gophers. This family is distinguished from some of the old world jumping mice by a number of osteological characters.

Genus Zapus Coues.

Zapus Coues, Bull. U. S. Geol. Surv., Terr., Vol. I, 2d Ser., No. 5, p. 253, 1875. Preble, N. Amer. Fauna, No. 15, 1899.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{1-1}{0-0}$; M, $\frac{3-3}{3-3}=18$.

Generic characters.—Upper incisors with grooves on their anterior faces; deep orange in color; premolar small and cylindrical; molars with somewhat complicated and crowded folds of enamel.

Skull (fig. 13) rather high and rounded, similar in shape to the skull of the house mouse except that it is more arched in the interorbital region. Body largest posteriorly. Hind legs and tail very long.

About 18 species and subspecies are known from North America and at least one is found in China. A single form occurs in Indiana.

ZAPUS HUDSONIUS (Zimmerman).

HUDSON BAY JUMPING MOUSE.

Dipus hudsonius Zimmermann, Geog. Geschichte, Vol. II, p. 358, 1780.

Zapus hudsonius Coues, Bull. U. S. Geol. Surv. Terr., 2d Ser., No. 5, p. 253, 1875.

Zapus hudsonicus Evermann and Butler, Proc. Ind. Acad. Sci- for 1893, p. 125.

Diagnostic characters.—Size of body approximately that of the house mouse; hind feet and tail very much longer; color a bright yellowish, not unlike that of the white-footed mouse in winter pelage.

Description.—The upper parts are yellowish fawn color or dark ochraceous and this is overlaid by a number of long hairs with darker tips. In a line down the middle of the back, these dark tips predominate and form a dark stripe reaching from the head to the base of the tail. This dark stripe is not so distinct in the fall and early winter. The belly and feet white or slightly yellowish.

Measurements.—Measurements of Indiana specimens are not at hand. Preble, in his revision of the genus, gives the following measurements as the average of eleven specimens from Tower, Minnesota: Total length, 219 mm. (8 12/16 in.); tail, 133 mm. (5 5/16 in.); hind foot, 30.2 mm. (1 3/16 in.).

Skull and teeth.—The cranial characters given for the genus serve to distinguish the skull (fig. 13) of this species from all other Indiana mammals.

Range.—From Hudson's Bay to southern Indiana and Maryland. It is probable that the jumping mice in this State are intermediate between *hudsonius* and its subspecies *americanus,* but as Mr. Preble records a specimen from Terre Haute as the typical form they may all be considered as belonging to it.

Other Indiana records are: Roselawn, Albion, Lagrange County, Winona Lake, Wabash County, Starke County, Carroll County, Howard County, Richmond, Bicknell, New Harmony.

Habits.—As the above records show, the jumping mouse is to be found in every section of the State, yet it is nowhere abundant. The writer spent the first twenty years of his life on a farm in southeastern Indiana, where he was familiar with most of the animals, yet he never saw a jumping mouse. Later, in collecting more than 300 small mammals in the State, but one jumping mouse has been obtained through his personal efforts. This is in accord with the experience of most other naturalists, although a number of specimens may sometimes be obtained in one season where they had not previously been seen. They are said to be most easily captured in some localities by following the mower as the grass of a low meadow is being cut.

Prof. W. B. Van Gorder writes of its occurrence in Noble County: "In Albion Township in 1895 I took the first jumping mouse I ever saw. In 1907 I saw another, and in 1908, while watching for birds in a willow swamp four of them (jumping mice) came to my notice only a few feet away. They were playing and running about and were very sportive and interesting, when all at once they bounded away like so many little kangaroos."

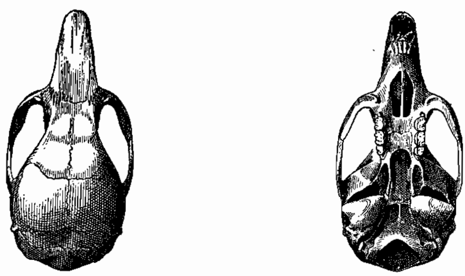


FIG. 13.—Skull of *Zapus hudsonius*: a, dorsal view; b, ventral view. After Preble. N. Am. Fauna No. 15, Bureau of the Biol. Sur., U. S. Dept. of Agri.

When frightened these mice make great leaps, apparently going aimlessly and depending on their extraordinary appearance and movements to startle and discomfit their enemies. They can leap six or eight feet and, according to some writers, much farther. Because of this method of locomotion they do not make runways under the grass like most small terrestrial mammals.

The nest is made of grass and is globular in shape, being usually placed in damp meadows above ground, but sometimes it is underground. The young are usually five or six in number and are born in May or June.

These mice are said to have an unusually long period of hiber nation, sometimes remaining dormant until May, although they have also been seen running about during mild winters. Mr. Chansler found one in midwinter near Bicknell, hibernating in an underground nest on a side hill near some damp woods. It seemed very stupid and inactive, but ran about some when dug out.

Their food is said to consist principally of the seeds of grass and weeds.

The rarity of the species makes it unimportant from an economic standpoint.

Family ERETHIZONTIDAE.

PORCUPINES.

Rodents with stiff, pointed quills mixed with the fur; feet plantigrade; toes four in front and five behind; molars rooted, four on each side of both the upper and lower jaw.

Porcupines are aften confused, in the popular mind, with hedgehogs. The latter, however, belong to the order *Insectivora* and are therefore related to the moles and shrews and are limited to the old world. The porcupines, on the other hand, belong with the squirrels, mice, rabbits and other representatives of the *Glires* or gnawing animals.

The American porcupines belong to a family distinct from those of the old world. They differ from the latter in lacking a thumb, in having complete clavicles and in several other anatomical details.

Genus Erethizon F. Cuvier.

Erethizon F. Cuvier, Mem. mus. d'hist. nat. Paris, Vol. IX, p. 426, 1822.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{0-0}{0-0}$; M, $\frac{4-4}{4-4} = 20$.

Generic characters.—Tail short, thick and not prehensile; form stout and clumsy; quills not equalling the hair in length.

This genus is confined to northern North America, where it lives chiefly in the forests. Two species, each with several subspecies, are recognized. Only one is native to the eastern United States, and it is now extinct in Indiana.

ERETHIZON DORSATUM (Linnaeus).

[*Hystrix*] *dorsata* Linn., Syst. Nat., Ed. 10, Vol. I, p. 57, 1758.
Erethizon dorsatus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 125.

Diagnostic characters.—Those of the family and genus.

Description.—Color dark brown or blackish; quills tipped with yellowish white, two to four inches long and partly concealed by the dark colored hair. The quills are most numerous and longest on the back and are short on the tail, head and limbs, and lacking on the underparts. They usually lie fairly close to the skin and, with the hairs, point backward, but can be erected by muscular contraction.

Measurements.—The following measurements are given by Miller, none being available for Indiana specimens: Total length, 700 mm. (28 in.); tail, 200 mm. (8 in.); hind foot, 90 mm. (3½ in.).

Skull and teeth.—The skull bears a slight superficial resemblance to that of the woodchuck (*Arctomys*) from which it differs in many details, however, and the animals are not closely related. The porcupine skull lacks the post-orbital process possessed by the woodchuck. In the latter animal the rostrum is flat dorsally and squarish in outline. The porcupine skull has a very deep rostrum which is arched upward beyond the level of the braincase and is rounded both dorsally and ventrally. The lower jaw is rounded laterally. The incisors are thick and rounded. The crowns of the molars are characterized by isolated islands of enamel which do not connect with the external ring of enamel.

Range.—Eastern Canada and the northern United States as far south as southern Indiana. Mammalogists who have stated that the range of the porcupine is limited to the Canadian zone are in error, as Wied includes it in his list of mammals from New Harmony in the lower austral zone.

It was once to be found throughout Indiana, but there is probably not a single individual living within the boundaries of the State at the present time. The following is a summary of our knowledge of its occurrence in the State: The Prince of Wied states that it was rare at New Harmony at the time of his visit in 1832-1833. Dr. John T. Plummer wrote in 1844 that it had been killed in the suburbs of Richmond "in the last few years." Mr. Cicero Sims states that they were once numerous in Miami County. Prof. Van Gorder says of it in Noble County: "In 1854 my father killed the only porcupine he had ever seen. The animals were not abundant, as was learned from various sources. The dog jumped on this one with the evident intention of tearing it to pieces at once, but immediately relinquished his grasp." In the course of several years' trapping along the Kankakee about 1870, Mr. I. N. Lamb saw but one porcupine. Two specimens in the State Museum are said to have been taken in Laporte County not many years ago. Mr. Chansler says that a number of old settlers have spoken of it as being common in Knox and Daviess counties in the period previous to 1836. The last record for that region is 1864, when F. F. Chambers saw one near Chambers' pond in Knox County.

Evermann and Butler give the following records: Lafayette, about 1882; Franklin County, date not stated; Lagrange County, 1860-1870; Huntington County, about 1885; Randolph County, about 1875; Grant County, 1892. The last is the latest authentic record I know for the State, although it probably survived along the Kankakee a few years later.

Habits.—The porcupine is a good example of a species over-specialized for a certain mode of life. In his native woods he was sometimes attacked by lynxes, panthers and perhaps wolves, when these animals were driven to desperation by extreme hunger. But even these fierce creatures often paid the penalty of their greed with their lives. For although the porcupine is an unresisting foe, has armature is dangerous to any captor, and the sharp, barbed quills work their way deeper into the flesh and sometimes penetrate the vital organs. The quills can not be shot out from the animal like arrows, as some people suppose, but they have very sharp, barbed points so that the slightest touch is sufficient to get them into the flesh. Being loosely attached to the animal, they are pulled away, and the barbs prevent their ready extraction and cause them to work deeper into the flesh with every movement of the muscles.

The food of the porcupine is the bark, buds and twigs of trees, and hence there is always an abundant supply in the forests where these animals make their homes. They are active principally at night, and during the day sleep in a hollow log or a hole among the rocks with their spiny backs towards the entrance. They do not hibernate for the entire winter, but remain in their dens during bad weather, apparently from sheer laziness, as an abundance of food is always near.

From the foregoing statements it will be seen that the struggle for existence is almost a negligible factor in the life of the porcupine. Consequently, he has become the slowest, the clumsiest and the most stupid of North American mammals, knowing neither fear nor hurry. Even the task of producing young has been found less necessary than among most species, since the death rate is low. The female gives birth to one or two young each April or May, and the male pays no attention to them. One can not help wondering what the courtship of these sluggish and uncouth brutes is like and whether the young are ever active and frolicsome. But I know of no one who has made observations on this point.

It is in consequence of his over-specialized habits that the porcupine has disappeared from our fauna. Without destructive habits and having no value for food or fur, he would have survived as long as any forest remained had he exhibited any cunning or adaptability. But his uncouth appearance excited man's desire to kill, and the spiny armature, in whose protective powers the creature had absolute reliance, proved wholly inadequate against shotgun and rifle.

Family LEPORIDAE.

RABBITS AND HARES.

This family, which is of world-wide distribution, belongs to a distinct suborder of rodents (*Duplicidentata*) distinguished from the rest by the presence of two pairs of upper incisors, the one pair being directly behind the other. There are also a number of other anatomical peculiarities. The wrist can not be turned as in most rodents and the soles of the feet are thickly covered with fur. The hind legs are much longer than the front ones. The ears are long and the tail is short and carried erect. The names "hare" and "rabbit" are loosely used, the former being generally applied in this country to the larger species, while the smaller ones are everywhere known as "rabbits."

Genus SYLVILAGUS Gray.

Sylvilagus Gray, Ann. and Mag. Nat. Hist., 3d Ser., Vol. 20, p. 221, 1867. Lyon, Smith. Miscel. Coll. (Quart. Issue), Vol. 45, p. 396, 1904.

Dental Formula.—I, $\frac{2-2}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{3-3}{2-2}$; M, $\frac{3-3}{3-3} = 28$.

Generic characters.—The species of this genus were formerly united with large varying hares, jackass rabbits and others in the genus *Lepus*. Lyon and other mammalogists have recently regarded this as a distinct genus because of a number of minor anatomical characters. The genus can be readily distinguished from those others found in the United States by its smaller size. The species of this genus are the common rabbits or cottontails of central North America. About fifty species and subspecies are known, all of them being found in North America. Apparently only one form occurs in Indiana.

SYLVILAGUS FLORIDANUS MEARNSI (Allen).

COMMON RABBIT; PRAIRIE COTTONTAIL.

Lepus sylvaticus mearnsi Allen, Bull. Amer. Mus. Nat. Hist., Vol. 6, p. 171, 1894.

Lepus sylvaticus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 125.

Lepus floridanus transitionalis McAtee, Proc. Biol. Soc., Washington, Vol. 20, p. 5, 1907.

Lepus floridanus mearnsi Hahn, Proc. U. S. Nat. Mus., Vol. 32, p. 462, 1907.

Diagnostic characters.—Hind foot about four inches; rump paler than back; no dark spot on top of the head between the ears.

Description.—General color of back decidedly brown, with a mixture of black and gray-tipped hairs. Underneath white, with a brown band across the chest. Ears without distinctly blackish margins. The subspecies *transitionalis*, with a more northern range, differs from the above in being slightly smaller, with more black-tipped hairs on the back, the brown being also deeper and richer; the ears are more thickly furred and have blackish margins, and there is a distinct black spot between them. The subspecies *mallurus*, which may be found to occur in the southern part of the State, is also smaller, with shorter, coarser, duller colored hair and the rump nearly as dark as the back.

Measurements.—Ten specimens from Mitchell average: Total length, 435 mm. (17½ in.); tail, 50 mm. (2 in.); hind foot, 95 mm. (3 13/16 in.); ear, 69 mm. (2 13/16 in.).

Skull and teeth.—The skull does not differ greatly from those of the closely related forms. However, the skull and teeth of rabbits differ from those of other rodents in several characters not yet pointed out. The skull is very long and the rostrum is quite deep as compared with the shallow braincase. The sides of the rostrum (maxillary bones) are perforated by many holes, which give it a lattice-like appearance. The ventral surface of the skull is also remarkably open, the palatal region being occupied by the very large incisive foramina. The interorbital foramen is large, so that in a lateral view of the skull, it is seen to be perforated by a large hole, passing through the eye region from side to side. The molars and premolars are wide in a transverse direction and the upper ones vary narrow antero-posteriorly, with a transverse ridge of enamel in the middle; the last one is small, however, and the first is also of different form. The teeth of the lower molar series each consist of two lobes.*

Range.—The prairie cottontail occupies the upper Mississippi valley from Minnesota to southern Indiana and east to New York and Ontario. Specimens from Mitchell have been identified by Mr. E. W. Nelson, the best authority on American rabbits, as belonging to this subspecies. Those from the northern part of the State are also *mearnsi,* and hence it probably occupies the whole State, although examples from the lower Wabash valley may be found to intergrade with the subspecies *mallurus.* There is not a county, perhaps not a township, in the State in which the cottontails may not still be found.

Habits.—It would be difficult to find two species of mammals that show more contrasts than the rabbits and porcupines. The former are among the most defenseless of our mammals. They can not climb trees nor do they burrow to any extent. When they find a natural cavern among the rocks or occupy a woodchuck's deserted den, they are still liable to attack by bloodthirsty weasels. They have been ruthlessly shot, snared and chased to death by men. The natural enemies include every predatory mammal and rapacious bird.

Yet in spite of their enemies, and in spite of the fact that their intelligence is of a low order, they have frankly acknowledged† their shortcomings, their weaknesses and even their cowardice. As an adaptation to these conditions, they have learned to produce a large number of young each year, so that some may be left to continue the species, although many perish.

Consequently, where the porcupine with few enemies has disappeared, the rabbit still holds his own, although persecuted incessantly. I think it is safe to say that where sinkholes, stony hillsides or thickets and uncultivated land have been left for retreats, the rabbits have not been reduced in numbers since the country was first settled. Although shotguns play havoc with

* This description is based on *S. f. mearnsi* and applies, for the most part, to other cottontail rabbits as well.

† The writer does not mean to imply by this or similar expressions that the animals have reasoned it out. In the race history natural selection has forced upon the species the same results which might have been arrived at by a process of reasoning and perfect control of surroundings.

their numbers, these agencies of destruction have been counterbalanced by the extermination of wolves, coyotes, wildcats and other enemies. But where intensive cultivation removes harboring places, the rabbits are rapidly thinned out, although they do not completely disappear, even in the suburbs of the larger cities.

The cottontails possess another valuable asset in their unspecialized taste. Although they never eat animal food, almost any kind of vegetable matter serves as food. Tender clover, cabbage, apples and other fruits and juicy vegetables are preferred, but when such delicacies are not to be obtained they subsist for weeks on twigs, bark, small shrubs or other coarse vegetation. During the winter they sometimes destroy young orchards or forest trees by gnawing the bark from their bases. However, they prefer the more tender vegetation, such as the wahoo, Christmas fern, young dogwood, sassafras, etc., to the hardwood trees like the oak, and it is only in new plantations that they do much damage to forests.

Occasionally they damage gardens, eating cabbage, beets and other vegetables. I have seen a small plot of peas in an unfenced garden cropped so closely by the rabbits that they never reached the height of an inch. Clover, alfalfa, corn in the shock or the growing ears in the milk are also eaten.

During the summer evenings rabbits will lie at full length on bare patches of compact clay and gnaw at the earth. This may be for the purpose of obtaining salt or other mineral matter, but I have watched them doing it along paths and in fields where there was no reason to believe that there was a considerable quantity of salt in the soil. At Mitchell I used to see them repeatedly in the same place in the open woods near the cabin on University Farm. The tooth marks were plainly visible as long as there was no rain, and in this way it was possible to form an idea of how much they ate. During one period of ten days they gnawed away the earth to a depth of from one-fourth to half an inch, or even more, on an area of approximately a square yard.

One would expect to find that such timid, defenseless creatures would select a secure spot or dig an extensive burrow in which to rear their young. On the contrary, they most often bring them into the world in a nest made of grass, lined with fur from the mother's body and placed on top of the ground, although they sometimes use a ready-made hole in the ground, or a hollow log, or even excavate a little cavity in soft earth under an old stump. The young are usually four in number, but may be from two to seven. Mr. Butler records finding young at Brookville on January

8, 1890. I have found a female with young not ready for birth on August 21st in Porter County. The exact number of litters produced in a year is not known, but probably averages three or four, and as the period of gestation is about a month, the potential number is larger.

Economic status.—As the foregoing account shows, rabbits sometimes do considerable damage to gardeners and fruit growers. Methods of trapping and hunting rabbits are too well known to require discussion here. The animals are usually hunted enough to hold them in check so that they do not become a serious pest, but it is not desirable they be given any further legal protection at present.

The Biological Survey of the U. S. Department of Agriculture recommends the application of the lime-and-sulphur wash, used in spraying for the San José scale, to the trunks of young trees needing protection from rabbits. It is made by boiling 15 pounds of sulphur and 20 pounds of unslaked lime in 15 gallons of water for one hour, then adding 30 gallons of water and applying with a brush. A single application is said to protect trees from rabbits for an entire winter. The trees can also be protected by various wrappings or by permanent cylinders made of poultry netting or screen wire. Where orchards are kept free from underbrush, tall grass and weeds, the rabbits are not apt to be numerous. In favor of the animals, it must be remembered that rabbit hunting furnishes good sport and that their flesh makes a very palatable food.

Genus Lepus Linnaeus.

Lepus Linnaeus, Syst. Nat., Ed. 10, I, p. 57, 1758. Lyon, Smith. Miscl. Coll. (Quart. Issue), Vol. 45, p. 389, 1904.

Dental formula.—The same as *Sylvilagus.*

Generic characters.—As restricted by Lyon, this genus includes only the jackass rabbits of America and varying hares of this country, Europe and Asia. As here understood, the water hares of the southern United States are also included. They are distinguished by their large size and by a number of anatomical characters.

Three subgenera and about fifty species and subspecies are included in this genus which is limited to the northern hemisphere. Thirty-five or more species are found in North America, three of them may occur in Indiana.

They may be distinguished by the following key:

Legs and ears very long (ear 4½ in.). Jack rabbit.
L. campestris, appendix.

Legs and ears shorter, the former under 4 in.
Species northern, turning white in winter.
L. americanus phaenotus, appendix.
Species southern, color always brownish; habits aquatic.
L. aquaticus, p. 538.

LEPUS AQUATICUS Bachman.

WATER HARE.

Lepus aquaticus Bachman, Jour. Acad. Nat. Sci. Phila., Vol. 7, p. 319, 1837.
Kennicott, Patent Office Report. 1856.
Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 139, 1894.
Butler, Proc. Ind. Acad. Sci. for 1894, p. 85, 1895.

Diagnostic characters.—Size larger and hair coarser and stiffer than in the cottontail rabbits.

Description.—Back mottled with buff, brownish-red and black, the amount of black being less than in the cottontail; belly and underside of tail white; hind foot relatively short and scantily haired on the underside; ears longer than in the cottontail. The total length is about 21 inches the size therefore being intermediate between the jackrabbit and the cottontail. I have no detailed measurements.

Skull and teeth.—The skull is larger than that of the cottontail and is further distinguished by having the postorbital process solidly joined to the side of the cranium.

Range.—The water hare is limited to the lower Mississippi Valley. Kennicott states that it was not uncommon about Cairo, Ill., in the fifties. Butler has recorded it from Indiana on Mr. Chansler's report. I have no additional records excepting Chansler's statement to me which is as follows: "A very few of these are found here (Knox County). They are larger than the common rabbit and of a brownish color. One of these rabbits was seen by my brother Will, September 17, 1898; also another by Will Staley. It was also seen in 1894; no recent records; seems to be rare; usually found about water or swampy places." I consider these statements reliable enough to give the species a place in the fauna of the State, although no specimens are extant.

Habits.—Kennicott said of the water hare in Illinois that it was generally found in the denser woods and especially the cypress swamps. Two or more litters of young are produced each year, the nest being placed on hillocks in the swamps or in fallen hollow trees.

In Tennessee, according to Mr. Rhoads, they are never seen on the hills and seldom in the open, but they have held their own in numbers in the cane brakes and deep woods. When pursued they take to the water by preference and can outswim a dog, not infrequently swimming sloughs and streams many yards wide. During the spring freshets they may be seen sitting on floating logs far out in the streams. The water hare is doubtless extinct within our limits at the present time, but it has always been too rare to have been of much importance in the fauna of the State. Because it shuns the vicinity of human beings, this species does not do injury to crops and orchards as the other rabbits sometimes do.

Order FERAE.

THE FLESH-EATERS.

Mammals adapted for eating flesh and for capturing and killing their prey. The canine teeth are well developed and the molars have sharp, cutting crowns; the incisors are generally small and placed in a transverse row between the canines; the tooth row is not broken between the incisors and the molar series, but the teeth are all relatively close together. (See fig. 2.) Feet provided with strong, sharp claws. Brain large and eyes and ears well developed. Size medium or large, the weasels being the smallest American representatives of the order.

This order is indigenous to all parts of the world except Australia. It contains about a dozen families and probably more species than any other order of mammals excepting the *Glires*. About 15 species, belonging to five families, are members of the Indiana fauna, past or present.

Family FELIDAE.

THE CATS.

Feet not plantigrade; toes retractile; hind toes four; front toes five, the inner one not reaching the ground; skull short and rounded; teeth 28 or 30.

This family has a world-wide distribution (excepting Australia) but contains only two or three genera and relatively few species. Two genera are native to North America and both were found in Indiana in the early days of its settlement.

Genus Felis Linnaeus.

Felis Linnaeus, Syst. Nat., ed. 10, I, p. 41.

Dental Formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{3-3}{2-2}$; M, $\frac{1-1}{1-1} = 30$.

Generic characters.—Body slender; tail long; ears rounded, total number of teeth, 30.

This genus includes the domestic cat, together with about a dozen species and subspecies of North American cats, and a number of species in the old world. The panthers, jaguars and ocelots are the typical American representatives of the genus.

FELIS COUGAR Kerr.

COUGAR; AMERICAN PANTHER; PUMA; PAINTER.

Felis couguar Kerr, Animal Kingdom, p. 151, 1792.
Merriam Proc. Wash. Acad. Sci., Vol. 3, p. 582, 1901.

Felis concolor, Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 138.

Diagnostic characters.—Distinguished from other members of the cat tribe in eastern America by its great size, long tail and brownish color.

Description.—Color, yellowish brown above, darker along middle of back; under parts yellowish white; tail blackish at the tip; feet large; ears without tufts of long hair; tail long and rounded, thickly furred and powerful.

Measurements.—I am not aware that there are any measurements in existence for the cougar of the eastern United States nor are there any specimens from which such measurements can be obtained.

Three males and three females killed by President Roosevelt in Colorado are said to have averaged seven feet two inches, the largest male being eight feet in length. The tail is about three feet; the hind foot ten inches.

Range.—Cougars formerly inhabited all of the wooded parts of North America. Several species have been named, but their relationships and distribution are not known. The eastern species, *cougar,* certainly inhabited all of Indiana.

Our knowledge of the occurrence of the species in this State is limited. It probably became extinct about 1850, although it was very rare long before that time.

Most of the county histories are silent as to the occurrence of the animals, even when they speak of bear and deer, and there seems to be a consensus of belief that the species was never abundant in this State after the beginning of the nineteenth century.

The Prince of Wied says that it had already become extinct at New Harmony in 1832. Mr. Chansler gives the following records for Knox and Daviess counties: One seen in 1825 by Mr. B. Thompson; one in 1828 by N. B. Bruce; two in 1833 by A. Stafford; one near Vincennes in 1837 by Felix Buchie.

Evermann and Butler say that two young were taken east of Brookville in 1838. The historian of Morgan County says that panthers were killed in that county, but gives no dates. In the history of Brown County it is stated that they were seen as late as 1836, and the following incident is given: "Green Graham, on one occasion, went from Jackson's salt works east past Weed Patch Knob. He was riding a mare and was accompanied only by a colt and a cur dog. On nearing the summit of the hill he thought he heard some one call. He answered and the call was repeated several times, growing nearer all the while. At last, just as he reached the top of the Knob, his horse became frightened and he noticed that his dog was also frightened. A minute later the leaves rustled at the right and he saw two huge cat-like forms skulking through the weeds. He knew that the animals were panthers, and put the whip to his mare, going down the hill at a breakneck pace and escaping the animals."

Dr. U. H. Farr, of Paragon, tells of seeing an animal in 1851 when a child of five, which older people told him was a panther, judging from his description. Mr. Cicero Sims tells of capturing "what was called a mountain lion" in a wolf pen in Clinton county. The exact date is not given, but must have been about 1840. His description of the animal leaves no doubt that it was a cougar.

Dr. S. C. Richardson, of Indianapolis, tells of going fishing one night in 1851, when he and three companions were threatened by a panther which they frightened away by rushing toward it with their fish gigs and an ax. It was only seen indistinctly in the moonlight, but its screams were heard as it retreated through the woods. Dr. Richardson's father killed a panther which he discovered crouched in a tree, apparently waiting to spring upon him, sometime previous to 1850. The exact date and place are not given. About the same time one of his steers was attacked in the woods not far from home and horribly lacerated by one of these great cats.

Habits.—According to the most reliable naturalists who have studied the cougar, we must class as "nature fakirs" those who write stories of adventure in which the great cats figure as courageous beasts that will stalk a man and attack him without provocation. That they will fight desperately when brought to bay, goes without saying. Most carnivorous, and many herbivorous animals will do the same. But courage is not one of the common attributes of the cougar—at least not of the cougar of the present day, although its habits have doubtless been greatly modified where it has come into conflict with guns and hunting dogs. President Roosevelt, who has hunted them extensively and has published one of the best accounts of their habits (Scribner's Magazine, 1901), thinks they are always cowardly and will never attack a man. There is good evidence, however, that some of these animals in the early days, when they had not become acquainted with white men and their weapons, showed considerable courage, and also that they sometimes lay in wait for game and sprang upon it, or even upon a man from vantage points.

Their favorite game, under natural conditions, seems to have been deer. These creatures were stalked until the cougars were within a short distance, when they rushed upon them with a succession of tremendous leaps, springing upon their backs and biting at the neck and throat till the quarry dropped from loss of blood or exhaustion. On the cattle ranges of the west they have been very destructive at times. Although they usually kill calves, colts and sheep, they do not hesitate to bring down an old bull or a full grown horse if other food is scarce. When an animal the size of a sheep is killed, it is often carried away, especially if there are young to be fed, but larger animals are eaten on the spot. Smaller animals are also killed and eaten, and it is said that the cougars will even kill and eat porcupines and skunks.

The den is usually placed in a rocky cavern or under a ledge. The young are born in such a den just at the end of winter. They are from two to four in number, and are naked and blind when born, but soon become active and playful. The young climb trees readily, but the adults seldom do so unless closely pursued.

The species was early exterminated because it came into direct conflict with man. Its great size, strength and ferocity aroused the dread of the early settlers and, rightly or wrongly, they considered their lives endangered by the presence of these beasts. The added effect of their raids on the poultry yard and the stock yard made the conflict the more deadly. As Stone and Cram have pointed out, no species of animal can long survive where its presence is feared by man, and hence the pioneers exerted themselves to their utmost to exterminate the species.

Genus LYNX Kerr.

Lynx Kerr, Animal Kingdom, I, p. 155, 1792.

Dental Formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{2-2}{2-2}$; M, $\frac{1-1}{1-1}=28$.

Generic characters.—Form rather stout and heavy; tail short; teeth 28 instead of 30, as in *Felis;* ears pointed with tufts of long hair.

This genus, which resembles the typical cats (*Felis*) except in the characters given above, is found in the northern part of both hemispheres. The species are commonly known as lynxes, wildcats or "bobcats," the latter name being given on account of the short tail. About 15 species and subspecies, divided into two subgenera, are known from North America. Two formerly existed in this State. They can be distinguished as follows:

Feet very large, twice as long as the tail; ear-tufts large; fur long and loose. *canadensis.*

Feet moderate, not much longer than the tail; ear-tufts smaller; fur short and close. *ruffus.*

LYNX CANADENSIS Kerr.

CANADA LYNX. Sometimes called "WILD CAT."

Lynx canadensis Kerr, Animal Kingdom, I, p. 157, 1792.
Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 138.

Diagnostic characters.—The characters given in the key serve to distinguish the species.

Description.—Color light gray and dark brown, mingled so as to give a somewhat mottled effect; under parts white; tail tipped with black; ear tufts also blackish. The hair is exceedingly fine and so long that it is very soft and yielding, tending to pack into hard lumps when made into furs and robes; the hair of the cheeks is still longer and forms a sort of ruff about the broad rounded head, which makes the animal look much more formidable than it really is. The ear-tufts, which are about two inches in length, add to this appearance. The densely furred, large feet serve as snow shoes for the animal.

Measurements.—The following are the measurements given by Miller: Total length, 1,000 mm. (40 inches); tail, 100 mm. (4 in.); hind foot, 225 mm. (9 in.); breadth of front foot about 80 mm. (3 3/16 in.).

Skull and teeth.—The skull is very broad and powerful as compared with that of the bay lynx.

Range.—Formerly from Indiana, Pennsylvania and Maine to the northern limit of trees in Canada. Now extinct except in the more sparsely settled regions.

In Indiana the records are greatly confused with those of the smaller bay lynx, and, to some extent, with accounts of the cougar. The differences between these three species are well known to hunters and trappers where all are found, but they are all called "catamounts" and "wild cats" by the later settlers, who heard of them now and then, but seldom saw them.

I can not be certain, from the Prince of Wied's account, whether this species was found about New Harmony in 1832-33. He records the lynx as "not rare" and then recognizes the validity of Godman's two species (*canadensis* and *ruffus*), but does not state that both live near New Harmony. Chansler gives a record of one killed near Bicknell in 1832 and mentions several newspaper "records" from Knox County in recent years, but does not place credence in them. Dr. Plummer omits it from his list of Wayne County mammals in 1844. The historian of Steuben County wrote in 1885 that "both lynxes disappeared at least a third of a century ago." The lynx is mentioned in several other county histories, but it is impossible to tell which species is meant. Evermann and Butler give the following records: Franklin County, "formerly found, but never common"; Lagrange County, 1875; Montgomery County, one killed November 22, 1890, near Garfield; Tippecanoe County, one killed in 1885 seven or eight miles west of Chauncy." I think it is extremely probable that these last two records should refer to the bay lynx rather than to the Canada lynx.

Habits.—According to most accounts, this is one of the fiercest animals that roams the northern woods, excelling the cougar in boldness, though lacking its strength. It is the dreaded *Loup Cervier* of the French Canadians and northern Indians.

When game of all sorts is scarce in the northern woods and the lynx becomes fierce with hunger, there are few creatures that he will hesitate to attack. Well authenticated instances are on record of the animals following a man, and since they move rapidly and silently through the tree-tops, there is little reason to doubt that they will sometimes make a fatal attack on a lone hunter. They capture deer by lying in wait and springing on the animal's back, biting and clawing till the deer drops from loss of blood and exhaustion, unless it can get rid of its dread foe by running under the low branches of a tree or jumping into water.

Macfarlane states that the lynxes are subject to periodic increase and decrease in numbers in the Northwest Territories of Canada. The minimum number of skins obtained by the Hudson's Bay Company in any one year was 4,448 in 1863; the maximum was 76,556 in 1868. In 1903 this company obtained more than 9,000 skins. The animals are usually snared by the Indians, although they are also caught in steel traps and hunted with dogs and guns. The flesh is white and tender and much prized by the natives.

The young are born in these northern countries in June or July and have the eyes partly open, but are helpless and are suckled about two months by the mother. There are from two to five young in a litter.

LYNX RUFFUS (Gueldenstaedt).

BAY LYNX; WILD CAT; CATAMOUNT; BOB CAT.

Felis ruffus Gueld., Novi Comme. Acad. Acient. Imp. Petropolitanae, Vol. 20, p. 484, 1776.

Lynx rufus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 138.

Diagnostic characters.—General color yellowish brown instead of gray; proportions as given in the key.

Description.—Color yellowish brown, with dark brown or blackish spots and streaks and a blackish line down the middle of the back; belly white with dark spots; throat more or less brownish. Feet small; tail moderate; ear tufts about one inch; fur short and dense, much as in the house cat.

Measurements.—From Miller: Total length, 900 mm. (36 in.); tail, 170 mm. (6¾ in.); hind foot, 180 mm. (7⅛ in.); breadth of front foot about 50 mm. (2 in.).

Skull and teeth.—The skull is narrower than that of the Canada lynx and of course smaller.

Range.—From Georgia to Maine and west to the Rocky Mountains. Closely related species are found to the south, north and west, but all have been greatly reduced in numbers and exterminated in much of their former range.

Indiana records are as follows, the dates being the latest authentic records I have been able to find for different parts of the State, but not necessarily the date of extermination; New Harmony, not rare in 1833 (Wied); Wheatland, January 10, 1900; adult and two young killed near Montour's Pond in Knox County in 1894 (Chansler). In Franklin County Dr. Haymond reports them as occasionally seen, but rare in 1869, and Butler remarks that this was about the end of their existence in that county. Dr. Plummer says that they were seldom seen near Richmond after 1823. Edwin Dinwiddie, in T. H. Ball's history of Lake County, says that two were seen about Pleasant Grove in that county from 1855 to 1867, but that there are no authentic records since the latter date.

Mrs. Annie Anderson, of Oxford, relates the following story concerning the occurrence of lynxes in Benton County: "In August, 1870, when I was about ten years old, my brother and I were gathering berries on the banks of Pine Creek, about four miles south of Oxford, when I spied in some hazel brush what I thought to be a maltese cat. I called to the kitty and started to catch it, when my brother stopped me, saying that he did not like the looks of its eyes. It was standing still, staring at us, evidently as much surprised as we were. In the following autumn some hunters killed a lynx in the same place, and it proved to my maltese kitty or one like it. I have not heard of any since until about three years ago (1905) some boys killed a bobcat about a mile from the same place."

Mr. Theo. F. Upson states that he killed a "bobcat" near Lima, Lagrange County, in the fall of 1857, and knows of none in that vicinity since. Robert S. White, Jr., killed a "catamount" on Pigeon Creek, Warrick County, in the winter of 1906. This is the latest record that I have been able to obtain. Newspapers frequently print more or less sensational stories about wildcats in various parts of the State, and no doubt some of them are true, but I have not been able to verify any of them. As the accounts usually do not state positively whether the animal in question is a wildcat, a wolf, or an escaped circus lion, I have not taken these stories into account. Nevertheless it is very probable that a few wildcats remain at the present time in the less accessible swamps and woods in various parts of the State.

Habits.—This lynx is merely a smaller edition of the preceding species and, so far as I am aware, does not greatly differ from it in habits. The smaller size may render it unable to kill some of the animals on which the larger species preys. Both hunt by stealth and rely on chance to find their quarry, since they can not trail it as do the wolves.

They have learned to hunt even more quietly since the country has become thickly settled, and thus have escaped extermination. They have a shrill, piercing cry, but this is seldom heard, even at night. Their size and strength is not sufficient to make them dangerous to human life, although they are much feared. They often kill poultry, and also lambs and pigs, but those animals that have habitually molested farmers have been hunted down and only the ones that conduct their still hunt in the swamps and forest have survived. Because they have learned retiring habits, they escape observation and have lived for years in places where their presence was not suspected. When hunger drives them from their retreats to seek food about the farms, people are astonished and unduly alarmed by their presence.

Family CANIDAE.

DOGS, WOLVES, COYOTES AND FOXES.

The members of this family resemble the cats (*Felidae*) in being carnivores with digitigrade feet. The toes are four on the hind feet and five on the front ones (except in the Cape hunting dog of South Africa, which has only four toes in front). The claws can not be retracted into a sheath and usually are comparatively blunt and straight. The skull (figs. 2 and 14), especially the jaws and rostrum, are long and the teeth number 42 in all the American species.

Like the *Felidae*, this family contains only a few genera, but the species are probably more numerous. The family has a world wide distribution, one species being found in Australia, where it was doubtless introduced. Three genera are found in North America, all being represented in Indiana.

Genus Urocyon Baird.

Urocyon Baird, Mamm. N. Amer., p. 121, 1857.

Dental Formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{4-4}{4-4}$; M, $\frac{2-2}{3-3}=42$.

Generic characters.—Front teeth with straight cutting edges (no lobes); skull with two crests or ridges along the temporal region (fig. 14); instead of the single median crest usual among the carnivora; tail with a mane of stiff hairs.

The gray foxes of this genus are limited to the western hemisphere, where they have a range extending from South America into southern Canada. Ten or twelve species and subspecies are known, only one of which occurs in Indiana.

UROCYON CINEREOARGENTATUS (Schreber).

GRAY FOX.

Urocyon cinereoargentatus (Schreber), Säugethiere, Vol. 3, pl. 92, 1775.

Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 52, 1894.

Hahn, Proc. U. S. Nat. Mus., Vol. 35, p. 575, 1908.

Diagnostic characters.—The generic characters serve to distinguish the gray fox from other Indiana species.

Description.—General color of the back, gray; the hairs being banded with black and white or gray; the black predominates in the middle of the back, forming a median dorsal stripe; tips of the ears and the middle line and tip of the tail also black. Sides of the neck, most of the ears, a band across the chest, the sides of the belly, the hinder and part of inner surfaces of the fore legs, the inner surface of the hind legs and the under part of the tail are all brownish in color, the exact shade varying somewhat in different parts of the body as well as different individuals. Throat and belly whitish; a spot between the eye and the tip of the nose blackish; lips mostly white; form somewhat stouter than that of the red fox.

A subspecies, *Urocyon cinereoargentatus ocythous,* has been described by Bangs from southwestern Wisconsin near the Mississippi River. The Indiana specimens are, perhaps, somewhat intermediate between this and the typical form. The skin of the only Indiana specimen I have taken was lost and, unfortunately the detailed description and measurements of the fresh specimen are also lost. However, I carefully compared it at the time with Baird's description of a specimen from Washington, D. C., and noted no important differences except that the Indiana specimen was tinged with cinnamon over the white of the throat and most of the belly.

Measurements.—Miller gives the following measurements: Total length, 900 mm. (36 in.); tail, 260 mm. (10¼ in.); hind foot, 125 mm. (5 in.).

Skull and teeth.—The striking features of the skulls of the gray fox are the temporal crests which extend along the edges of the dorsal side of the skull (figs. 2 and 14), meeting in the occipital region, diverging anteriorly, and joining with the postorbital process. The top of the skull between these crests is smooth, while the sides below them are roughened for the insertion of muscles. The rostrum is shorter and broader and the interorbital region is also broader than in the red fox. The nasal bones extend farther posteriorly, than the maxillaries, while in the red fox they do not extend as far. The lower jaw is remarkable in having a notch on the lower edge just in front of the angular process, which appears to be an accessory process for the attachment of muscles of mastication. The teeth are smaller in the gray fox than in the other.

Range.—Gray foxes are found throughout most of the United

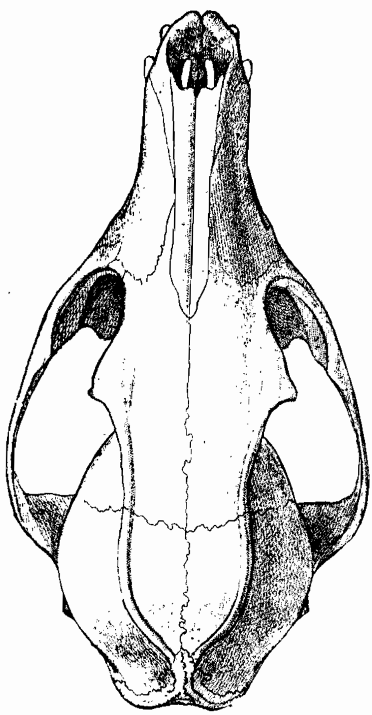


FIG. 14.—Skull of *Urocyon cinereo-argentatus.* After Baird.

States. The typical form extends from Florida to New York and from the Atlantic west to Indiana.

The gray fox was formerly common in nearly all parts of the State, but it is fast disappearing. Wied states that it was abundant at New Harmony in 1832. Dr. Plummer says of it in 1844 that it is "still found in the more wooded districts." Dr. Haymond, in 1869, says that it is probably as abundant as ever near Brookville. Butler says in 1893 that it is still found in Franklin County, but it is rare. Mr. Chansler knows of no positive records for Knox County since about 1895, although he states that what was called a silver fox, but probably was this species, was taken near Emison, Knox County, in 1905. Prof. Van Gorder states that it formerly occurred in Noble County, but is now rare or extinct. Mr. I. W. Burton, of Roselawn, and others familiar with the Kankakee region, have told me that the gray fox never inhabited the swamps, but that it has been known to occur in the higher woods in that part of the State. At present I know of but two localities in which these foxes still live, although there are doubtless others. These places are the rough, partially wooded hills along Willow Creek in Ohio County and the rough land along the East Fork of White River near Mitchell.

Habits.—The gray fox is more retiring and shy in disposition than its red cousin. It is a creature of the forest and is seldom found where the timber has all been cut away.

Exactly why these creatures should be driven out where their red brethren still abound, is a question I can not fully answer. They seem to have less cunning and to be quite unable to hatch up plans for deceiving men and dogs in the way the red foxes do. However, there seems to be something more, some innate hatred of the cultivated field and open range, which drives them away before advancing civilization. In some ways they seem to have an advantage over the red species, for they are more protectively colored and their pelts are of less value. Stone and Cram say they are equally swift, but there seems to be a general opinion among Indiana hunters that they are not so swift and their more stocky build also indicates this.

According to Stone and Cram, the gray foxes seldom live in burrows, but make their dens in hollow logs and old tree trunks. This may have been the case with the gray fox of former days, but it is not true in Indiana today. At the present time the dens do not differ from those of the red fox, but they are never placed out in the open fields as are those of the latter species. At Mitchell I found a den not more than 150 yards from an inhabited house, but it was in dense woods on top of a little knoll where there was little likelihood of its being discovered. Another den, likewise near a house, was in the bottom of a sinkhole which seemed to have connection with quite an extensive cavern. Some hunters ran a fox into this latter refuge one night and attempted to dig it out, but gave up the task when they discovered, after more than an hour's work, that the den was in a rock lined cavern, too small for a man to enter, but probably of considerable length.

At the same place I chanced to glance out of the window one quiet Sunday morning when the hounds were baying in the distance, just in time to see a gray fox trotting up a woodland path. It stopped about 30 yards away and listened, then made a detour to avoid the house, stopping several more times near by, apparently oblivious to my presence, although in the meantime I had quietly left the house and was in full view of the animal. It seemed to have used that path before, for it made for a place where there was a break in the close barbed wire fence, then crossed the road, sprang upon the rail fence, ran along its top for a rod, stopping to listen again, and then, as the hounds were coming nearer, it went on across a meadow at an easy trot.

Later in the year, when the spring rains had swollen the creek, I set a steel trap at the end of a log which spanned the current, placing some brush so that any animal crossing the bridge would have to leave it at the spot where the trap was placed. Next morning a large adult male gray fox had been caught in the trap. He first tried to spring away at my approach, but then showed fight. At about the same time, the middle of March, some boys in the neighborhood dug five cubs from a den in the woods, and kept them as pets for some time.

The food of the gray fox consists of any sort of small mammals or birds the animals can capture, supplemented by insects, frogs, fishes, snakes, carrion and sometimes fruits and nuts. The animals sometimes rob poultry yards, but their retiring habits and rarity make them lesser offenders in this respect than the red foxes. Their bark resembles that of the red fox, but has less volume.

Genus VULPES Frisch.

Vulpes Frisch, Das Natur-system vierfüss. Thiere, Tabl. Gen., 1775.

Dental Formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{4-4}{4-4}$; M, $\frac{2-2}{3-3}=42$.

Generic characters.—Size medium; upper incisors lobed; pupil of eye elliptical; fur soft and full all over, the tail being covered with the same kind of hair on all sides; skull with slender, elongated rostrum.

The genus *Vulpes* is found in the northern hemisphere, both in the old world and the new. More than 20 species and subspecies are found in North America, only one of them occurring in Indiana.

VULPES FULVUS (Desmarest).

RED FOX.

Canis fulvus Desmarest, Mammalogie, Vol. I, p. 203, 1820.

Vulpes fulvus DeKay, Zool. N. Y. State, Mammalia, p. 44, 1842. Hahn, Proc. U. S. Nat. Mus., Vol. 32, p. 462, 1907.

Vulpes vulpes Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 138, 1894.

Diagnostic characters.—Color of back fulvous or rusty yellow. This, with the generic characters, should serve to distinguish the species.

Description.—Back fulvous or rusty yellow, darkest on loins and shoulders and with grayish bands on the hairs of the rump and flanks which give a grizzled appear to those regions. Most of the under parts only slightly paler than the back but there is a narrow line of whitish along the middle of the belly which broadens out and extends down the inner side of the legs; lower part of face and chin and throat also whitish. Tip of nose, end of tail, outer side of legs and all of the feet blackish, the extreme tip of the tail being whitish, however. The ears are whitish on the inner side and edges, but black on the convex surface, except at the base.

The cross fox, silver fox and black fox are color varieties of this species. In the cross fox there is a broad, indistinct bank of blackish across the shoulders and another longitudinal band between them. The silver fox has blackish fur tipped with silvery gray, and the black fox is a melanistic form with the color chiefly black.

The ears are very large, the legs are long and slender and the tail very large, soft and bushy. The fur consists of two kinds of hairs, the soft under fur being concealed by long hairs. The latter are evenly distributed on the tail and do not there form a mane as they do in the gray fox.

Measurements.—From Miller I take the following: Total length, 1,000 mm. (40 in.); tail, 360 mm. (14⅜ in.); hind foot, 150 mm. (6 in.).

Skull and teeth.—The skull can be distinguished from all other north America *Canidae* (except closely related forms) by the long, slender rostrum. In the region between the eyes it is somewhat flattened dorsally, but is not nearly as broad, nor is the braincase as flat as in the gray fox. On the other hand, the teeth are broader and heavier, the canines being also much longer.

Range.—From southern Canada to Georgia and from the Atlantic to the Rocky Mountains. Related forms are found to the north and west. The range of this species, therefore, includes all of Indiana.

I think there can be no doubt that this species has been introduced into Indiana since the coming of the white man. It has long been a mooted question whether the red fox of North America is not identical with the species of Europe. Such able mammalogists as Baird and Merriam have decided independently that the species are distinct. However, the historical evidence is strongly in favor of the introduction of the species and this evidence has not been controverted. But it does not prove that there are no tangible distinctions between the foxes of the two continents at the present time, for more than two centuries have elapsed since the supposed introduction of the animals, and strongly marked domestic breeds of animals have been produced in a much shorter time; and evidence has been brought forward in recent years which seems to indicate that environment has a marked and direct effect on species. This being true, the time is ample to produce new species as is shown by the rapidity with which new varieties of domestic animals are evolved.

The following is a brief summary of evidence of introduction into Pennsylvania as given by Rhoads (Mamm. Penna. and N. J., pp. 145-147). Kalm stated in 1770 that the red foxes were very scarce in Pennsylvania and New Jersey, and that the Indians stated that they were never in the country until the coming of white men. The first red fox ever seen in Perry County, Pennsylvania, was killed in 1787. The people did not, at first, know what it was, but finally an old Jerseyman stated that it was an English fox and that one of the first English governors of New York had imported the foxes from England and turned them loose on Long Island for the purpose of sport. The cave deposits from Carlisle and other bone caves in Pennsylvania contain many remains of the gray fox, but none of the red. I am unable to understand Mr. Rhoads' statement that the red fox must have been in the region to the north of the Great Lakes in pre-Columbian times, and do not know whether he thinks that some of the foxes were imported while others are the descendants of a native American race. This seems to me an impossible supposition.

The evidence of the introduction of the species into Indiana is as follows: Prince Wied (Säugethiere Nord Amerika) mentions its occurrence in Pennsylvania and New York in 1832, but does not mention it at New Harmony, although he speaks of specimens of the gray fox. In his "Reise" he speaks of both species at New

Harmony, but this is a general account of the itinerary published previously to the publication of his little book on mammals; the latter was probably based more carefully on notes and specimens and would naturally be the more accurate of the two. Dr. Haymond, in 1869, distinctly stated that it had not been observed until the last ten or fifteen years. Dr. Plummer, in a list of 43 species of mammals found about Richmond in 1844, includes the gray fox, but omits all mention of the red species. Mr. Chansler states that he does not know of any records from Knox County previous to 1870, when one was killed close to the junction of White River and Indian Creek.

At the present time these foxes do not seem to be diminishing in numbers. Most of the evidence I have on this point was collected during the summer of 1905. At that time they had become very bold and numerous in the fertile, thickly settled valley of the Ohio River between Rising Sun and Aurora. In a distant part of the State, at Mountayr, Newton County, they were also a pest. One farmer there told me that he had lost not less than 150 chickens from their depredations that year. He poisoned the bodies of some of the chickens they buried, and found carcasses of four foxes which the poison killed. He did not know how many hid away where their dead bodies were not found. In 1908 they were very abundant and bold near Bascom, Ohio County.

Habits.—So many of the traits of the fox have passed into proverb and story that it does not seem possible to add much to our knowledge of its habits, except through detailed studies of its psychology. Certainly, much that has been written concerning the cunning and almost human sagacity of the red fox, or "Reynard," should be classed with the fables rather than the natural histories. But fables aside, foxes are undoubtedly among the most cunning, the most adaptable of our mammals and an accurate account of the life history of one of the creatures, together with experiments to determine its teachability, would be a valuable contribution to animal psychology. The fox is at his best when leading the hounds a merry chase. His tricks for throwing them off the scent are innumerable and their chief aim and result is to make the progress of the hounds slower rather than to make them lose the trail entirely. One of the simplest of his devices is to double on his own track, going back to some convenient point on the trail, then leaping far to the side, often over a bank or into a thicket. The baffled hounds have to circle far and wide before they can pick up the lost scent. The old-fashioned rail fence afforded other opportunities and the fox would run along the top rail for some distance, then spring aside into the bushes. In places where there is much ice in winter it is said that the light-stepping fox delights to cross on thin ice, leaving a good trail on either bank, and the heavier hounds, coming down with a rush, often break through.

Stone and Cram say that the fox delights to trail the hunter, and give an instance of two hunters hurrying to head off a fox where they thought it would cross a stream, while all the time the fox was following in their footsteps. These authors, who base their observations chiefly on New England foxes, say: "It does not worry him in the least to have the dogs close on his heels; he knows that they are afraid to touch him and that he can easily leave them miles behind whenever he cares to. I have more than once seen a fox turn and drive the hounds back when they got too close."

What miserable, cowardly curs they must use for fox hunting in New England! I have heard it said that a dog will not attack a female fox during the mating season. But when the lust of the chase is strong and the pack, led by some giant, bass-noted black and tan, with the tenor of the brindle and the shrill soprano of the "yelper" (mongrels all, but trained to the chase) swelling the chorus, bursts over the hilltop and catches the warm, body scent as the fox speeds down the lower slope, there is neither fear nor mercy in the hearts of the hounds. The race then becomes deadly earnest to the fox, for his life hangs in the balance. Little time is there then for strategy and none at all for delay. Speed, and speed only can save the fox, although he may choose the roughest paths and lead the chase uphill, where his wind lasts better than that of the hounds, and so gain a breathing space in which to execute other maneuvers for throwing the dogs off the scent.

I have known of a number of instances in southern Indiana where dogs have run down foxes and killed them without hesitation. When they fail to kill it is invariably because they can not catch the sly brutes.

It can not be questioned that foxes are among our most destructive animals. At the same time, there is a dash and wit about their thievery that makes one feel somewhat lenient toward them. A fox would about as soon take a chicken from a farmyard when there are two or three men in sight as at any other time, and he seldom fails to make a successful get-away with his booty. The chicken yard suffers most from their depredations, but other poultry are also relished, and rarely a young pig or lamb is the victim.

The stealing is usually done in daylight, although geese and ducks or other poultry roosting on the ground are not safe at night. The fowls are usually seized by the neck, given one quick bite to prevent any squawking, and thrown over the fox's shoulders so that he can carry them without greatly interfering with his speed. Stone and Cram state that thirty pullets have been taken by one fox in a single night. The foxes do some good in return by destroying great numbers of field mice, ground squirrels and woodchucks. But it is doubtful whether they compensate for the loss they cause to poultry raisers.

The foregoing account shows that hunting with dogs is not an effective method of destroying the animals. Poisoning is often more effective. Foxes have a habit of burying surplus poultry when they get more than they can eat. Strychnine introduced into the carcasses so buried will sometimes destroy the animals, but care must be taken to touch the carcass only with gloved hands, for an adult fox is wary of the man scent.

For the same reason it is not easy to trap them, as they have learned to be very cautious about approaching a baited trap. Perhaps the most effective way of trapping is to place the trap at the end of a log which bridges a stream, placing brush so that the animal is compelled to leave the log where the trap is hidden. Foxes are exceeding chary about wetting their feet and invariably seek for some bridge insteady of wading or swimming a stream.

However, the fox-drive is one of the most effective ways of ridding a neighborhood of the pests. In these drives a hollow square, several miles across, is formed by a large number of men and boys. At a given time all of the lines move toward a central point previously agreed upon. The shouting of the men as they advance through the woods and fields drives the foxes from their hiding places, and as the lines draw near together the men are too near each other for them to escape. Even in such circumstances the fox's cunning does not fail him, and the writer knows at least one instance in which a fox, finding the line too strong to break through, hid among some briars and weeds along a fencerow until the men were past. By accident, he was discovered, but it was too late to turn him into the square and he escaped.

It must be admitted that the above method is not a very sportsmanlike way of hunting, but it is justifiable on the ground that the animals are a pest where they are numerous. As they kill large numbers of quail and songbirds, I doubt that their beneficial qualities ever equal the harm they do, unless we take into consideration the sport that fox-hunting furnishes. In recent years, the English custom of hunting on horseback has grown up to some extent, but it is in a very much modified form, the horses being generally mere farm or driving horses and their riders a few enthusiastic farmers instead of a company of fashionably dressed men and women.

Genus CANIS Linnaeus.

Canis Linnaeus, Syst. Nat., ed. 10, p. 38, 1758.

Dental Formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{4-4}{4-4}$; M, $\frac{2-2}{3-3} = 42$.

Generic characters.—Upper incisors with distinctly lobed cutting edges; pupil of the eye circular instead of elliptical as in the foxes; size usually rather large in the wild American species.

The genus *Canis* includes our familiar domesticated dogs and hence has a world wide distribution. The wild species are also native to most parts of the world, nearly 20 species being found in North America. Two species occur in Indiana. They may be distinguished as follows:

Color gray, darkest on back and shoulders; hind foot about 9 inches; tail 15 inches or more ***occidentalis.***

Color more yellowish; hind foot less than 8 inches; tail under 8 inches. ***latrans.***

CANIS OCCIDENTALIS (Richardson).

GRAY WOLF; TIMBER WOLF.

Canis lupus occidentalis Richardson, Faun. Bor. Amer., I, p. 60, 1829.

Canis lupus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 135, 1894.

Canis occidentalis Bangs, Amer. Nat., Vol. 32, p. 505, July, 1898.

Hahn, Proc. U. S. Nat. Mus., Vol. 32, p. 462, 1907; Vol. 35, p. 576, 1908.

Canis nubilis McAtee, Proc. Biol. Soc. of Wash., Vol. 20, p. 6, 1907.

Diagnostic characters.—The gray fur with the darker shoulder patches, and large size, distinguish this species.

Description.—Back usually grizzled gray, darkest along middle line and over the shoulders and hips; sometimes more yellowish; belly dirty white. The color varies greatly; hair long and rather coarse; body large and powerfully built.

Measurements.—I have no measurements of Indiana specimens.

Miller gives the following for the species: Total length, 1,465 mm. (58 in.); tail, 405 mm. (16 in.); hind foot, 225 mm. (9 in.).

Skull and teeth.—Skull very large and teeth strong and powerful; a median crest of large size is found along the mid-dorsal line in old individuals, especially males, but is lacking in the young. The skull of an old male in the New Harmony collection measures 8.5 inches in greatest length; maxillary tooth row 3⅝ inches.

Range.—The range of this species is unknown but it probably extended in former times from the gulf states to the Arctic regions and from the Atlantic Ocean to the Rocky Mountains. It is also somewhat uncertain as to whether the specific name, *occidentalis,* is the correct one for the wolf of this region. A large number of specific names have been bestowed on American wolves and their status and relationships have not been worked out.

There is no doubt that timber wolves were abundant throughout Indiana in early days, although the records are somewhat confused with those of the prairie wolves. Wied says the former were not uncommon in the great woods about New Harmony in 1832 and 1833, and their howling was often heard on cold nights. Dr. Plummer says that none had been seen near Richmond for 15 years previous to 1844.

The great abundance of wolves in the early days is attested by many accounts. In Jefferson County, Prof. Glenn Culbertson states that a den was found as late as 1830. A Mr. Hamer, of Mitchell has told me that he has often heard his grandfather speak of the pack of wolves which followed him into the valley leading from Hamer Cave when he took up a homestead there about 1835. He did not reach the place till nightfall and had a small herd of cattle and hogs which doubtless attracted the beasts.

This was probably about the time they began to decrease in numbers and after 1840 they were not generally abundant in the southern part of the state. Those that have been found in Brown, Lawrence and Knox counties in recent years are doubtless descendants of a small colony that has survived in that region and there may have been others in a few of the swamps and rough regions of the state. In the northern part they were numerous until about 1840. The historian of Wabash County tells of seven being killed in one afternoon in 1849, but it is not certain whether these were timber wolves or coyotes.

Mr. Upson states that wolves disappeared from Lagrange County about 1840. Mr. Sims tells of the capture of 8 timber wolves, one of them black, in Clinton County, but does not give the date.

Mrs. Annie Anderson has contributed the following amusing account from Oxford: "It was about 1874 that Benton County had its lion scare. Full grown hogs and sheep and even yearling colts and calves were hurt so that they died or had to be shot. Some of the farmers kept watch, and finally saw the animal but were too much frightened to shoot, and seeing it in the half light, declared it to be like a female lion full grown. As time went on more stock was killed and the people in the central and north part of Benton County were afraid to send their children to school.

"Finally they organized a 'lion' hunt and hunters came from all parts of the country. The excitement had become so great that an American across the ocean read in the European papers that 'Benton County, Indiana, U. S. A., is infested by lions.'

"When the day came the hunters formed in a circle, and coming together near the center of the county, caught and killed the 'lioness,' which proved to be a large *timber wolf*, larger and fiercer than any of his prairie brothers, and none of his kind have since been seen."

Chansler states that Mr. James Sprinkle helped to kill a wolf in Gibson County in 1890. He also says that Mr. Nute Chambers killed a white wolf with just a little tinge of blue on the under parts on the McCray marsh north of Bicknell, Knox County, in 1880. McAtee records it from Brown County in 1902. In March, 1907, an animal was killed at Springville, Lawrence County, which was pronounced a timber wolf by those who saw it. Mr. C. H. Cobb, on whose farm it was killed, has furnished me with a somewhat crude description of the animal, and from this I judge that the identification was correct.

December 19, 1908, a wolf was killed near Monroe City in Knox County. Prof. Max M. Ellis of Vincennes University saw the animal and writes me that it was not a coyote but a timber wolf, measuring about three and one-half feet from tip of nose to root of tail. This record is more positive and reliable than any others of recent date and removes all doubt concerning the survival of species up to the present time.

Papers in Indianapolis and other towns in the State, as well as in Chicago and other cities, contain frequent accounts of wolf hunts in northern Indiana, but all of these that I have been able to run down apparently refer to the prairie rather than the timber wolf. However, Hon. L. Darrow, of Laporte, who has hunted the animals, regards some from northern Indiana as gray wolves, or crosses between the gray wolf and coyote. One that he killed weighed 63 pounds, which would be a very heavy, though not impossible weight for a coyote.

Habits.—The methods of the wolves in seeking their prey afford a marked contrast to the habits of the lynxes and other members of the cat tribe. Instead of the ambush and still hunt used by the latter animals, the wolves resort almost wholly to the open chase, not attempting to slip up on their quarry, but relying on fleetness of foot and soundness of wind. All the while they make the night resound with their howling, which serves not only to strike terror into the hearts of the weaker creatures of the forest and plain, but also to call their kind to aid in bringing down the quarry. They are social animals more truly than the bison or any other mammals, for their success in securing food depends largely on their united efforts. Their social habits are not prompted by love, and if we may believe the tales of many pioneers and hunters, they turn upon the weak and wounded of their own kind in times of famine and devour them. It seems, therefore, that this habit of hunting in packs has been developed by natural selection. The wolves that joined forces fared better than those that did not, and hence the habit of joining forces for the hunt has been perpetuated.

The early settlers lived in considerable fear of wolves. It is possible that the animals would attack a lone and unarmed man, when driven by hunger, in those days before they learned to know and dread the white man. Certainly a child alone in the woods on a winter night would not be safe. But the wolf is a cowardly, skulking animal, and where it survives at the present time there is little danger that even the largest and hungriest pack will attack an active man. They are, moreover, cunning and teachable animals, and have learned that man is their superior, and hence leave him alone. Mr. Ernest T. Seton's stories of wolves that have learned to profit by all sorts of experiences, and have taught others of their kind to avoid traps, poisons and man, are to be regarded as idealized rather than scientifically accurate accounts, but they are founded on many incontrovertible facts.

The family life, like the social life, of these animals, is more highly developed than is usual among mammals. The animals mate in late winter, the young being born two or three months later. The pair remain together during the summer, the male doing most of the hunting while the whelps are small. Later the parents teach the young to hunt and during the summer and fall they join with other families to form the pack. It is stated by some observers that the male and female remain mated for life, but this has not been certainly established.

Deer constituted a large portion of the food of wolves in the primeval forests. They were probably fleeter than the wolves on solid ground, but were easily captured where the snow was deep and crusted slightly so that it bore the weight of the wolves but allowed the sharp hoofs of the deer to break through. At other times the habit of hunting in packs made it possible for some of the wolves to turn the deer from a straight course while others could cut across the angles made by the quarry, and so head it off. Rabbits, ground-squirrels, mice and birds also furnished food for the wolves and nothing in the way of flesh or carrion is refused in time of hunger.

CANIS LATRANS Say.

COYOTE; PRAIRIE WOLF.

Canis latrans Say, Long's Exped. to the Rocky Mts., I, p. 168, 1823.

Hahn, Proc. U. S. Nat. Mus., Vol. 32, p. 462, 1907

Diagnostic characters.—Smaller than the timber wolf, with fur yellowish gray, grizzled with black.

Description.—Long fur of back fulvous, with black tips; under fur gray; head more brownish; back of ears reddish brown; legs tawny; tail the same color as the back except on the under part at the base, where the black tips of the hairs are not found; soles of feet black. The above description is taken from two specimens killed in Jasper County, three miles north of McCoysburg, by C. W. Bussel on May 16, 1906, and sent by him to the National Museum at Washington.

Measurements.—Measurements taken from the above mentioned specimens in the flesh are as follows: Adult male, total length, 1,095 mm. (43 inches); tail, 165 mm. (6½ in.); hind foot, 195 mm. (7¾ in.); ear from crown, 105 mm. (4⅛ in.); height at shoulder, 560. mm. (22 in.). Adult female, total length, 1,040 mm. (41 in.); tail, 130 mm. (5⅛ in.); hind foot, 185 mm. (7½ in.); ear, 110 mm. (4⅜ in.); height at shoulder, 500 mm. (20 in.).

Skull and teeth.—The skull resembles that of the timber wolf in its more prominent features but is smaller.

Range.—Coyotes are distributed from Indiana to the Pacific Ocean and from Central America to within 300 miles of the Arctic

Circle. They are divisible into a number of species, the ranges of the different ones not being very well known. The species *latrans* apparently occupies all of the country from Indiana west to the Missouri River and perhaps to the Black Hills region, and north to Athabasca.

The history of its occurrence in Indiana is peculiar, and it does not seem to have been recorded from the State in any publication likely to fall into the hands of a naturalist, except Butler's notes on Indiana mammals, published in 1894, and the author's List of the Mammals of the Kankakee Valley, published in 1907, although the settlers in the northern part of the state recognized it in the early days.

As far as I can ascertain, it did not occur in the southeastern part of the state; it is an inhabitant of the prairie rather than of the forest. Wied speaks of the abundance of timber wolves at New Harmony and then says a different species occurs on the prairies to the west. From this I infer that he did not see it in Indiana. Neither Plummer nor Haymond mention it in their lists and Evermann and Butler also omit it. Mr. Chansler mentions it as being moderately common about the prairies near Vincennes in early times. He says: "one was observed following a man with some beef just north of Vincennes in 1858. One was observed by Mr. M. S. Kelshaw in 1870."

In the northern part of the State the coyotes were once numerous, then became almost extinct, and in recent years have again increased greatly in numbers. Edwin Dinwiddie, in Rev. Ball's history of Lake County in 1884, mentions them in the past tense. The historian of Jasper County also mentions both timber wolves and coyotes in the past tense in 1883, but gives no details of their occurrence except the mention of a "drive" in the early 40's in which six or eight wolves were killed. Prof. Van Gorder says they disappeared from Noble County in the early 40's. Hon. L. Darrow, writing in 1904, said: "They were unknown three or four years ago, at least to the oldest inhabitants of this [Laporte] County." Mr. Upson says they became extinct in Lagrange County about 1840.

In recent years there have been many reports of wolves killed at various places in northwestern Indiana. As stated in the account of the timber wolf, it is not possible to tell definitely in most cases whether coyotes or timber wolves were the ones killed, but all reports that I have been able to trace up seem to refer to coyotes. The following records are those which I have considered reliable, some of them having been verified and a few taken from newspapers: Otterbein, Benton County, four killed in the winter of 1905-6 by H. A. Sutton, of Montmorenci (Sportsman's Review, Feb. 3, 1906). Calumet, Lake County (several apparently reliable accounts in Chicago papers). Toleston, Lake County, Mr. A. Rump wrote to the Smithsonian Institution in 1905, offering to get specimens of wolves of two kinds from Toleston. Roselawn, Newton County, one killed by I. W. Burton early in 1905. A pair were chasing Mr. Burton's dogs early one morning. The dogs turned on them when near the house and there was a fight in which the dogs were cut badly. When they separated a little, Mr. Burton killed one of the wolves with a charge of heavy shot. The other barrel of the gun missed fire and one wolf escaped.

McCoysburg, Jasper County, C. W. Bussel killed or captured 10 in the winter of 1903-4. He also killed two May 16, 1906, which are now in the National Museum at Washington, their numbers being $\frac{143633}{49889}$ and $\frac{143634}{49890}$. I do not know how many others may have been killed by Mr. Bussel. L. Darrow killed five in Laporte County in 1903-4. At one time he saw eight in a pack and at another time 20. He regards them as crosses between the coyote and timber wolf.

Near Leesburg, Kosciusko County, Mr. R. E. Gunter reports five killed by John Harmon, James Hamilton, Jefferson Plummer, Arthur Hoffein and Sam Griffith. A pack of moderate size was seen in the winter of 1906-7. None weighed over 45 pounds and they are there regarded as prairie wolves. There have been wolves reported from other localities also but I have not been able to verify these reports.

Habits.—It will be seen from the foregoing account that this species has in some way been rejuvenated in Indiana in recent years. I am unable to give any definite reason for this. Mr. Burton, who has hunted and trapped in the Kankakee marshes for about four decades, says that the wolves were formerly common and were hunted by men on horseback. This method was so successful that their numbers were greatly reduced. In recent years the marshes have been fenced for grazing land and hunting on horseback has become impossible.

I do not believe this will fully account for their increase. The early settlers have little to say about the cunning of either species of wolf. At the present time the general opinion seems to be that of one correspondent who says of the coyote, "he can discount the fox for cunning." Members of the dog tribe have everywhere and always been able to better adapt themselves to man than any other carnivora, as is evidenced by the dogs of most savage tribes; the different breeds have probably sprung from several different stocks.

The coyote of the old days was unacquainted with cultivated fields, domestic animals, traps and guns. Hence he was sometimes too bold and too open in his attempts to get food from the farm-yard. Consequently the race was reduced in numbers. The remnant, which for several decades led a precarious existence in the inaccessible swamps, were timid and cautious. At last they found that they could secure food about the farms under certain conditions. They again became bolder, but at the same time were cautious. They fared better now and increased in numbers, and at the same time advanced in knowledge of traps and guns. The present generation are bold, yet cunning, and there is apparently little hope of exterminating them completely except by draining swamps and reducing all of the land to cultivation. Even then it is probable that some, like the foxes, will remain in rough ground along creeks and rivers. They have extended their ranges in the last five or six years, and there is danger that they will spread over the entire State unless vigorous measures are taken to check them.

All correspondents agree that they are very destructive to poultry, pigs and lambs, as well as game. Mr. Darrow says: "A region where they are abundant is almost destitute of game." Mr. Bussel says: "They are especially destructive to turkeys. They would kill a flock of 50 turkeys and leave most of them lying on the ground, possibly eating one apiece. * * * There is no doubt in my mind but what these wolves have destroyed thousands of dollars worth of poultry, lambs and pigs."

Their method of killing, like that of the larger wolves, is to give a slashing cut with the teeth, not holding on, but slashing and dodging. This is what makes them so destructive to a flock of poultry, and a large flock will be destroyed in a few minutes by the animals dashing among them and biting right and left. They use the same method in fighting, and hence are more than a match for a dog of their own size and strength. They hunt in packs and capture their prey in the open chase like the timber wolves.

The mating season is in February, and the young are born between the first and 15th of April. A burrow is usually dug by the parents in a high place in the prairie, where the adults can lie at the entrance and keep an outlook for danger. Sometimes the den is in a hollow log in the more open woods.

According to Mr. Bussel, the young, which number from five to eleven, are moved about a great deal after they are a month old. He says that it is almost impossible to find the dens because they are moved every time a man or dog comes near. A single dog venturing too near the den, will be attacked by both of the old coyotes and badly injured or killed.

Family MUSTELIDAE.

MINKS, WEASELS, SKUNKS, BADGERS, OTTER, ETC.

Carnivorous animals of small or medium size, with digitigrade feet and claws partially or not at all retractile; five toes on fore and hind feet; anal glands which secrete a fetid fluid, often present.

This family contains more genera and species than any other in the order *Ferae*, and is found in all parts of the world except the Australian region. As the common names indicate, the species differ very greatly in appearance and also in the anatomical characters which fit them for different modes of life. Some are almost wholly arboreal; others burrow into the ground and some are aquatic, the sea otter being better adapted to aquatic life than any other mammal excepting the whales and seals.

The family is generally divided into several subfamilies and 20 or more genera. Ten or more genera occur in North America, eight of which are recorded from Indiana.

Genus LUTRA Erxleben.

Lutra Erxleben, Syst. regni animal, I, p. 445, 1777.

Dental Formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{4-4}{3-3}$; M, $\frac{1-1}{2-2}=36$.

Generic characters.—Toes webbed, with small curved claws; head very broad and flat; tail thick at the base and tapering toward the tip; fur very dense, short and generally colored plain brown; habits aquatic.

The genus has a distribution nearly as wide as that of the family, but does not contain a great number of species. About seven forms are now recognized in North America. There is a little uncertainty as to just which of the subspecies occurs in Indiana, and it is even possible that the otter of the Lower Wabash Valley differ from those of the Kankakee Valley. The point can not be easily determined at the present time.

LUTRA CANADENSIS LATAXINA (F. Cuvier).

SOUTHERN OTTER.

Lutra lataxina F. Cuvier, Dict. des Sci. Nat., Vol. 27, p. 242, 1823.

Lutra hudsonica Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 138, 1894.

Lutra canadensis Hahn, Proc. U. S. Nat. Mus., Vol. 32, p. 463, 1907.

Diagnostic characters.—Toes webbed; color yellowish brown; habits aquatic.

Description.—The characters said to distinguish this subspecies from the northern otter, *L. canadensis,* are the lighter color and more sparsely haired webs on the soles of the feet. The body bears some resemblance to that of the mink in shape, but is much larger. The head is broad and flat, with the muzzle naked for a quite a large space. The ears are small and rounded; legs very short and feet very broad, the tips of the toes forming a semicircle when outspread. In southern specimens they are nearly naked underneath, while in the northern race they are densely furred.

In addition to geographic reasons for assigning the Indiana otter to the subspecies *lataxina,* Baird describes one from Fort Wayne,* saying that it has less hair on the under side of the feet than one from Washington City. The latter is *lataxina* and the lack of hair on the soles of the Indiana specimen would seem to indicate that the characters of the southern form are even more pronounced in the Indiana otters.

Measurements.—Miller gives the following: Total length, 1,100 mm. (43¾ in.); tail, 420 mm. (16½ in.); hind foot, 125 mm. (5 in.). Baird gives the total length of the specimen mentioned above as 49 inches.

Skull and teeth.—The skull (fig. 15) is remarkably wide in proportion to its depth. The rostrum is very strong and consequently does not lack much of being as deep as the braincase; braincase broad and tapering to a distinct constriction back of the orbits; postorbital processes short, broad and strong and placed very far forward relative to the zygomatic arches; last upper premolar and true molar both broad and strong, but not marked with strong projections or cusps.

Range.—This subspecies was formerly found from the Gulf States about to the Canadian border and from the Atlantic at

* In the table of measurements he gives this locality as "Fort Wayne, Ark.," but there is good reason to believe that this is a misprint and that Fort Wayne, Indiana, is intended.

least to the Rocky Mountains. At the time the State was first settled by the whites, otters lived along all of the larger water courses. They have been rare for many years, but are not yet entirely exterminated.

The Prince of Wied states that otter were abundant along the Wabash at New Harmony in 1832-33; he mentions a pure white one taken on the Mississippi. A specimen was taken near New Harmony in the winter of 1906-07. Mr. Robert S. White says that otter still live along Pigeon Creek in Warrick County. Mr. Chansler says "a few are still taken in the southern part of Knox County, but they are about extinct. In the early days they were common, and peopled killed them in the snow as they traveled from one pond to another. A snow white one was caught in a trap near Vincennes in March, 1902. Another white one was caught by Mr. M. Armstrong south of Vincennes, December 17, 1905." I am unable to learn that white otters are generally common and it would seem that the albinistic quality may be an hereditary character of certain otters in that vicinity. An otter in the State Museum was taken in Pike County in 1904. Mr. Blatchley reports it from Putnam County in 1871.

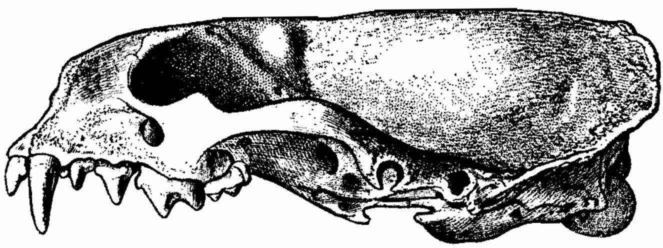


FIG. 15.—Skull of *Lutra canadensis lataxina* from Washington, D. C. After Baird.

Dr. Plummer says otters were very scarce about Richmond in 1844. In 1869, Haymond states "that it is barely possible that a few still linger along the Whitewater (Franklin County). None have been seen for many years." Prof. Van Gorder states that the last otter in Noble County was killed near Skinner Lake in 1863.

Along the Kankakee they have remained until very recent times, perhaps still exist, although the draining of the swamps is rapidly exterminating them. Mr. I. W. Burton saw one which was taken near Roselawn in the winter of 1903-04. The skin sold for $11.50.

Habits.—Fish constitute the principal food of otters. They pursue them actively, swimming and diving with great agility, and even catching such active members of the finny tribe as trout and salmon. They resemble seals in their movements in the water, and are equally graceful and playful. They are more active on land than their form would indicate, for the legs are so short that the body drags the ground when walking. Where they travel in the snow the body scoops out a furrow along the path.

Otters do not hibernate during the winter, but seek out springs and the swift places in streams where the water does not freeze. They also fish under the ice, and in the far north are said to stay under the ice for hours at a time. At all seasons, they travel from stream to stream, and they seem to follow somewhat regular routes. They are sometimes away from home for several weeks, and appear to have regular stopping places along the way. They are sociable, and a pair, or even a whole family, are often found together.

These animals are fond of sliding down embankments, and wear furrows on the banks of streams where they resort frequently for this sport. In winter snow freezes to their wet fur and enables them more readily to slide down declivities to which they come in their wanderings, and they always take advantage of this, and walk up hill and across level places, but slide down all inclines.

Some observers think that otters remain mated for life. At any rate, the pair remains together during the summer, and the male assists in caring for the young. From one to five is the number in a litter. It is said that the young are afraid of the water, and that the mother carries them in by force when she is teaching them to swim.

The home is in a burrow in the bank of a stream. Rhoads has given us an account of a very extensive one which he examined. A chamber "large enough to hold a horse and cart" was broken into by some workmen excavating brick clay. It was in a high bluff overlooking a marsh and seventy-five yards from a creek. An underground tunnel probably led beneath the marsh to the creek. Mr. Rhoads thinks the chamber "probably had been dug hundreds of years ago," and that "it is possible the large amount of earth thrown out by the otters was the ultimate cause of the obstruction of the creek and its final abandonment of that channel for the one now occupied on the opposite side of the marsh."

The fur of the otter has always been highly prized, and it has resulted in great persecution of the animal by trappers. Only the shyness of the otters has prevented their complete extermination.

Genus MEPHITIS Geoffroy & Cuvier.

Mephitis E. Geoffroy & Cuvier, Mag. Encyclop., Vol. 2 (6), p. 187, 1795.

Chincha Howell, N. A. Fauna, No. 20, p. 14, 1901.

Dental Formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{3-3}{3-3}$; M, $\frac{1-1}{2-2}=34$.

Generic characters.—Form stout, the body being especially heavy behind; nose pointed; ears rather small; legs long. The color is always black and white and the white is usually in two broad stripes along the middle of the back (Plate 5, fig. 1); sometimes the stripes are joined into a single broad band; often there is a spot or spots of white on the head; occasionally the animals are entirely black. Anal glands are highly developed and are surrounded by muscles which can contract and eject the extremely offensive fluid secreted by the glands to a distance of four or five yards from the animal.

The genus is restricted to North America, where it is represented by some seventeen or eighteen species and subspecies. Two of these are found in our State. They are distinguished principally by the form of the posterior border of the bony palate.

Palate with a short, blunt spine (Plate 6, Fig. 2) projecting from the middle of its posterior border. *M. putida.*

Palate cut off squarely (Plate 6, Fig. 4) or a little notched in the middle. *M. mesomelas avia.*

MEPHITIS PUTIDA Boitard.

EASTERN SKUNK.

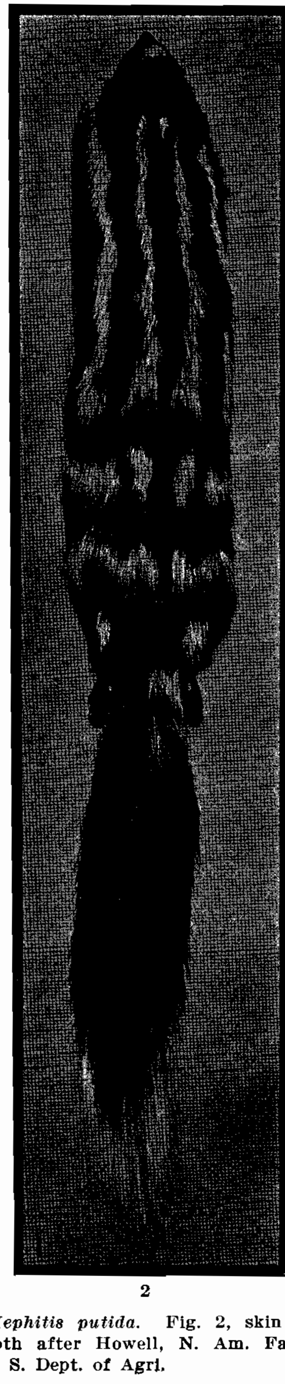
Mephitis putida Biotard, Jardin des Plantes, Mamm., p. 147, 1842.

Mephitis mephitica Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 136, 1894.

Chincha putida Howell, N. Am. Fauna, No. 20, p. 25, 1901.

Diagnostic characters.—Distinguished from the next species by the small process at the posterior border of the palate and by its smaller size and longer tail.

Description.—The color is always black and white or entirely black, the amount of white being extremely variable. In some animals it consists of two rather narrow stripes separated, except on the neck and shoulders, by a median black line. On others, the white covers most of the back and may extend along the sides of the tail. There is sometimes a broad band of white on the head; in other individuals the white of the head is reduced to two small



1 2

PLATE V.—Fig. 1, skin of large skunk, *Mephitis putida*. Fig. 2, skin of small striped skunk, *Spilogale putorius*. Both after Howell, N. Am. Fauna Nos. 20 and 26, Bureau of the Biol. Sur., U. S. Dept. of Agri.

spots (the star skunk of fur dealers). Some individuals are entirely black on the head and body, but I have never seen any in which the white tip of the tail was lacking. Size smaller and tail longer than the next species.

Measurements.—Howell gives the average of six males from New York as follows: Total length, 575 mm. (23 in.); tail, 229 mm. (9 in.); hind foot, 60 mm. (2⅜ in.). The females are larger and six from the same locality average: Total length, 603 mm.; tail, 223 mm.; hind foot, 62 mm.

Skull and teeth.—The skulls of the skunks, like all other members of the family, are very compactly built. Most of the bones become fused at an early age and they are thick and strong. The skull of this particular species (Pl. VI, figs 1 and 2) is broad across the zygomatic arches and the small posterior process in the middle of the palate is peculiar to it. However, this spine is reduced or wanting in the females.

Range.—From Virginia to southern New England and west to Indiana. In this State, according to Howell, its range meets that of the next species, but the two do not intergrade. I am unable to give the limits of distribution for the two forms, the only record for the Illinois skunk being that of Howell from Benton County. The present species appears to be the one occurring throughout most of the State.

The opinion of most of my correspondents seems to be that skunks are growing scarce. However, I feel quite sure that these animals are as abundant or more abundant about my boyhood home in Ohio County than they were twenty years ago. Evermann and Butler state that they were still abundant in Franklin County in 1893. I do not think that they have been completely exterminated in any county of the State.

Habits.—Last summer, while setting traps for field mice in an old pasture, I noticed a great many small, conical holes going down through the grass and into the hard ground for an inch or two. It was evident that some animal had been searching for grubs and insects there. I was uncertain at first as to what sort of animal had been doing the work, but one evening about sun-down I saw a large skunk come out of a sinkhole and begin nosing around in the grass.

I watched it for some time, going up to within eight or ten yards of it (I feared to go nearer). It went about, watching me over its shoulder and appearing uneasy because of my presence, but not running away. It would thrust its nose down through the

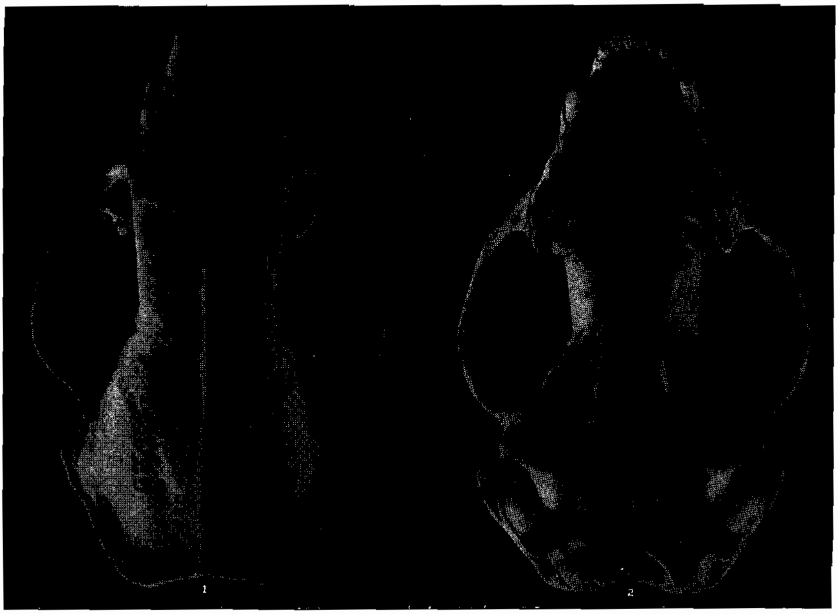


PLATE VI.—Skulls of skunks: 1 and 2, *Mephitis putida;* 3 and 4, *Mephitis mesomelas.* After Howell, N. Am. Fauna No. 20, Bureau of the Biol. Sur., U. S. Dept. of Agri.

close mat of short blue grass, apparently being able to make a hole into the hard earth with its snout alone, although it used both claws and teeth to work deeper when necessary. I could not see what it was eating, but grubs and other insect larvae were probably abundant there. When I clapped my hands and shouted, it turned and went slowly back to the sinkhole, standing in the entrance a moment and then retreating further when I threatened it again.

Had I ventured to strike at it with a club I might have had the whole story of its activities and mode of defense—but I preferred to omit the final chapter.

Insects constitute a large part of the food of these animals. In the tobacco growing region of the State they are indefatigable in their search for tobacco worms. Unfortunately, they are so clumsy that they break more leaves from the tobacco to get one worm than a dozens worms would eat in an entire summer. But they destroy cutworms in the cornfields and grasshoppers in the meadows without causing damage there. Besides insects, they eat mice, snakes, lizards, frogs, young birds and birds' eggs, as well as some vegetable matter. Sometimes they raid a poultry yard, but this does not happen often nor do they destroy many birds.

Their means of defense is one of the most effective ever devised by nature, and no animal likes to brave their malodorous discharge, although some of the larger carnivores will do so when driven by hunger. The smell of the skunk is very penetrating and very enduring. Contrary to popular belief, it is not the urine, and never enters the bladder, but is secreted by a pair of glands lying along the rectum and is dscharged from them through the anus.

Skunks have come to rely implicitly on this fetid discharge for protection, and will not get out of their way for any animal, large or small. I have known a horse, ridden by a man, to stumble over one in the road, and the skunk came off with the least damage. I have also heard a true story of a young German farmer, who had not yet become acquainted with our animals, attempting to pick up one of these pretty "cats" to take home as a pet for his children. The skunk allowed him to place his hands on it out in the open field, but he decided not to take it home to the children. The fearless little brutes like to make their homes near a human dwelling, and it is said that a family of them was found residing under the front veranda of one of Indiana's most noted college presidents.

On account of their sluggishness, due principally to immunity from danger, they have been compelled to resort to an insect diet, supplemented by vegetable food and now and then small birds or mammals. Since most of the things they eat are dead or hidden deep in the ground during the winter, skunks hibernate for several months, coming out, however, in February or March. Perhaps the excessive fat they acquire in the fall also has something to do with their hibernation. Often several individuals den up together. I have known of seven being dug from a small sinkhole in Switzerland County in February, and a still larger number is sometimes reported. They do not always remain inactive, even till February, but sometimes leave the den and return to it after a foraging expedition. It is at this time of the year that poultry yards are most apt to suffer.

They are generally nocturnal in habits, although they sometimes venture out in daylight. Wied says that they were more active during the day on the Upper Missouri than in the inhabited regions. Their meat is said to be tender and white like that of a young chicken, and very palatable if the scent glands are removed as soon as the animal is killed. However, not many white people would have the courage to eat it.

The young are born in April or May and there may be as many as eight in a litter. The female cares for them during the summer and teaches them all of the lore of their ancestors. The white colors of the parent no doubt serve as recognition marks by means of which the little ones are able to follow their mother in the darkness.

MEPHITIS MESOMELAS AVIA (Bangs).

ILLINOIS SKUNK.

Mephitis avia Bangs, Proc. Biol. Soc. Wash., Vol. 12, p. 32, 1898.

Chincha mesomelas avia Howell, N. A. Fauna, No. 20, p. 30, 1901.

Diagnostic characters.—Tail shorter in proportion to the body than in the eastern skunk; palate without a posterior spine.

Description.—As this species is only a little less variable than the eastern skunk, individuals of both species may be found with exactly the same markings. In general, the Illinois skunk has less white than its eastern relatives, and the white tip of the tail is small or wanting. The species are very distinct, however, as their skulls and proportions show.

Measurements.—Howell gives the following as the average of two adult males from San Jose, Illinois: Total length, 641 mm. (25½ in.); tail, 184 mm. (7⅜ in.); hind foot, 65 mm. (2⅝ in.).

Skull and teeth.—Skull rather small and narrow, with the palate ending squarely behind, without a spine projecting backward (Pl. VI, figs. 3 and 4); teeth smaller than in the eastern skunk.

Range.—This subspecies is known only from Indiana, Illinois and Iowa. It is more closely related to forms to the southwest than to the eastern skunk.

The only positive record from Indiana is the one given by Howell for Fowler, Benton County. It is very probable that this is the species inhabiting all of the northwestern part of the State, but the material necessary to determine this point is not at hand.

Habits.—I know of no way in which the habits of this species differ from that of the other, although its home is on the prairies and undoubtedly it lives a somewhat different life from the skunks of the rocky hills and woods. In the Kankakee Valley I learned that the skunks generally occupy deserted woodchuck holes.

Genus Spilogale Gray.

Spilogale Gray, Proc. Zool. Soc. London, 1865, p. 150. Howell, North. Amer. Fauna, No. 26, 1906.

Dental Formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{3-3}{3-3}$; M, $\frac{1-1}{2-2}=34$.

Generic characters.—Form rather slender; skull relatively broad and flat; highly developed glands connected with the rectum. The color is always black and white, and although the pattern is not the same in different species, the white is always divided into at least four nearly parallel stripes on the upper surface of the body or a number of spots (Pl. V, fig. 2); it is never united into one or two white bands as in *Mephitis*.

SPILOGALE PUTORIUS (Linnaeus).

ALLEGHENIAN SPOTTED SKUNK.

Viverra putorius Linnaeus, Syst. Nat., Ed. 10, p. 44, 1738.

Mephitis putorius Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 139, 1894.

Spilogale putorius Howell, N. Amer. Fauna, No. 26, p. 15, 1906.

Diagnostic characters.—Body black, with four white lines, or rows of white spots on the body.

Description.—Form more slender than the common skunks, less slender than the weasels; body black with the exception of one or more white patches on the forehead, four white stripes running from the back of the head to the posterior part of the body, some white spots on the rump and flanks and the tip of the tail. The prairie spotted skunk (*Spilogale interrupta*) is similar, but has much less white.

Skull and teeth.—The skull of this species is long and narrow compared with the other members of the genus, although the general form is much like that of the large skunks. The zygomatic arches are widely spreading and the teeth are heavy.

Measurements.—Howell states that seven adults vary from 470-563 mm. (18¾ in. to 22½ in.) in total length; tail, 193-219 mm. (7¾ to 8¾ in.); hind foot, 45-51 mm. (1¾ to 2 in.).

Range.—*Spilogale putorius* has previously been known in the southern Appalachain region and Gulf States, the nearest records being from Tennessee and West Virginia. I am indebted to Mr. E. J. Chansler, of Bicknell, who has furnished me with so many valuable records, for all the knowledge I have concerning the occurrence of this species in the State. In his list of Knox County mammals first sent to me in April, 1907, Mr. Chansler mentioned the "civet cat," saying that a fur dealer who formerly resided in Vincennes stated that he had obtained a few "civet cats" from the southern part of the State. He stated that they had several curved white stripes and spots on the body. The civet family (*Viverridae*) are not inhabitants of America at all, and at my request Mr. Chansler set about getting further information. In reply to his inquiries Funsten Brothers Company, of St. Louis, one of the largest dealers in raw furs in the United States, stated that they obtained a few civet cat skins from Indiana and they further gave him an accurate account of the range of the genus *Spilogale* and a brief but accurate statement concerning some of its different species. Andersch Brothers, of Minneapolis, also informed him that they obtained a few civet cats from this State.

A more definite record, and one which seems to certainly establish the occurrence of these animals in the State, is the capture of a "civet cat" near Overshot bridge on the Vandalia railroad, between Bicknell and Bruceville, in Knox County. Although the skin was not seen by any trained naturalist, the man who trapped the animal reported it to Chansler and stated that he received a small price for it, as the fur was in poor condition. I have learned from several fur dealers that the skins of these skunks are handled under the trade name of "civet cats" and there does not seem to be any possibility of confusing them with other animals. Moreover, all of the fur dealers consulted have been able to give identifiable descriptions of the animals and definite information as to their distribution. It is certain that these skunks are very rare in the

State, but I believe that the above facts are sufficient to record the species, although I have been wholly unable to secure specimens.

There may be some question as to the specific identity of the animals mentioned, but I think the description, "curved stripes and spots on the body" makes it much more probable that the species is *putorius* than that it is *interrupta.* The known distribution of the species also makes the former the more probable. There is, of course, a possibility that they may be a form at present unrecognized.

Habits.—The habits are much like those of the large skunks (*Mephitis*). They are more slender and active and climb trees more readily. They also appear to be more strictly flesh eaters, although they are known to eat insects at times.

According to a number of observers, they are easily domesticated, and in some localities are welcome residents of the barn or cellar, because they drive away or kill the rats and mice. However, they are equally fond of chickens, and can not be given much freedom where poultry is unprotected.

Genus Taxidea Storr.

Taxidea Storr, Prod. Meth. Mamm., p. 34, 1780.

Dental Formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{3-3}{3-3}$; M, $\frac{1-1}{2-2}=34$.

(In the young animals there is an additional premolar in the lower jaw.)

Generic characters.—Body very broad and stout; legs and tail short; claws of fore feet very long; color grizzled grayish or brownish; skull very wide posteriorly.

This genus is confined to North America, the European badgers being generically distinct. It contains but a single species which is separable into four subspecies. Only one of these occurs east of the Mississippi.

TAXIDEA TAXUS (Schreber).

AMERICAN BADGER.

Ursus taxus Schreber, Säugethiere, III, p. 520, 1778.

Taxidea americana Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 137, 1894.

Diagnostic characters.—Those of the genus; the only animal for which it could possibly be mistaken is the woodchuck. It is easily distinguished from the latter by having six small front teeth above and below instead of two large ones.

Description.—The legs are very short and placed wide apart so that the body is carried low and, except for the fact that the back is somewhat rounded, the animal looks as though it had been stepped on and mashed. The back is always grizzled with black and yellow, but the color varies greatly. In some individuals the general effect is a deep, rusty brown; in others it is paler yellow and in some a gray, not dissimilar to that of the rabbit; middle of back darker, as are also the sides of the face and legs; white line from the nose to the top of the head or nape of the neck. The hair is coarse and long.

Measurements.—I have no detailed measurements. The total length as given by Baird is about 27 inches; tail 5 inches.

Skull and teeth.—The skull is broad and flat, bearing some resemblance to that of an otter in its general shape. However, the zygomatic arches are not so spreading and the braincase is as broad as the arches. The teeth are strong, the upper molars being rounded, the last upper premolar large and triangular and the others small and simple. The outer upper incisor is considerably larger than the other two.

Range.—From Ohio west to the Rocky Mountains or farther. Some of the subspecies are found throughout all of western North America, from southern Mexico to about 55 degrees north latitude.

The badger has never been very abundant in Indiana. Evermann and Butler give the following localities and dates: One killed five miles south of Newport, Vermillion County, in 1880. One was caught in Lagrange County in 1887, and three others in the same county within a few years previous. One was caught in the eastern part of Elkhart County in 1888. In 1880 a black one was taken in Noble County. July 28, 1889, a badger was killed near Metamora, Franklin County, and two others were said to have been killed in 1888. These authors also report it from Grant, Kosciusko, Steuben and Dekalb counties. Butler later reported it from Newton County.

I have very little to add to this record. Prof. Van Gorder says the badger was supposed for a long time to be extinct in Noble County, but that he saw one taken in Green township in the spring of 1895, and one or two have been reported in the county since that time. Mr. I. N. Lamb saw one near English Lake in 1871. Mrs. Anderson mentions their occurrence in Benton County and Mr. Upson saw one in Lagrange County in the spring of 1908.

Habits.—The badger digs extensive underground tunnels in the prairie. He is a nocturnal animal and is seldom seen in the day-time. The color of the animals is well suited to protect them from observation.

This protective coloring is probably of as much use in enabling them to creep up on their own prey as it is in enabling them to escape enemies. The larger beasts of prey probably get them now and then, but they are very strong and are a match for a good-sized bulldog in a fair fight. Their food consists of small mammals and probably snakes and frogs as well as insects. They are thus useful in destroying noxious rodents and in some places help greatly in reducing the number of prairie dogs and pocket gophers. They dig open the burrows of these animals and drag them out by force. Badgers hibernate during the cold months.

Genus GULO Storr.

Gulo Storr, Prodr. Meth. Mamm., p. 34, 1780.

Dental Formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{4-4}{4-4}$; M, $\frac{1-1}{2-2} = 38$.

Generic characters.—Body stout; legs, ears and tail short, the latter bushy; most of the sole applied to the ground in walking as in the bears. The genus is represented by only two living species, one in the northern part of North America and one in the northern part of the old world.

GULO LUSCUS (Linnaeus).

WOLVERENE; CARCAJOU; GLUTTON.

Ursus luscus Linnaeus. Systema Naturae, ed. 10, p. 47, 1758.

Description.—Color dark brown, with a yellowish white band running from behind the shoulders up to the rump and joining a similar band from the opposite side; similar patches occur on the head and under the breast; feet and face blackish. The hair is long, especially on the tail, and both head and tail are carried low, after the fashion of a low-spirited dog. The body is much more clumsy and thickset than that of any other member of the family. The skull and teeth are large and powerful.

Measurements.—Miller gives the following: Total length, 760 mm. (30 in.); tail, 200 mm. (8 in.); hind foot, 170 mm. (6¾ in.).

Range.—Northern North America, formerly south to the United States. It will doubtless be a matter of surprise to many that this animal should be included in the fauna of Indiana. I have hesitated somewhat over the evidence, but as there are two well attested, though unpublished, records from widely separated parts of the State, I can not pass over them. Prof. Van Gorder says: "In

1840 an animal was shot in Washington Township (Noble County), which at that time was named the wolverene, the only one reported to have been seen in the county."

Concerning its occurrence in Knox County, Mr. Chansler writes: "As strange as it may seem for this animal to be caught this far south, Mr. N. B. Bruce declares that a Mr. Simondson killed one of them near Edwardsport, this county, in 1852. I questioned him and he gave its size, color, form and general makeup all right. What it was doing as far south, I am at a loss to know."

I have less hesitation in recording the wolverene on the basis of such reports than I would have for most other species of mammals. Its form, size, and color are so different from any other animal that could possibly occur in the State that there seems to be no chance for a mistake. This is the more true because in the days when these animals were reported, the pioneers were familiar with every beast of the woods. Moreover, there is a definiteness about the reports which makes them creditable, the statements in each case being that the animal was *killed* at a certain place in a certain year. The evidence of its occurrence in Indiana is almost exactly parallel to that given by Rhoads for Pennsylvania, and is, I think, quite as strong, although Indiana is somewhat more remote from the known range of the species than the latter State. In his native forest, the wolverene is a great wanderer, and the animals found in this State were without doubt strays.

Habits.—Probably no animals, not even snakes, are so universally detested as is the wolverene in the great north, where he is best known. Many a voyageur who has left a well-built cache of food for a time of need, returns to find the store broken open and a part of it eaten and the rest defiled by the filth which this animal deposits on surplus food to prevent others from using it. So offensive are the odors and substances which he deposits on this food that no other animal of the forest, however hungry, can eat it.

His very method of hunting makes him seem despicable. He can not climb trees like the more agile members of the family to which he belongs; and he has neither the speed nor the cunning to capture the swift creatures of the wood in a fair race. Therefore, he feeds on offal, carrion, or lamed, starved or entrapped animals and on such food as he can steal in one way or another.

Another habit which makes the species universally hated by the men of the north is that of systematically following a line of traps for the bait or the animals which have been caught. In this way a great number of traps are sprung or destroyed and many a valuable skin is made worthless. Nor is this robber easily captured. He seems to have an instinctive knowledge of traps which enables him to spring them without running any risk of being caught. Indeed, only the strongest wolf or bear trap will hold him.

The strong claws and powerful muscles enable him to dig with great rapidity, and not only the homes of mice and other humble creatures, but even fox dens are opened and the cubs of the latter eaten. During the summer, he is less offensive, and frogs, snakes, mice, birds and birds' eggs are the staple articles of food.

The one redeeming character of this animal is the solicitude which both parents exercise for their young. From three to six of these are born each year, in June or July, in some sort of underground burrow. The family remain together for several months, and the young are defended with great courage. At other seasons the wolverene is generally solitary.

Genus LUTREOLA Wagner.

Lutreola Wagner, Schreber's Säugethiere, Suppl., II, p. 239, 1841.

(*Lutreola* has been regarded as a subgenus of *Putorius* by writers in the past. I have followed Dr. Merriam and some other recent authors in treating it as a full genus.)

Dental Formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{3-3}{3-3}$; M, $\frac{1-1}{2-2} = 34$.

Generic characters.—Color nearly uniform brown all over, with a white spot on the chin and sometimes on the chest. Never white in winter. Feet webbed. Size larger than that of the weasels, smaller than the otters, to which the minks bear some resemblance.

This genus is limited to the northern hemisphere. About six forms are recognized in North America. Only one occurs in this State.

LUTREOLA VISON LUTREOCEPHALUS (Harlan).

SOUTHEASTERN MINK.

Mustela lutreocephala Harlan, Fauna Americana, p. 63, 1825.

Putorius vison Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 137, 1894.

Lutreola vison McAtee, Proc. Biol. Soc. Wash., Vol. 20, p. 6, 1907.

Hahn, Proc. U. S. Nat. Mus., Vol. 32, p. 463, 1907. Vol. 35, p. 576, 1908.

Diagnostic characters.—Color dark chestnut brown, with a white spot on the chin and another between the fore legs. Length about 27 inches.

Description.—The mink resembles the otter quite closely in form of body, but the legs are proportionally longer and the animal is more active on land. The color is darker and the tail is about one-third as long as the head and body; outer third of tail darker in color.

Measurements.—Miller gives the following: Total length, 635 mm. (25 in.); tail, 210 mm. (8¼ in.); hind foot, 70 mm. (2¾ in.). The size varies greatly, and I have seen a few minks very much above the average size. I am not absolutely sure that these large ones may not be a distinct species, although they have not been recognized as such. One of unusually large size was taken near Hazelton in 1908.

Skull and teeth.—The skull is compact like that of all other *Mustelidae*. The bony palate extends considerably farther back than the rather short tooth row and is V-shaped behind instead of being somewhat square as in the skunks. There is a considerable space between the outer upper incisors and the canines. The upper molar is broader (transverse to the skull) than long, and the last upper premolar has three prongs, making it somewhat Y-shaped.

Range.—This subspecies has a range extending from the Gulf States to southern Canada. Other minks are found throughout most of the country from Mexico to the Arctic Ocean.

Minks were once numerous throughout most of Indiana. They have been trapped and hunted for their fur to such an extent that they are now considerably reduced in numbers, but even yet are by no means rare where swamps and woods remain. In 1893 Butler saw three in daylight, playing about a drift pile along a little stream within the corporate limits of Brookville.

Habits.—These animals are very perfectly adapted for a life of activity, danger and destruction. In the water they swim and dive with the agility and speed of an otter. On land, they hunt with the stealth of a cat and run with the speed of a coyote. They are instinctively timid, and do not blunder into traps with the stupidity of a rodent, but they never learn to keep away from habitations or to avoid the smell of man and iron, in this way seeming unable to profit by experience, as do foxes and coyotes. This latter fact probably has more to do with the diminution of their number than does the great amount of persecution.

Referring to their speed and ability to hide anywhere, Stone and Cram say: "I have seen them disappear instantly among the dry oak leaves that carpet the open where hardwood grows, and they will do the same thing in short thin grass or shallow snow with a suddenness that leaves the beholder wondering. At such times, if they deign to show themselves again, it will in all probability be several rods at least from where they first disappeared, and then perhaps only for the briefest glimpse.

"Only yesterday I was sitting beneath a sheltered bank, warmed by the thin sunlight of late November and well out of the reach of the roaring north wind, when I heard a rustling among the leaves eight or ten rods away. Looking toward the sound, I saw, just for an instant, a beautiful little female mink with the sun full on her back, then saw only the russet-colored leaves sloping up between the tree trunks; but even while I looked there was the mink again, several rods farther away and just in the act of vanishing as before.

"I squeaked like a mouse to call her, but the wind was so loud in the trees that I failed to make myself heard; so I imitated the chatter of a red squirrel as closely as I could, and instantly the mink came skipping toward me over the ice of a little pond that lay between us.

"I do not think that I have ever seen any other four-footed creature, not even a deer or a fox, run with such baffling swiftness. I could just catch one image of her coming, head up across the sunlit ice before she disappeared in the sere frozen water grass almost at my feet."

As already indicated, minks obtain much of their food from the water. They swim with enough speed to enable them to catch fish, of which they are very fond, and in addition they eat crayfish and mollusks. They destroy great numbers of mice and also many of the smaller game animals, such as muskrats, rabbits and squirrels. Song and game birds are also killed. However, the greatest harm done by these animals is in the poultry yards. Prof. Cox has recorded the killing of 24 half-grown chickens by a mink in a single night. I have heard of one of the animals killing twelve chickens one night and seven in the same poultry house the next night. In both instances the animal was frightened away or might have killed more. Where they come upon such a supply of food as this, they never eat much of the flesh, but suck the warm blood. They travel long distances in search of food. One hunter writes me of following a mink track nearly all day in the snow, traversing about 20 miles, and finally ending at a den not far from where he started.

With so many harmful qualities added to the value of its fur, it is no wonder that minks are killed wherever possible. The fur makes the animal one of considerable economic value, and its extermination is not desirable. Partially successful attempts have been made to raise the animals in colonies or "minkeries," and it is to be hoped that other ventures of the same sort will be made with this and other fur-bearing animals. Minks are relatives of the ferrets, and can be tamed and used to exterminate rats and other noxious rodents.

The young vary greatly in number. From four to six is probably the more usual size of the litters, although Marfarlane states that as many as 12 have been observed in northern Canada. The den is sometimes in a hollow log, but most often in a burrow in the bank of a stream.

Considering the fecundity of the species, the security of the young in their underground homes and the ability of the adults to secure food and to escape being food, it is difficult to see why the species did not become even more abundant than it was before the country was settled by whites. However, the competition for food was greater then than now, for although some of the animals which mink eat have been reduced in numbers, the larger carnivores which depended in part on the same food have almost wholly disappeared.

Genus PUTORIUS Cuvier.

Putorius Cuvier Regne Animal, I, p. 147, 1817.
. Merriam, N. A. Fauna, No. 11, 1896.

Dental formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{3-3}{3-3}$; M, $\frac{1-1}{2-2}$ = 34.

Generic characters.—Species smaller than those of *Lutreola,* which they resemble in many ways; color generally paler on the under side than on the upper, often changing to white in winter; body slender and tail also more slender than in *Lutreola.*

This genus contains both the ferrets and weasels and species belonging to it are found in all of the continents except Australia. The ferrets constitute a distinct subdivision and are represented in North America by a single native species on the western plains. On the other hand, more than 30 species and subspecies of weasels occur north of Panama. Only one form is known to occur in Indiana.

PUTORIUS NOVEBORACENSIS Emmons.

NEW YORK WEASEL.

Putorius noveboracencis Emmons, Report on the Quadrupeds of Massachusetts, p. 45, 1840.

Merriam, N. A. Fauna, No. 11, p. 16, 1896.

Putorius erminea Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 137, 1894.

Diagnostic characters.—Tail about one-half the length of the head and body together; color brown above and white below, sometimes becoming white all over in winter.

Description.—The size is smaller and the body is relatively more slender than that of the mink, and it is carried higher above the ground. The color is slightly paler above and the white extends all along the under side of the animal and generally includes part of the upper lip also. Tail with a black tip, even in winter when the rest of the fur sometimes becomes pure white. This change to the white coat is always due to the shedding of the hair and so is the return to the brown coat in spring; the hairs do not change color. In the spring and fall the animal is sometimes mottled and spotted, while the molt is taking place, but the change does not require a very long time.

Measurements.—An adult male from Mitchell measured: Total length, 400 mm. (16 in.); tail, 125 mm. (5 in.); hind foot, 45 mm. (1¾ in.). A male from Hebron is somewhat smaller, measuring but 387 mm. in total length. Females are always much smaller, the average being only 324 mm.

Skull and teeth.—The skull of this species is large for a weasel, with long, narrow audital bullae and rather straight zygomatic arches. Teeth much like those of the mink, but smaller and with differences in the details of their shape.

Range.—The range of the species, as defined by Merriam, extends from Maine to North Carolina and west to the Mississippi. Since Dr. Merriam's revision of the genus, a subspecies has been described by Bangs from North Carolina as *Putorius noveboracensis notius*. It is said to differ from the typical form in having the under parts yellow instead of white and in not changing to the white coat in winter. Some of the weasels in this State become white in winter and some do not. However, I am unable to see any other differences between them and until more is known concerning this change of coat, it can not be regarded as a sufficient basis for distinguishing a subspecies. I am unable to say just what per cent. of the weasels of the State change color in winter. Brown winter specimens are apparently found throughout the State. I have records of white individuals from Monroe, Miami and Knox counties and the Kankakee valley.

The New York weasel is the only species recorded from the State, and its range, at the present time, seems to include every county.

Habits.—Weasels are the most bloodthirsty of all our mammals. Like the mink, they will invade a chicken-house and kill a large number in a single night. They are also good mousers and sometimes do good by entering barns and destroying the mice and rats there. Field mice and wood mice are also killed in large numbers, but the good they do in this way is counterbalanced by the birds they destroy. They are better climbers than either the skunk or mink, hence do much more damage among the songbirds. Grouse and quail are also numbered among their victims, and it is said that a hundred quail may sometimes be destroyed in a single night.

Nor do they stop with the smaller animals. Woodchucks and muskrats are doubtless killed in their homes, while rabbits form one of their staple articles of food. I have often seen tracks in the snow where weasels had been following a rabbit. Rhoads tells of a hunter following the track of a weasel in the snow and finding eleven dead rabbits which the bloodthirsty little animal had killed in a single night. They were either hidden in the hole that they had started from, or pulled under the snow, sometimes 20 feet or more to some brush pile. They are killed by biting between the eye and the ear, the wound being so small that it is difficult to find. The hunter who gave this account had spent much time hunting and trapping weasels. He declared that they never rest, but are always killing. With the snow eight inches deep and the mercury 7 degrees below zero, he was unable to catch up with one he was tracking.

Because of their small size they can enter the burrows of ground-squirrels and rats, as well as those of the larger rodents, and no inhabitant of the woods, excepting the larger carnivores, are safe from their depredations. They are not at all averse to coming near dwelling houses, either at night or during the day. I have known in a number of instances, of persons seeing them about a barn or garden during daylight.

Because they are such good travelers, it is not easy to find their dens and set traps for them, even when their tracks are found in the fresh snow. They wind in and out among the trees, entering the base of a hollow tree here, a hollow log there, next a deserted woodchuck hole and then a natural cavern. But they almost always emerge at the same or another entrance and go on. Indeed they probably have no permanent homes except at the breeding season, but hunt till tired and satiated, then enter some convenient shelter for sleep, only to emerge and go on to another den miles away.

The young are said to number five or six to the litter and are born in April or May. The nest is sometimes placed in an extensive, labyrinthian burrow which the animals are supposed to make for themselves. More often, however, it is placed in a rock-pile or behind the wall of a bridge, where the wagons rumble by unheeded. Hollow logs, natural caverns or holes which other animals have made and deserted, or from which they have been ejected by force, are also used as homes by these animals.

Genus MUSTELA Linnaeus.

Mustela Linnaeus, Syst. Nat., ed. 10, Vol. I, p. 45, 1758.

Dental formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{4-4}{4-4}$; M, $\frac{1-1}{2-2}$.

Generic characters.—Size larger than a mink; tail long and thick; ears short; claws partly retractile; toes only, applied to the ground in walking; habits principally arboreal.

This genus includes the martens, sables and fishers and is found in the northern parts of both the eastern and western hemispheres. Only a few species are known. Five forms are recognized from North America. One of these formerly occurred in Indiana and it is possible that another, the pine marten (*Mustela americana*) once lived in the State, although we have no evidence of it.

MUSTELA PENNANTI Erxleben.

FISHER; PENNANT'S MARTEN; PEKAN.

[*Mustela*] *pennanti* Erxleben, Systema Regni Animal, Vol. I, p. 470, 1777.

Description.—Larger than the mink, with a longer, more bushy tail and a fox-like head. Legs, tip of tail and belly nearly black, with light spots on throat or under part of body; back dark brown or blackish posteriorly, the head and shoulders being lighter brown and generally grizzled with hoary tipped hairs.

The skull is very much larger than that of the mink and longer in proportion to its breadth; the zygomatic arches do not flare out so much, but the skull narrows abruptly in front of them; the audital bullae are more rounded and prominent.

Measurements.—Miller gives the following: Total length, 890 mm. (35 in.); tail, 355 mm. (4 in.); hind foot, 120 mm. (4¾ in.).

Range.—The fisher is an animal of the northern forests and is generally supposed to be limited to Canada, the extreme northern edge of the United States, and the Alleghany Mountains. I am compelled to include it in the list of mammals from this State on account of two records. The first is by Wied, who mentions it as "*Mustela canadensis* Linn. Gmelin, Der Pekan Marder." *Mustela canadensis* is a synonym of *M. pennanti*, often used by the earlier naturalists, and the vernacular name "Pekan" is also used exclusively for this species. Wied says that he did not see the animal in the flesh, but that it had been sometimes taken at New Harmony. The other record is that of Dr. Plummer, who includes it in his list of mammals of Richmond with the statement that it had not been seen since 1820.

Habits.—I am unable to say how this animal got the name "fisher" for, according to all accounts, it does not enter the water to fish. Its food is principally rabbits, especially the large snowshoe hares of the northern woods. Fishers are said to be able to kill porcupines, of whose flesh they are especially fond. Birds are eaten and also any sort of small mammals up to the size of the raccoon.

These animals are perfectly at home in the trees and can travel in their tops, springing from branch to branch with even greater agility than a squirrel. They are among the wildest and shyest of all our mammals, and do not remain in a region where settlements have become numerous.

Family PROCYONIDAE.

RACCOONS.

Like the bears, members of this family rest the sole of the entire foot, from the heel down, on the ground when standing. The claws are moderately long and not retractile as they are in the cats. There are five toes on each foot. The tail is generally ringed with black and white. In our species the teeth are 40 in number.

Most of the species are found in temperate and tropical America, but there is one genus in the old world. The North American genera number six and the species 18 or 20. A single genus is found in the eastern United States.

Genus Procyon Storr.

Procyon Storr, Prod. Meth. Mamm., p. 35, 1780.

Dental formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{4-4}{4-4}$; M, $\frac{2-2}{2-2} = 40$.

Generic characters.—Body stout; head broad behind, but with a pointed nose; legs and tail rather short, the latter cylindrical and ringed with black and yellowish white; color always more or less black (never red or brown).

The genus has a range extending from Brazil to about 60 degrees north latitude in Canada. About ten forms occur in North America and an unknown number in South America. A single species is found in the eastern United States north of the Gulf States.

PROCYON LOTOR (Linnaeus).

RACCOON.

[*Ursus*] *lotor* Linnaeus, Syst. Nat., ed. 10, I, p. 48, 1758.

Procyon lotor Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 136, 1894.

Diagnostic characters.—Distiguished from other mammals of the eastern United States by the ringed tail and pointed nose.

Description.—General color yellowish gray, with many hairs tipped with black; the soft under fur dusky. Face yellowish white with broad black streaks extending across the cheeks and including the eyes, but with a yellowish spot enclosed by the black just above the eyes; naked tip of nose also black. Ears yellowish, except at the bases which are dusky; dorsal surface of feet yellowish; soles of feet naked and dull black. Tail ringed with black and yellowish, the black forming the tip.

The above description is based on a male, scarcely mature, from Mitchell. The color varies considerably and sometimes specimens are nearly white while others are coal black, with perhaps faint traces of a lighter color.

Measurements.—I have no measurements of Indiana specimens that are near the maximum size; the one from Mitchell, mentioned above, was only a trifle over 25 inches long. Miller gives the following measurements: Total length 830 mm. (33 in.); tail, 250 mm. (10 in.); hind foot, 120 mm. (4¾ in.).

Skull and teeth.—The skull is rather high but smoothly rounded on the dorsal surface. The palate is broad and the skull does not taper as much as the pointed external form of the head might lead one to suppose. Teeth heavy; canines proportionally smaller than in the dogs and cats.

Range.—The common raccoon is found in wooded regions from the Atlantic to the Rocky Mountains and from Florida and Texas to the northern boundary of Athabasca, about 60 degrees north latitude. They do not usually live far away from timber, and hence their numbers are diminishing with the forest.

They were very numerous in the great woods of southern Indiana in the early days and were also found in the timbered swamps to the north, but were not abundant on the prairies. At the present time I do not think they have been completely exterminated in any county in the State, but they are not abundant in thickly settled counties like Marion or in the prairie regions like Benton County.

Habits.—The raccoons combine aquatic and arboreal habits to a greater extent than any other species of mammal that I know. The home was always in a tree in former times, although Mr. E. B. Williamson tells me they now live in tile ditches in Wells County. The name *lotor*, meaning one who washes, was bestowed because of their habits of washing meat in a stream before eating it. I am not at all sure that this is an invariable custom, but it is often done and the animals are fond of playing in the water. One that I once had as a pet liked nothing better than a dish of water in which he dabbled with his feet, sometimes washing his nose and lips also, but generally watching something else and paying little attention to the water as long as he could keep his feet in it.

The food is obtained in part from the water. The animal can swim about as well as he can do anything else; he is extremely clumsy in all his movements. But he usually watches at the water's edge for fish and crayfish instead of trying to catch them in deep water. Pond snails and fresh water mussels are also eaten.

Besides aquatic animals, raccoons eat young birds, birds' eggs, poultry, probably some mice and young squirrels, blackberries, apples and other fruit, corn in the milk and, more rarely, mature corn in the shock, acorns and nuts. Honey is also taken from stores of the wild bees. It is therefore apparent that the animals are not strictly carnivorous, but are omnivorous.

No doubt the omnivorous diet has been useful in enabling the animal to hold its own fairly well under great odds. For the raccoon is a clumsy, slow moving animal, unskilled either in defense or flight. His most dangerous trait is his curiosity. It leads him to run along every fallen log and cross every foot bridge and thus enables the trapper to set his traps where the animal will be likely to get into them. Curiosity also leads him to tamper with the trigger of a steel trap placed in water and covered with bright tin foil. In this way the 'coons are often caught without bait.

There is a peculiar charm about 'coon hunting where the animals are numerous enough to make it reasonably certain that the dogs will tree one. A good 'coon dog is the first requisite, for dogs that will trail a fox or a rabbit will not always tree a 'coon. When a warm trail is struck it is seldom long before the animal is treed and the dogs gather around the tree, making the woods reverberate with their bellow. A lantern with a good reflector is the next thing needed, to "shine the 'coon" as the process is called. When the hunters come up, the light from the lantern is thrown up among the branches and if the 'coon is there, his greenish yellow eyes can usually be seen, glaring down from high in the top, and the hunter uses them as a mark at which to aim. In the days of good marksmen, the use of any weapon but a rifle was scorned. At the present day the choke-bored shot gun is more often used and it will generally carry high enough to bring down the animal from any tree left standing in our forests.

It was stated above that the animals are poorly adapted for either flight or fight, but they can fight desperately when brought to bay. I once saw an old female, standing in a shallow pool of water with her back to an overhanging bank, keep four husky dogs at bay for ten or fifteen minutes. She was finally captured alive by slipping a noose over her head from the bank above and swinging her up into a box.

A hollow stub of an oak had been cut to drive her out. Besides the adult, five young, weighing perhaps eight or ten ounces each, were found in the nest of leaves inside the stub. They were all taken alive and kept for some weeks. They showed very great differences of disposition and only one became really tame. He remained a pet until late summer, when he escaped. Two or three days later he came back and began paddling in his dish, which was his way of asking for food. He was chained up and remained until October, when he again escaped and was not seen afterward.

He would eat anything the cats would eat and was fond of milk, but he resented any interference when eating and was always less tractable with strangers than with those he knew. Besides his ordinary food, he once caught a salamander and ate it, and another time a garter snake. However, the delicacy he most esteemed was crayfish, and it was always difficult to persuade him to leave when he was taken to the creek to catch them. This he did with his hands without being pinched by their chelæ, but I am unable now to say just how the feat was accomplished. He showed a disposition to attack poultry, but was never given an opportunity to do so.

Raccoons are near relatives of the bears and resemble them in many habits. Their fingers are long and flexible and the thumb is somewhat separated from the other digits, although not opposable to them. Hence they possess considerable agility with their hands and use them to pick up and hold food. They can also rear up on their hind feet and move about quite actively in this position.

Family URSIDAE.

BEARS.

Animals of large size, with rudimentary tail and plantigrade toes, five on both fore and hind feet; claws not retractile; teeth in American species, 42.

Bears are found in all of the continents except Australia. Four or five genera are now recognized, most of which contain only a few species. Two genera are represented in North America. The one contains only the polar bear and the other is divisible into three subgenera of which the Kadiak, grizzly and black bears are the American representatives. Only one genus is found in the eastern United States.

Genus Ursus Linnaeus.

Ursus Linnaeus, Syst. Nat., ed. 10, Vol. I, p. 47, 1758.

Dental formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{4-4}{4-4}$; M, $\frac{2-2}{3-3} = 42$.

Generic characters.—Color never white; head short and broad with very heavy jaw teeth. There is no danger of confusing the genus with any other in North America.

The genus occurs in the northern half of both eastern and western hemispheres and also has representatives in South America. Sixteen or 18 species are found in North America. Only one species is found in the northeastern part of the United States.

URSUS AMERICANUS Pallas.

BLACK BEAR.

Ursus americanus Pallas, Spicilegia zoologica, fasc. 14, p. 5, 1780.

Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 136, 1894.

Diagnostic characters.—Front claws not longer than hind ones; color black or dark brown.

Description.—Body covered with a coat of long, loose hair, which varies in color from cinnamon brown to dark chestnut and coal black. The forward part of the face is generally brownish. The ears are rather short, densly furred and rounded. The body is highest just in front of the hips, rounding off in the one direction to the mere rudiment of a tail, and in the other sloping to the rather low shoulders and still lower head. The legs seem to be unusually loose from the body and give one the impression of props, hinged to the dorsal part of the body, instead of a component part of it, as they appear in most mammals. The low-carried head, which can be raised to the level of the top of the back only when the animal rears itself on its hind legs, is also peculiar. Add to this the shuffling, swinging gait and you have an animal so grotesque that it is not difficult to see why it is so often caricatured by comic supplements and "Teddy Bears."

Measurements.—I have no definite measurements of the species; the total length is about five feet.

Skull and teeth.—No other mammal in this region has a skull so powerful and compact, although those of the elk and bison exceed it in length. The skull varies considerably and the older animals have a sagittal crest which is not found in the young adults. The males have larger skulls than the females. Baird gives the length of a New York skull as 10.7 inches; greatest width, 7.6.

The molar teeth have broad, flattened crowns, with folds and tubercles of enamel, and present a very compact appearance, markedly different from that of the ungulates. The canines are thick and powerful but not long.

Range.—The black bear formerly inhabited all of the region from Mexico and the gulf states to the limit of trees in Canada. At one time the black bear was fairly common in all parts of Indiana, although the species was never as abundant as wolves, deer and most of the smaller animals. It survived some decades after the elk, beaver and bison had disappeared.

The Prince of Wied states that bears were already becoming scarce along the Wabash near New Harmony in 1832-33. One was killed that winter near Mount Vernon on the Ohio. Robert S. White writes me that the last bear was killed in Warrick County in 1842. Mr. Chansler says of the region near Vincennes: "Bears were quite common in the early days." Dates given are 1830, 1834, 1845; one in Washington County in 1839; one killed near Bee Hunter Marsh, Knox County, in 1860 by Mr. Walker; in Black Creek Marsh, Greene County, one was killed in 1870, and another in 1875.

The Vincennes Commercial reported two young killed near Montour's Pond, Knox County, in 1882. Mr. Chansler thinks these must have been strays, and that the species was extinct there at an earlier date.

In Franklin County, according to Dr. Haymond, the last one was taken about 1840. Dr. Plummer says that the last one was killed in the immediate vicinity of Richmond in 1824. Mr. George Leak of Lizton states that a Mr. Osborn killed a bear in Hendricks County in the early forties.

The historian of Lagrange County says, "occasionally still a bear strays into the county and raises a commotion." This history was published in 1882 but probably written a year or two earlier. Evermann and Butler, on the authority of Steininger, give 1878 as the last date for that county. Mr. Upson, who is well informed on the natural history of this county, gives 1853 as the latest record. A cub was killed in the fall of that year by Hon. S. P. Williams.

In Noble County Prof. Van Gorder says bears were never common and none have been seen since 1846. However, Weston A. Goodspeed says in his history of the county (p. 164) that the forest fires in Michigan in 1860 "drove many bears and other wild animals down into Indiana and Ohio. A large black bear came to Mr. Bourie's residence and was first seen by Mrs. Bourie, who thought it was a large black sheep. When it jumped over a fence she realized its true identity. Mr. Bourie and others started in pursuit but it made for the river and finally escaped."

In the history of Allen County, edited by T. B. Helm and published in 1880, he says (p. 154): "A large marsh known as Bear's Nest covers the northern part of the township [Jackson]. Exterminated elsewhere, this spot was left as their peculiar possession. As recently as four years ago bears were seen and killed in this swamp." The history of Lake County by Goodspeed states that a bear was killed in that county in 1850. Mr. Sims says they did not live in Clinton County subsequent to 1836, although tracks were seen where one went across the county.

In the hilly region of Morgan, Monroe and Brown counties bears seem to have been very numerous up till about 1836. There are a number of instances of bears being killed mentioned in the history of Monroe County, but the latest date positively mentioned is 1829 or 1830. In 1819 a track was found in the light snow and followed to a point near Elletsville, where it was found that the animal had entered a large sycamore tree. The tree was cut and a large female and two cubs, three-fourths grown, were found inside and killed. In Brown County, bears are recorded as late as 1836 and doubtless were found later. M. W. Gregory states that he and three other persons still living partook of the meat of a bear killed near Martinsville in 1837, after a long chase, during which the bear crossed White River seven times.

Habits.—Although the bears belong to the order of carnivorous animals, they do not restrict themselves to a flesh diet. During the summer they live principally on berries and other fruits, together with roots and tender plants, supplementing this vegetable matter with insects, fish, mice, frogs and a great variety of other matter. A number of correspondents tell stories of bears carrying away hogs. They usually give no dates, but I suspect this usually occurs in the spring when the animals have but recently come forth from the winter's fast.

In their search for insects and other smaller animals, the bears use their powerful feet and long claws, tearing up stumps and old logs and overturning rocks with ease. They are also experts at fishing and in the rivers of the Northwest, where the salmon run, they live exclusively on these fish at certain seasons and become very fat.

As a rule, bears are not dangerous to human life and they can generally be frightened away. Dr. U. H. Farr, of Paragon, relates two adventures which his mother had with a bear in Morgan County in the period about 1830. On one occasion she and her sister were hauling maple sap from trees to a camp, with an old mare hitched to a sled. The horse became frightened and on looking for the cause the girls espied a large bear coming into the clearing. They both climbed on the horse and, lashing her into a run, made for camp, tearing the sled to pieces on the stumps and hummocks. Their father started in pursuit of the bear which was killed next day. On another occasion, the same girl was crossing a bayou on a log foot-bridge some distance from any habitation; chancing to hear a noise, she looked down the creek just in time to see a large bear rearing up on some logs to look at her from the distance of a few rods. She was much frightened but began to clap here hands and halloo. At first the bear paid no attention but at the third shout he turned around and started slowly away.

Dr. S. C. Richardson also relates several incidents which came within his personal knowledge when a boy in southern Indiana; his experiences reach back to 1828. On one occasion when returning home with his mother at dusk, they came upon a full-grown bear in a path in the woods. Mrs. Richardson was a strong, courageous woman, and began to shout and beat on some saplings with a club and the bear slowly got out of the path, allowing them to make their escape. A few days later, near the same place, two brothers and a sister saw a bear lying high up in the forks of a tree.

Not long after the events recounted above, a girl named Matilda Blakely, in the same neighborhood, while washing clothes beside a creek, was attacked by a bear which got his paws about the girl's throat and injured her so badly that she was confined to bed for a number of weeks. This bear, which was an old female, was killed by the men who rushed to the girl's rescue on hearing her screams, and three cubs were captured.

In spite of their awkward appearance and clumsy movements, bears are very active animals. They are very shy in regions where they have been hunted, and are often treed by dogs, for they can climb a tree with great agility. Mr. Rhoads says they will drop 20 or 30 feet from the branches of a tree when discovered by a hunter, and make off unhurt. They can slip away through a dense thicket and make scarcely any noise.

It is well known that bears hibernate during the winter. However, they do not go into winter quarters until November or December, and now and then venture out even in mid-winter. As far as I can learn, they do not suspend breathing; certainly the heart does not stop, during the hibernating period.

The mating season is just before they begin to hibernate. The young are born about forty days later, that is, in January or February. The female remains in her den for some weeks longer. From one to five cubs are produced in a litter, two or three being the most frequent.

With the possible exception of the opossum, no mammal is so small when born, in proportion to its adult size. The naked and blind cubs weigh only from 9 to 12 ounces when born. The adults sometimes reach a weight of about 300 pounds, but probably do not average more than 250 pounds. The increase in weight is, therefore, from 300 to 650 per cent.

The females breed but once in two or three years. The slow rate of increase is compensated for, in part, by the immunity from danger which adult bears have in their native haunts, and in part by the care which the mother bestows on her offspring. They usually remain with her for two years, sometimes hibernating with her the second winter. When they do this the mother probably does not breed again until the third year.

The she-bear will fight for her cubs with great ferocity. Bears will also fight when wounded or when brought to bay. They use their paws to strike with, but also bite when they get into close quarters. Their well-known habit of hugging is used chiefly in carrying off live animals, as hogs.

Order INSECTIVORA.

MOLES, SHREWS AND THEIR RELATIVES.

This order comprises a number of mammals of small and medium size. They differ from the rodents in always having two or more incisors on each side of the upper and lower jaws; in the presence of canines, and the sharp, triangular cusps of the molars. The muzzle is usually narrow and pointed and most members of the order live in burrows, although a few oriental species climb trees. In the American species there are no external ears, the eyes are rudimentary and the fur is very dense and soft. Two families are represented in North America, the moles (*Talpidae*) and shrews (*Soricidae*). The broad fore foot of moles is the most obvious character which distinguishes them from the shrews.

Family SORICIDAE.

SHREWS.

This family contains a large number of species and genera and is distributed throughout the northern hemisphere. The members of the family are all small animals that live chiefly under ground. Their food consists principally of insects and worms which are perceived by the sense of smell. Hearing is also acute, but vision is poor or lacking.

The American species all belong to the subfamily *Soricinae* which is characterized by red pigment on the crown of the teeth. None of the American species exceed five inches in length.

Genus BLARINA Gray.

Blarina Gray, Proc. Zool. Soc. London for 1837, p. 124, 1838.

Dental formula.—I, $\frac{3-3 \text{ or } 4-4}{2-2}$; C, $\frac{1-1}{0-0}$; Pm, $\frac{2-2}{1-1}$; M, $\frac{3-3}{3-3} = 30$ or 32.

Generic characters.—Ears small and hidden by the fur; eyes also small and rudimentary; fore feet slender as in the mice, not broad like a mole's; tail shorter than the body without the head; nose pointed.

This genus is limited to America, a single species being known from South America, and more than twenty from North America. Three forms occur in Indiana. They may be distinguished by the following key:

Teeth 30; body slender; tail longer than head. (Subgenus *Cryptotis.*) *parva*, p. 602.

Teeth 32; body thickset; tail about the length of the head. (Subgenus *Blarina.*)

Hairs of back tipped with brown; average length about 4⅛ inches. *carolinensis*, p. 601.

Hairs of back all blackish or slate; length about 4½ inches or longer. *brevicauda*, p. 598.

BLARINA BREVICAUDA (Say).

SHORT-TAILED SHREW; LARGE SHREW; MOLE SHREW.
Sometimes called Mole Mouse.

Sorex brevicaudus Say, Long's Expedition to the Rocky Mts., Vol. I, p. 164, 1823.

Blarina brevicauda Baird, Mammals of N. America, p. 42, 1857.

Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 132, 1894.

Merriam, N. Amer. Fauna No. 10, p. 10, 1895.

Diagnostic characters.—Form thickset; tail and legs short; fore and hind feet slender; color glossy plumbeous black; fur thick and soft like a mole's; length of head and body a little less than four inches.

Description.—The typical form of this species is the largest of our North American shrews. The color is sooty plumbeous above and but very slightly paler below. The back shows little or no trace of the brownish color which is characteristic of the southern subspecies, *carolinensis.* Feet, pale flesh color, covered with short whitish hairs; soles and inner side of hind feet plumbeous.

Measurements.—Ten specimens collected in Newton, Porter, Lagrange and Noble counties had the following average measurements: Total length, 115.3 mm. (4 11/16 in.); tail, 23.7 mm. (15/16 in.); hind foot, 15.5 mm. (11/16 in.). Merriam states that specimens from the type locality, Blair, Nebraska, are larger, measuring 127 mm. in total length; tail, 26.5 and hind foot 16.5.

Skull and teeth.—The skull (Fig. 16) is very large and strong for a shrew. Three from Winona Lake have an average length of 23½ millimeters and the greatest breadth is 13 mm. The skull of this species, like those of its near relatives, is triangular both in cross section and in longitudinal outline. The base is flat; audital bullae wholly on the under side of the braincase; palate arched upward in the middle. The middle upper incisor teeth are large, with a strong downward process and large posterior keel. The other incisors, and also the canines, are small and confusion sometimes arises from the fact that the incisors are supposed to be two above and two below.

Range.—In Indiana the typical subspecies is found throughout the state, except in the southwestern portion, where it is replaced by

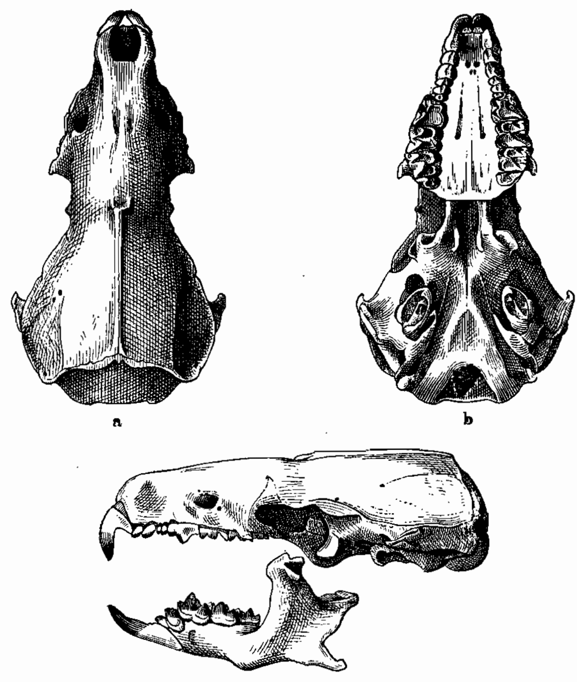


FIG. 16.—Skull of *Blarina brevicauda,* enlarged: a, dorsal view; b, ventral view; c, lateral view. After Merriam, N. Am. Fauna No. 10, Bureau of the Biol. Sur., U. S. Dept. of Agri.

the subspecies *carolinensis.* Probably one form or the other occurs in every township in the State. The range of a species, as a whole, extends from Missouri to Manitoba and east to the Atlantic.

Habits.—One of the best accounts of the habits of this species was published by Dr. John T. Plummer, of Richmond, Indiana, as early as 1844.* His observations were made on captive animals. The following are the most important points in his observations: One specimen was an adept in catching flies. It was fed some

* Amer. Journ. Sci. and Arts, Vol. 46, pp. 245-249.

cooked meat and died soon afterward, but whether from the effects of eating the meat he did not know.

Another was kept in a glass vessel about five inches deep. It moved a cover weighing one pound and escaped from the enclosure during the night. It was retaken next morning and put in a box with some decayed wood and soon made for itself a nest by building up a very compact wall of the rotten bits of wood, afterward lining its home with paper and rags which it cut into very fine bits.

It became very tame and would eat corn, insects or worms from Dr. Plummer's hand, sometimes tugging and pulling at a worm that was held between the finger and thumb. Fresh fish and meat were also eaten, as well as various grains. Excess of food was stored away for future use, but living or fresh food was preferred to that which was stale or putrid.

It learned to come at call and never failed to respond. It would usually come out of its box on hearing the buzzing of a fly, but on warm summer noons generally retired to its box and either did not hear or did not respond to this sound. Except when called out into the middle of the room, it always stayed close to the wall or crept about under furniture.

A full grown mouse placed in the box crept away into the shrew's runways. It soon emerged, however, with the shrew in full pursuit. The mouse exhibited the greatest terror and when it was finally caught, did not offer any resistance and was killed almost instantly. A younger shrew, placed in the box, was also pursued frequently. Finally it gave combat and was killed. The older shrew carried the body away to its nest and then began at once to construct a new nest.

The voice of the shrew is almost exactly like the rapid chip-chip-chip of the ground squirrel. Light and smell do not appear to have an effective range of more than one-half inch from the head of the animal. Hearing is very acute.

In a state of nature, these shrews live in tunnels and runways, which they construct under old logs, in loose soil, the dry leaves of the forest, and dense grass. They are both diurnal and nocturnal. Their food consists chiefly of insects and worms, but seeds and nuts are also eaten. Their natural ferocity is not exaggerated in Dr. Plummer's account of the killing of the mouse. I have known one, in the wild state, to kill a mouse larger than itself.

Prof. E. D. Cope has contributed the following note which further illustrates the ferocity of these animals. "I placed a water snake two feet long in a fernery which was inhabited by a shrew.

The snake was vigorous when placed in the cage in the afternoon and bit at everything within reach. The next morning the glass sides of the prison were streaked with dirt and other marks to the height the snake could reach, bearing witness to his energetic efforts to escape. He was then lying on the earthen floor in an exhausted state, while the *Blarina* was busy tearing out his masseter and temporal muscles. A large part of the flesh was eaten from the tail, and the temporal and masseter muscles and eye of one side were removed. The shrew had apparently not been bitten by the snake."

In the winter, in some localities at least, they eat large quantities of snails.

Economic status.—It is apparent from the foregoing account that the short-tailed shrew is one of the most useful of our small mammals. The amount of grain or other crops eaten by the species is insignificant, while the good it does by destroying noxious insects and other pests is considerable. The eagerness with which these animals attack mice, indicates that the latter are a regular article of food for the shrews. They sometimes enter cellars and barns and their presence should always be encouraged. They have a disagreeable odor which renders their flesh distasteful to cats and other rapacious beasts and birds.

They are fairly prolific, from two to five young being produced in each litter. The young are born in a nest of grass and leaves, usually placed under an old log. The number of litters per season and other details of their breeding habits are unknown.

The short-tailed shrews appear to be much more abundant in the northern part of the State than in the southern portion, although quite common there also.

BLARINA BREVICAUDA CAROLINENSIS (Bachman).

CAROLINA SHORT-TAILED SHREW.

Sorex carolinensis Bachman, Journ. Acad. Nat. Sci., Phil., Vol. VII, pp. 366-370, 1827.

Blarina carolinensis Baird, Mam. N. Amer., p. 45, 1857.

Blarina brevicauda (part) Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 132, 1894.

Blarina brevicauda carolinensis Merriam, N. Am. Fauna, No. 10, p. 13, 1895.

Diagnostic characters.—Similar to *B. brevicauda* but smaller and more brownish in color. The basal portion of the hair is slate-color in both forms, but in *carolinensis* the tips, instead of having a leaden gloss, are very distinctly tipped with dark glossy brown. The brown is less distinct on the belly than on the throat and upper surface.

Measurements.—Average of specimens from Monroe, Knox and Lawrence counties: Total length, 102.8 mm. (4⅛ in.); tail, 22.2 mm. (14/16 in.); hind foot, 12.6 mm. (½ in.).

Skull and teeth.—The skull is slightly smaller than typical *brevicauda* but does not differ from it in any essential respect. Skulls from Mitchell average 22 mm. in greatest length and 12 mm. in greatest breadth.

Range.—The Carolina shrew has a range extending from the gulf states north to central Indiana and an east and west distribution from the Atlantic to Arkansas. Indiana localities are: New Harmony, Southern Knox County, Bicknell, Mitchell, Bloomington, Worthington. Terre Haute, Putnam County, Brookville, Switzerland County, Ohio County. Dr. Merriam has recorded a shrew from Richmond as *B. brevicauda* (typical). Of the typical forms I have no others from farther south than Winona Lake. However, the specimens from southern Indiana cannot be regarded as typical *carolinensis,* and there is an intergrading of the two forms throughout the state, but especially in the central portion. The average size of specimens from southern Indiana is less than of those from the northern part of the State, but the differences are not constant and I have relied chiefly on color in separating the two subspecies.

Habits.—What has been said concerning the habits of the northern form of the short-tailed shrew applies with equal force to the southern form. As far as I am aware, their habits are in all respects, similar.

BLARINA PARVA (Say).

SMALL SHREW.

Sorex parvus Say, Long's Expedition to the Rocky Mts., Pt. I, p. 164, 1823.

Sorex cinereus Bachman, Journ. Acad. Nat. Sci., Phil., Vol. 7, p. 373, 1837.

Sorex harlani Duvernoy, Mag. de Zool., 2d Ser., Vol. 4, pp. 37-41, 1842.

Baird, Mam. N. Am., p. 56, 1857.

Blarina exilipes Baird, Mam. N. Amer., p. 51, 1857.

Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 132, 1894.

Blarina cinerea Baird, Mam. N. Am., p. 56, 1857.

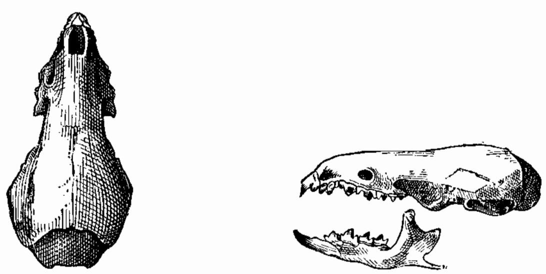
Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 123, 1894.

Blarina parva Merriam, N. Am. Fauna, No. 10, p. 17, 1895.

Diagnostic characters.—Size much smaller than the other shrews of the genus (under three inches in total length); tail not over three-fourths of an inch; color brown; eight teeth on each side of the upper jaw.

Description.—The color varies a great deal with the season. The worn summer fur is short and pale, being only a very little darker than the fawn color of Ridgway's plates. The fresh winter pelage is longer and darker; under side ash gray, generally stained with yellowish, especially on the throat and chest; tail dark; upper lip edged with white; feet whitish above, flesh color below, the colors sharply separated. A specimen taken at Mitchell on October 28 has the short summer fur still on the sides and shoulders, while the middle of the back is covered with the glossy brown of the winter coat.

Measurements.—Five specimens from Mitchell averaged: Total length, 72.4 mm. (2 14/16 in.); tail, 16 mm. (10/16 in.); hind foot,



a b

FIG. 17.—Skull of *Blarina parva*: a, dorsal view; b, lateral view. After Merriam, N. Am. Fauna No. 10, Bureau of the Biol. Sur., U. S. Dept. of Agri.

9.8 mm. (6/16 in.). This is slightly less than the average of specimens from the type locality at Blair, Nebraska.

Skull and teeth.—The skull (Fig. 17) is very much smaller than that of the other *Blarinas*. Five skulls from Mitchell average 16 mm. in greatest length and 8 mm. in greatest breadth. The widest portion is midway of the braincase and from this point forward the lateral outlines form a triangle. The braincase is more rounded than in the larger species of the genus. The dentition differs from that of the larger species also, one of the small upper premolars being absent. The skull is remarkably strong for one of its size and is not easily crushed.

Range.—The range of the species is from the Atlantic to Texas and Nebraska and from the Gulf of Mexico northward to Pennsylvania and central Indiana. In this State its range coincides closely with that of *B. b. carolinensis.* Indiana records are: Randolph County, Brookville, Ohio County, Jefferson County, Mitchell, Bicknell, Terre Haute, Putnam County and Irvington.

Habits.—The small size and retiring disposition of this little shrew make it difficult to observe, and but little is known of its habits. I have collected the species often, but have never seen it alive. The specimens I have taken were all found in grassy places, usually where briars and shrubs were mingled with the grass, but never in the woods. Its food consists largely of insects and worms, although it probably eats vegetable food also.

Genus Sorex Linnaeus.

Sorex Linnaeus, Syst. Nat., Ed. 10, Vol. I, p. 53, 1758.
Merriam N. Am. Fauna, No. 10, 1895.

Dental formula.—I, $\frac{4-4}{2-2}$; C, $\frac{1-1}{0-0}$; Pm, $\frac{2-2}{1-1}$; M, $\frac{3-3}{3-3} = 32$.

Generic characters.—Size small, total length scarcely more than four inches in our species; tail half the length of head and body or longer; body slender; eyes rudimentary; snout pointed; feet small and proportioned nearly as in a mouse; colors brownish or slaty.

SOREX PERSONATUS Geoffroy Saint Hilaire.

LONG-TAILED SHREW.

Sorex personatus Saint Hilaire, Mem. du Museum Paris, Vol. 15, p. 122, 1827.
Sorex forsteri Richardson, Zool. Journ., Vol. 3, p. 516, 1828.
Evermann and Butler, Proc. Ind. Acad. Sci., 1893, p. 139.
Sorex cooperi Bachman, Journ. Acad. Nat. Sci., Phil., Vol. 7, p. 388, 1837.
Sorex platyrhinus Baird, Mam. N. Amer., p. 25, 1857.
Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 133, 1894.
Sorex haydeni Baird, Mam. N. Am., p. 29, 1857.
Sorex personatus Merriam, N. Am. Fauna, No. 10, p. 60, 1895.

Diagnostic characters.—Size the smallest of any of our shrews and one of the smallest of all mammals; total length about four inches; tail one and a half inches; form slender and snout pointed.

Description.—Dorsal surface of body brown, brighter on rump than shoulders. The color fades gradually on the sides to a pale, silvery gray, sometimes tinged with brown on the throat and belly. There is no distinct line of demarcation between the pale color of the under parts and the darker color of the back. Hairs everywhere slaty at the base; tail dark above and light below as the body; feet pale brown. The snout is long and tapering and supports very long whiskers. The tail is about as long as the body without the head.

Measurements.—Average of eight specimens from Ann Arbor, Michigan (taken from Merriam, N. A. Fauna, No. 10): Total length, 95 mm. (3 15/16 in.); tail, 35.3 mm. (1 7/16 in.); hind foot, 11.3 mm. (7/16 in.).

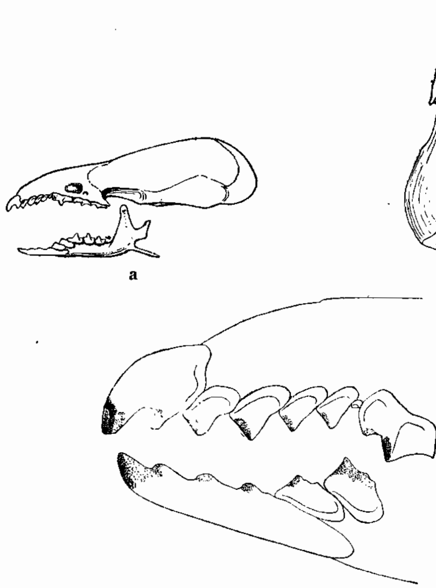


FIG. 18.—Skull and teeth of *Sorex personatus*: a, lateral view of skull; b, dorsal view of skull; c, lateral view of the anterior teeth, greatly enlarged. After Merriam, N. Am. Fauna No. 10, Bureau of the Biol. Sur., U. S. Dept. of Agri.

Skull and teeth.—The skull (fig. 18) is small and slender with a narrow, arched palate and very slender rostrum. Lower incisors ridged or notched except in very old animals with worn teeth.

Range.—From southern Canada to North Carolina and southern Indiana. In Indiana the species appears to be rare, but of general distribution. The only records which can be positively referred to this species are: North Manchester, New Harmony and

Logansport. I have trapped for it unsuccessfully in the sphagnum bogs and marshes of the northern part of the State as well as elsewhere.

Habits.—The long-tailed shrews appear to require more moist situations for their habitat than their short-tailed relatives. Like the latter, however, they most often make their homes under old logs and woodpiles and about hollow trees.

Their food consists chiefly of insects. They are active all winter and their tracks on the snow can sometimes be seen even in the coldest weather, showing where they have traveled about from log to log or stopped to search for food in the decaying wood at the base of a hollow tree.

Dr. Merriam has given us the following account of their habits: "While * * * sitting in the woods a slight rustling sometimes reaches the ear. There is no wind, but the eye rests upon a fallen leaf that seems to move. Presently another stirs and perhaps a third turns completely over. Then something evanescent, like the shadow of an embryonic mouse, appears and vanishes before the retina can catch its perfect image. Anon, the restless phantom flits across the open space, leaving no trace behind. But a charge of fine shot, dropped with quick aim upon the next leaf that moves will usually solve the mystery. The author of the perplexing commotion is found to be a curious sharp nosed creature, no bigger than one's little finger, and weighing hardly more than half a dram. Its ceaseless activity, and the rapidity with which it darts from place to place is truly astonishing, and rarely permits the observer a correct impression of its form. * * *

"Not only are these agile and restless little shrews voracious and almost insatiable, consuming incredible quantities of raw meat and insects with great eagerness, but they are veritable cannibals withal, and will even slay and devour their own kind. I once confined three of them under an ordinary tumbler. Almost immediately they commenced fighting, and in a few minutes one was slaughtered and eaten by the other two. Before night one of these killed and ate its only surviving companion, and its abdomen was greatly distended by the meal. Hence, in less than eight hours one of these tiny wild beasts had attacked, overcome and ravenously consumed two of its own species, each as large and heavy as itself."

SOREX LONGIROSTRIS Bachmann.

SOUTHERN SHREW.

Sorex longirostris Bachman, Jour. Acad. Nat. Sci. Phila., Vol. 7, Part 2, p. 270, Pl. 23, fig. 2. 1837.

Miller, N. Am. Fauna, No. 10, p. 52, 1895.

Merriam, N. Am. Fauna, No. 10, p. 85, 1895.

Amphisorex lesueuri Duvernoy, Magasin de Zoologie, Mamm., p. 33, Pl. 50, 1842.

Evermann and Butler (in part), Proc. Ind. Acad. Sci. for 1893, p. 134.

Diagnostic characters.—Size and color of *Sorex personatus,* but with the rostral portion of the skull much shorter and broader and the fourth upper incisor (third unicuspid) smaller than the third.

Description.—Dorsal surface dark rich brown, becoming paler on the sides; belly smoke gray; tail darker above than below, but the line of demarcation not very distinct; ears rather prominent.

Measurements.—Merriam gives the following as the average of six specimens from Raleigh, North Carolina: Total length, 85.6 mm. (3 7/16 in.); tail, 31.9 mm. (1 5/16 in.); hind foot, 10.7 mm. (7/16 in.).

Skull and teeth.—The specific name *longirostris* is a misnomer, for the rostrum, instead of being long, is unusually short and broad in proportion to the rest of the skull. The skull (fig. 19) is smaller than that of any of our other shrews from eastern North America. The peculiarities of the teeth have already been mentioned and can be best understood by reference to the figures (figs. 18 and 19).

Range.—As far as I am aware, this is the first published record for this shrew for any locality outside of the Carolinas. The species was described by Bachman from the swamps of the Santee river, South Carolina, in 1837. The name was ignored or reduced to synonymy until revived by Miller and Merriam in 1895. In 1842 Duvernoy described *Amphisorex lesueuri* from the Wabash River in Indiana. The identity of this species has never been certainly determined, but the discovery of the southern shrew in this vicinity makes it extremely probable that *lesueuri* is a synonym of *longirostris.*

Only one specimen is known from Indiana at present. It was taken by Mr. E. J. Chansler at Bicknell, Knox County, preserved by him in alcohol and sent to the Biological Survey at Washington. Dr. Merriam identified the specimen as *Sorex personatus,* but when the writer suggested that it might be the species under consideration he kindly had the skull removed and re-examined the specimen and states that it is an old *Sorex longirostris.*

Habits.—Nothing is known concerning the habits peculiar to this species. It is insectivorous, like all of the other shrews, and seems to live both in swamps and on high ground. The rarity of

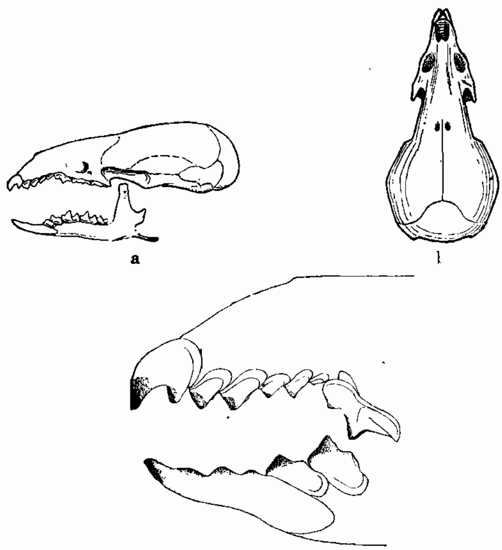


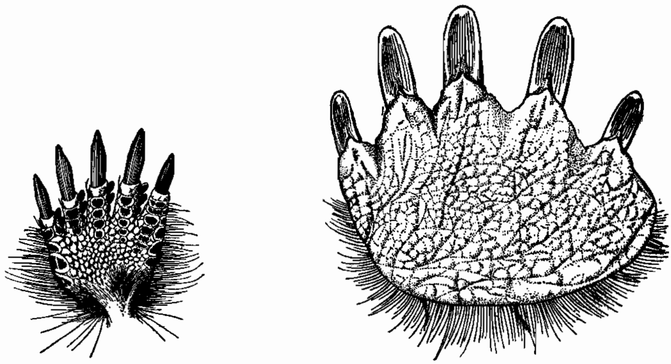
FIG. 19.—Skull and teeth of *Sorex longirostris*: a, lateral view of skull; b, dorsal view of skull; c, lateral view of the anterior teeth, greatly enlarged. After Merriam, N. Am. Fauna No. 10, Bureau of the Biol. Sur., U. S. Dept. of Agri.

this and the preceding species in Indiana add to their interest. The fact that three species were described by Duvernoy from the lower part of the Wabash Valley in this State, and that we are not now positive as to the identity of any of these species, also lends interest and makes it very desirable to secure as many specimens as possible.

Family TALPIDAE.

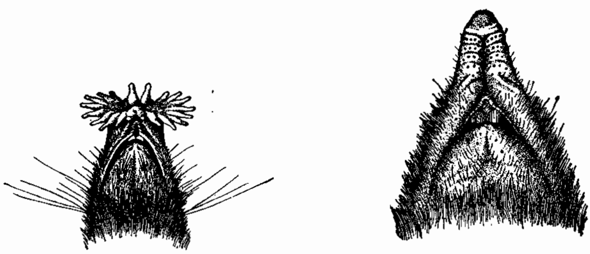
MOLES.

The moles are distributed throughout most of the northern hemisphere. Most of them exceed the shrews in size, but all resemble them in the form of the head, the character of the fur, the rudimentary eyes and external ears, and the triangular cusps of the molar teeth.



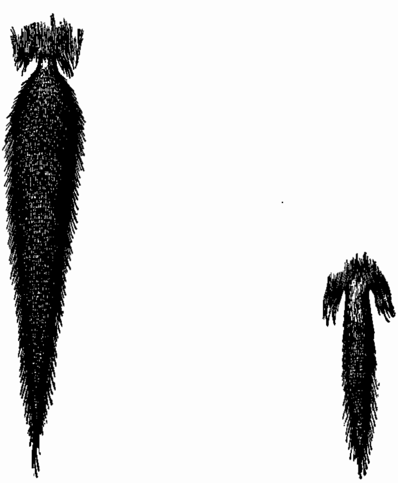
a b

FIG. 20.—Fore feet of moles: a, star-nosed mole, *Condylura cristata*; b, common mole, *Scalops aquaticus*. After True, Proc. U. S. Nat. Museum, Vol. 19.



a b

FIG. 21.—Anterior part of heads of moles seen from below: a, star-nosed mole, *Condylura cristata*; b, common mole, *Scalops aquaticus machrinus*. After True, Proc. U. S. Nat. Museum, Vol. 19.



a b

FIG. 22.—Tails of moles: a, star-nosed mole, *Condylura cristata*; b, common mole, *Scalops aquaticus*. After True, Proc. U. S. Nat. Museum, Vol. 19.

They differ from the shrews in being more perfectly adapted to an underground life. The fore feet (fig. 20) are very broad and the pectoral girdle is powerfully made to enable them to burrow. The pelvic girdle is also strong and the sacral vertebrae are partly fused. The teeth are always entirely white unless stained by food.

Genus SCALOPS Illiger.

Scalops Illiger, Prodr. syst. mamm. et avium, p. 126, 1811.

Dental formula.—I, $\frac{3-3}{2-2}$; C, $\frac{1-1}{0-0}$; Pm, $\frac{3-3}{3-3}$; M, $\frac{3-3}{3-3} = 36$.

Generic characters.—Nostrils (fig. 21b) on the upper side of the snout, not surrounded by fleshy protuberances; tail (fig. 22a) slender and uniformly tapering from base to tip, not very well covered by the sparse hair; fore feet very broad, elliptical in outline, the longest axis being transverse, and turned edgewise; claws of fore feet long.

This genus is found only in eastern North America, where it is represented by a small number of closely related forms, only one of them being known from Indiana.

SCALOPS AQUATICUS MACHRINUS (Rafinesque).

PRAIRIE MOLE.

Talpa machrina Rafinesque, Atlantic Journ., 1832, p. 61.

Scalops argentatus Audubon and Bachman, Journ. Acad. Nat. Sci., Phil., Vol. 8, p. 292, 1842.

Scalops aquaticus argentatus Coues, Bull. U. S. Geol. Surv. Terr. No. 3, p. 633, 1877.

Scalops aquaticus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 133, 1894.

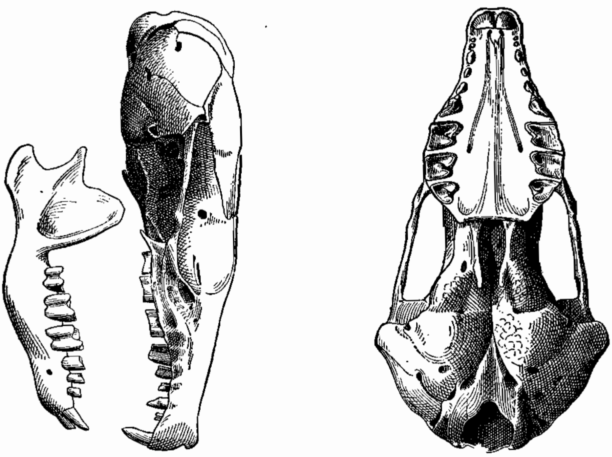
Scalops aquaticus machrinus True, Proc. U. S. Nat. Museum, Vol. 19, p. 20, 1896.

Diagnostic characters.—Feet very broad, shovel-like; color glossy plumbeous; fur soft and velvety; tail scantily haired, comparatively short, very slightly swollen in the middle. Size the largest of our American moles.

Description.—The subspecies *machrinus* is distinguished from the nearly related forms of *Scalops* chiefly by its large size. Color, glossy hair-brown, below paler with a silvery sheen; bases of the hairs everywhere dark slate color. The fore feet are about half an inch broad, placed vertically with the radial side downward; claws long; stout and flat on the ventral surface; hind feet more slender. Both fore and hind feet are flesh color; nose blackish; the nostrils completely separated and widely open; tail pale brown or flesh color.

Measurements.—Average of five from Bloomington: Total length, 172 mm. (6 14/16 in.); tail, 29 mm. (1 3/16 in.); hind foot, 26 mm. (1 in.). There is a variation in the series from 157 to 193 millimeters.

Skull and teeth.—The skull (fig. 23) is the largest of any of the moles. It is triangular in outline, with a broad, law, flat braincase,



a b

FIG. 23.—Skull of *Scalops aquaticus*: a, lateral view; b, dorsal view. After True, Proc. U. S. Nat. Museum, Vol. 19.

straight, slender zygomatic arches and tapering rostrum. The middle upper incisors are large, but, unlike those of the shrews, they have no posterior heel. The two lateral incisors are very small, as is the first premolar. The canine is about half as long as the middle incisors. Molars with w-shaped crowns. The second lower incisor is large and the lower canine is lacking. Bloomington skulls vary from 36 to 41 mm. in greatest length, with an average of 38.5 mm. and an average breadth of 19.7 mm.

Range.—This form is found throughout the upper Mississippi Valley, closely related races being found to the east and south. In Indiana it apparently occurs throughout the State, although the following localities are the only ones from which there are reliable records: Randolph County, Richmond, Brookville, Ohio County, Madison, Mitchell, Williams, New Harmony, Bloomington, Terre Haute, Carroll County, Boone County, Tippecanoe County, Winona Lake, Vawter Park, Lagrange County.

Habits.—The long ridges of loose earth and occasional heaps or "mole hills" which mark the work of moles are familiar to every farmer boy. However, there are very few people who really know anything about their habits.

Born in a chamber which is hollowed out in compact soil at a depth of eight or ten inches, the young moles are reared in darkness, learn to find food for themselves, take up their domestic duties, live on to old age and die without ever having felt the direct rays of the sun or the breath of a fresh breeze. Their life is one of almost ceaseless activity, and the amount of dirt moved by a mole in a lifetime must be enormous.

Their method of making tunnels has been described a number of times. The long claws of the hind feet are braced firmly in the bottom of the tunnel. The broad fore feet are placed, palms outward, beside the neck and they, together with pointed snout, are thrust forward into the compact soil. The feet are forced backward and outward and the head upward. The soil is, therefore, broken upward, and at the same time a quantity is pushed behind the animal. This is allowed to accumulate until several times the bulk and weight of the animal, when he pushes it back along the burrow and up to the surface to form the familiar mole hill. Where the soil is loose and the animal works near the top, most of the earth is broken upward and little is carried out. In short burrows, made only to catch a worm and not used again, the loose soil is sometimes left, and hence the hills are few in number as compared with the amount of earth actually moved.

Testimony varies as to the exact relation of the mole to the farmer. It is certainly blamed for much damage which it does not do. This is due to the fact that the pine mouse (*Microtus pinetorum scalopsoides* and *M. p. auricularis*) make somewhat similar tunnels and also use those of the moles.

On one occasion I was told that moles were eating the sweet potatoes in a certain garden. I insisted that they were not, because moles never eat sweet potatoes. As proof to the contrary, the mistress of the garden showed me their runways and a number of partially eaten sweet potatoes. I set traps and caught a young pine mouse and later found where a litter of young had been reared under the garden fence. They had done considerable damage to the vegetables and the blame had been laid at the door of the innocent moles, of which there had probably not been one in the garden all summer.

Moles are also blamed for following corn rows and eating the kernels of sprouting corn. When they do burrow in such places it is in search of cutworms and other insects rather than the corn. Here also the pine mouse is chiefly to blame, although it must be conceded that moles do sometimes uproot the corn by burrowing beneath it.

There is no doubt, however, that moles do damage at times. A beautiful lawn may sometimes be completely ruined by a family which have taken up their residence beneath it and thrust their ugly "mole hills" up through the grass. It is said that they sometimes do damage to strawberry beds by burrowing under the straw with which the latter are covered in winter, and uprooting the plants. Here again I am inclined to think the pine mouse is most often to blame, as it is fond of the roots of a number of plants and usually stays near the surface, while moles are apt to burrow deeper in winter. Both the mice and moles do harm by causing ditches to start where they have tunneled up or down clayey hillsides.

Genus Condylura Illiger.

Condylura Illiger, Prodr. Syst. Mamm. et Avium, p. 125, 1811.

Dental formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{4-4}{4-4}$; M, $\frac{3-3}{3-3} = 44$.

Generic characters.—Nostrils (fig. 21, a) at the tip of the snout, each one surrounded by a fringe of fleshy projections. The tail (fig. 22a) is nearly as long as the body without the head; it is small at the base, but much thickened about half an inch from the body, tapering from that point to the slender tip; it is sparsely haired; fore feet (fig. 20a) broad, but considerably smaller than in *Scalops*.

This genus is confined to eastern North America and contains but one known species. It is readily distinguished by the fringe about the nostrils which is unique among mammals.

CONDYLURA CRISTATA (Linnaeus).

STAR-NOSED MOLE.

Sorex cristatus Linnaeus, Syst. Nat., Ed. 10, p. 53, 1758.

Condylura cristata Desmarest, Journal de physique, Vol. 89, p. 230, 1819.

True, Proc. U. S. Nat. Museum, Vol. 19, p. 78, 1896.

Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 133, 1894.

Diagnostic characters.—Distinguished by the fleshy star about the nose.

Description.—The color is somewhat more brownish above than the common mole; paler and grayer on the under side than the upper. The feet are much smaller than those of the common moles, but are proportionally broader than with most mammals. The tail is also peculiar in that the diameter where it is joined to the body is less than half as great as it is farther away. The eyes are larger than in the other moles, but are much smaller than in most mammals.

Measurements.—Miller gives the following: Total length, 170 mm. (6¾ in.); tail, 72 mm. (2¾ in.); hind foot, 27 mm. (1 1/16 in.).

Skull and teeth.—The teeth number 44, but are much smaller than those of the common mole, the canine being the smallest of all. The skull (fig. 24) is very long and slender, highest in the middle of the braincase and depressed, anteriorly; palate very narrow; zygomatic arches straight and slender; angular process of the mandible very long and slender as it is in the shrews.

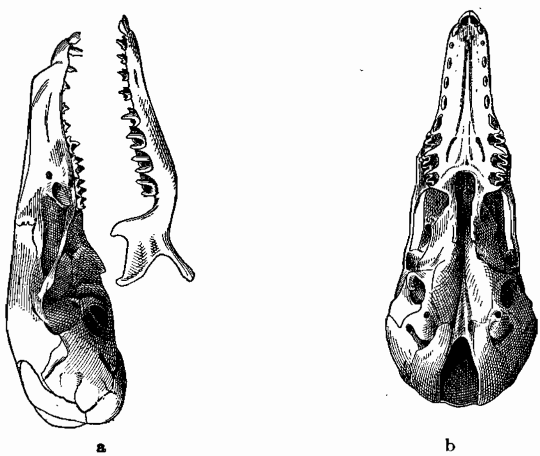


FIG. 24.—Skull of *Condylura cristata*: a, lateral view; b, ventral view. After True, Proc. U. S. Nat. Museum, Vol. 19.

Range.—The star-nosed mole is confined to eastern North America where it is found farther north than any of the other moles; the northern limit is near the shores of James Bay. In the east it is found as far south as Maryland, while Indiana is the southern limit of its range in the west.

In this State it is rare. Prof. Van Gorder has seen but one in Noble County. This one was found in 1886, while some men were moving a building. The first specimen from the State was taken near Denver, Miami County, in 1887. (Evermann, American Naturalist, Vol. 2, p. 359, 1888.) Mr. C. F. Fite, of Denver, took a specimen near that place on June 3, 1890, and another March 30, 1894. Butler recorded one from Bartholomew County. I am unable to give any other records from the State, although the species has been taken both in Ohio and Illinois.

Habits.—This mole is usually found in damp places and is said to enter the water voluntarily in the pursuit of aquatic insects. It is quite well adapted for aquatic life, and the large fore feet, primarily modified for digging, make good paddles for swimming also. The long tail no doubt serves as a rudder, much after the fashion of a muskrat's tail. The fore feet are much smaller and the shoulder girdle is weaker than in the common mole and this difference is probably a correlation with the difference in habitat; the star-nosed mole lives in softer ground and thus requires less force for digging its tunnels.

The remarkable nasal disk of this species seems to be the seat of tactile organs, of very delicate sensibility. Exactly what habits or conditions of life have brought about their development, we do not know. In the young animal the fingerlike process appear to be little more than ridges on the sides of the snout. The grooves which bound these ridges deepen and grow toward each other till they join and cut off the ridges, leaving them as processes, free from the snout except at their base.

Order CHIROPTERA.

BATS.

The members of this order are easily distinguished from all other mammals by having the fore limb modified into a wing suited for flight. In many respects bats are more highly specialized than any other group of our native animals. The structure of the sexual organs, the highly developed sensory apparatus, the peculiar habits and the adaptation for flight, including the modification of skeleton and muscle, all show that these animals have diverged far from the primitive type of mammals. On the other hand, the power of flight, together with nocturnal activity and the habit of hiding away in hollow trees, caves and other dark places, has reduced the struggle for existence to a minimum. As a result we find an inferior development of the brain and only a small mental capacity.

Family VESPERTILIONIDAE.

TYPICAL BATS.

All of the bats found in the United States belong to this family with the exception of a few species along the Gulf coast and in the southwest. The muzzle is simple without any surrounding folds of skin; the ears are well developed and always have a tragus (fig. 25, t); the bony palate is lacking in the middle line anteriorly;

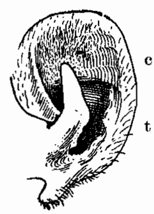


FIG. 25—Ear of a bat (*Lasiurus borealis*); c, ear conch; t, tragus.

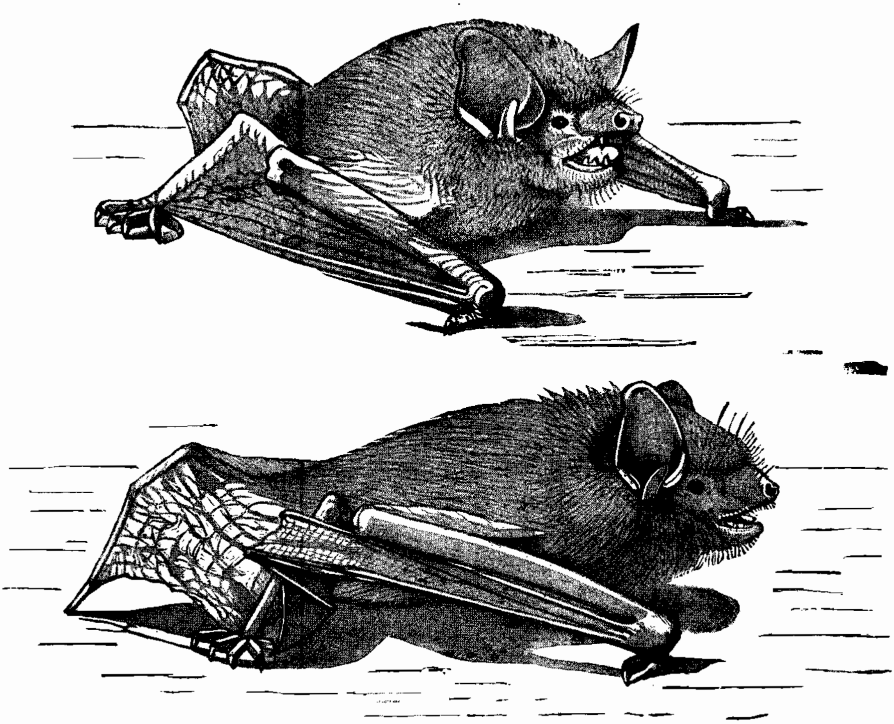


PLATE VII.—The large brown bat (*Eptesicus fuscus*) walking. After Harrison Allen, Bull. No. 43, U. S. Nat. Museum.

the teeth have w-shaped crowns with sharp cusps; the wing is highly specialized, the ulna being reduced to a splint; the interfemoral membrane is complete, reaching nearly or quite to the tip of the long tail.

The family is of world-wide distribution, being absent only from some of the smaller islands and the arctic regions.

Genus CORYNORHINUS H. Allen.

Dental formula.—I, $\frac{2-2}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{2-2}{3-3}$; M, $\frac{3-3}{3-3} = 36$.

Generic characters.—Ears very long and their bases slightly joined together across the forehead. Tragi long, narrow and pointed. A large glandular protuberance between the eyes and nostrils.

Skull (fig. 26) slender, with a high, rounded braincase and weak rostral portion. The dentition distinguishes this genus from

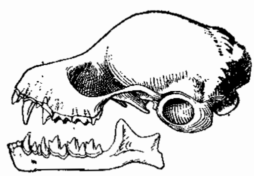


FIG. 26.—Skull of *Corynorhinus macrotis*. After Miller, N. Am. Fauna No. 13, Bureau of the Biol. Sur., U. S. Dept. of Agri.

any other found in Indiana with the exception of *Lasionycteris*, which, however, has short, broad ears and a flat, elongated skull.

The genus is represented by but one known species, with two subspecies, the entire range being from Central Mexico to the central part of the United States. Only the typical form is found in Indiana.

CORYNORHINUS MACROTIS (Le Conte).

BIG-EARED BAT.

Plecotus macrotis Le Conte, McMurtrie's Cuvier, Animal Kingdom, Vol. 1, Appendix, p. 431.

Corynorhinus macrotis Butler, Proc. Ind. Acad. Sci. for 1894, p. 86, 1895.

Miller, N. Amer. Fauna, No. 13, p. 51, 1897.

Diagnostic characters.—Easily distinguished from all other bats found in Indiana by its enormous ears, which are always more than an inch in length, measured from the crown.

Description.—The color of the back bears considerable resemblance to that of *Myotis subulatus,* described farther on. The hairs are dark brown at the base, and the outer third or a little more is golden brown; head and neck more yellowish; belly with the hairs rather darker at the base than those of the back; tips grayish white; throat and sides of breast yellowish, the color shading off gradually into that of the neck and back.

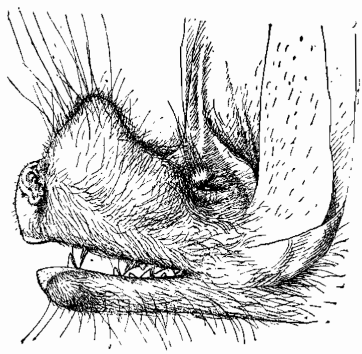


FIG. 27.—Head of *Corynorhinus macrotis* showing glandular protuberance of the nose. After Miller. N. Amer. Fauna No. 13. Bureau of the Biol. Surv., U. S. Dept. of Agri.

There is a thick glandular fold (fig. 27) arising from the muzzle just exterior to each nostril and projecting upward and inward so that the tips of the two touch. The ears are extraordinarily large for the size of the animal, almost equalling the body in length. The basal part of the anterior edges of the two are joined together across the forehead, the basal part, up to the point of union, being much thickened. The anterior edge is convex for its entire length; the posterior edge convex basally, with a slight notch just below the tip. General form of the ear, hastate. The tragus is long and gradually tapering to the narrowly rounded tip.

The membranes are thin and delicate, about the color of the basal part of the fur on the back. Fingers and fore arm the color of the surrounding membranes.

Measurements.—An adult female from Mitchell measured as follows: Total length, 92 mm. (3 11/16 in.); tail, 43 mm. (1 12/16 in.); hind foot, 10 mm. (6/16 in.); forearm, 43 mm. (1 12/16 in.); tibia, 21 mm. (1 1/16 in.).

Skull and teeth.—The skull (Fig. 26) is slender for the size of the bat. The highest point is not at the occiput, but in front of the root of the zygomata. Braincase rounded; base of the skull arched upward in the zygomatic region. Measurements of the skull of an adult female from Mitchell: Greatest length, 18 mm. (12/16 in.); length of palate, 6.5 mm. (4/16 in.); greatest breadth of braincase, 10 mm. (6/16 in.); depth over bulla, 9.5 mm. (6/16 in.); maxillary tooth row, 6.5 mm. (4/16 in.).

Range.—The southern states north to central Indiana. Until recently the species was not supposed to live north of the Ohio River. Prof. L. M. Underwood took two specimens in a cave near Greencastle, Indiana, in December, 1894, but the record published by Butler in the proceedings of the Indiana Academy for that year seems to have been overlooked. Dr. A. M. Banta took a specimen in Upper Spring Cave at Mitchell in 1902, but this was unfortunately lost. During the winter of 1906-7 the writer saw six individuals in the caves at Mitchell, two of which are now in the collection of Indiana University. In November, 1907, Dr. Charles Zeleny took another individual at the same place. It is apparent, therefore, that the species is firmly established in southern Indiana.

Habits.—I can find no published account of the habits of this species and my own acquaintance with it is not sufficiently extensive to permit a detailed description. Those that I have seen in the cave were all in dim twilight near the entrance. They hung head downward on the side walls of high passages; in one instance two of them were directly over the water. When sleeping in this position the long ears are curved backward and flattened against the sides of the neck. As far as I know this position of the ears is unique among mammals. The curve is edgewise and the upper or anterior edge of the ear forms a half ellipse. The middle of the posterior edge is formed in a number of small transverse folds. When the animals are awakened from sleep, they slowly straighten the ears, and with them erected, they are truly remarkable looking creatures.

Two of these bats which were seen on February 22, 1907, in Upper Spring Cave at Mitchell, escaped and flew out into the cold air, perching for a few moments on the rocky ledge at the mouth of the cave. The fact that all that have been seen in this region were near the mouth of the cave, may indicate that the species is not truly a cave dweller.

The long ears should make it easy to identify in flight if it comes out in the twilight. I have never seen it flying, and judge that it is a later flier. The flight of those that I have had captive, was swift and steady. In captivity, these bats seem to be delicate. Those that I have kept, refused food and soon died.

The special functions of the extraordinarily long ears and the glandular protuberances of the muzzle of this species are wholly unknown. A careful study of its habits and sensory adaptations, as well as the development and minute structure of these organs, should be well worth while.

Genus Myotis Kaup.

Myotis Kaup, Skizzirte Entw.-gesch. u. Natürl. Syst. d. Europ. Thierw., I, p. 106, 1829.

Dental formula.—I, $\frac{2-2}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{3-3}{3-3}$; M, $\frac{3-3}{3-3} = 38$.

Generic characters.—Size small; ears and tragi (fig. 28, a, b, c) slender and pointed; the latter generally straight. The only character which certainly distinguishes the species of this genus is the presence of six teeth behind the canine on each side of the upper jaw. This character is not possessed by any other bats found in eastern North America.

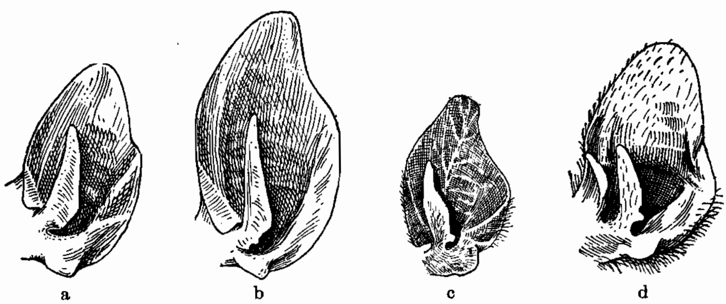


Fig. 28.—Ears of bats: a, *Myotis lucifugus* (x 2); b, *Myotis subulatus* (x 2); c, *Myotis velifer* (x 1½); d, *Pipistrellus subflavus* (x 2). After Miller, N. Am. Fauna No. 13, Bureau of the Biol. Sur., U. S. Dept. of Agri.

The genus is widely distributed, being represented by several species in each of the continents. In Indiana it is represented by three species which, to the unpracticed eye, bear a close resemblance to one another.

The following key will serve to distinguish them:

Size large; forearm 42 mm. (1 11/16 in.) or more. *grisescens.*
Size smaller; forearm never over 39 mm. (1 8/16 in.).
  Ear and tragus long, slender and gradually tapering. *subulatus.*
  Ear and tragus broad, the latter bluntly rounded. *lucifugus.*

MYOTIS LUCIFUGUS (Le Conte).

LITTLE BROWN BAT; CAVE BAT.

Myotis lucifugus Le Conte, McMurtrie's Cuvier, Animal Kingdom, Appendix, p. 431, 1831.

Vespertilio gryphus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 134, 1894.

Vespertilio subulatus Blatchley, 21st Ann. Rept. Ind. State Geol., p. 180, 1896.

Myotis lucifugus Miller, N. Am. Fauna, No. 13, p. 59, 1897.

Diagnostic characters.—A medium sized bat (expanse 10 in.), varying in color from glossy wood brown to dull blackish; ears when laid forward, barely reaching the nostrils; tragus short, broad at the base, and blunt (fig. 28, a); the most common bat in southern Indiana.

Description.—It is difficult to formulate a description which will enable anyone not familiar with bats to distinguish this species from the next with certainty. The hairs of the back are always sooty blackish at the base and this is usually concealed by the tips of gloosy wood- or chestnut-brown. Occasionally the tips are also dull sooty or clove brown. The belly is always paler and usually has a yellowish tinge. In *subulatus* the back is apt to have a grayer tinge while the hairs of the under side are usually, but not always, pure white or silvery without the yellow tinge. Membranes and ears dull blackish.

Ears rather short and blunt, broad at the base and suddenly becoming narrower one-third of the distance from the tip; tragus short, wide at the base, blunt and bent forward; membranes thick and naked except a narrow row of fur nearest the body and a few short hairs scattered over the surfaces; interfemoral and wing membranes arising from the base of the toes; calcar slender, with a narrow edge of membrane posterior to it.

Measurements.—Average of ten individuals from Mitchell: Total length, 89.4 mm. (3 9/16 in.); tail, 38.7 mm. (1½ in.); hind foot, 9.9 mm. (⅜ in.); forearm, 37.4 mm. (1½ in.); tibia, 16.6 mm. (⅝ in.); ear, 11 mm. (7/16 in.).

Skull and teeth.—The skull, for a *myotis,* is froad and has a gradually sloping forehead. The face line begins to rise almost from the tip of the muzzle, while in *subulatus* the braincase rises abruptly in the region of the eyes; braincase broader and higher in *lucifugus;* muzzle also broader and the skull, as a whole, appears to be much stronger and heavier; tooth row shorter in *lucifugus;*

first upper premolar much larger than the second; third upper premolar not high in proportion to its width as it is in *subulatus*. Cranial measurements for ten specimens from Mitchell average: Greatest length of skull, 15 mm. (10/16 in.); length of palate, 6.7 mm. (1/4 in.); maxillary tooth row, 6.9 mm. (1/4 in.); greatest width of braincase, 7.8 mm. (5/16 in.); depth of braincase over audital bulla, 6.9 mm. (1/4 in.).

Range.—This species is found from Newfoundland to Kamchatka and south to Florida and Texas. The typical species seems to be absent, however, from the Rocky Mountain region where it is replaced by a slightly different form. In Indiana it occurs throughout the state but is most abundant in the cave region of the southern part.

Habits.—The bats of this species are typically cave dwellers. In winter they collect in the caves of southern Indiana in enormous numbers. Blatchley records taking 401 from one and seven-tenths square feet of the roof of Saltpetre Cave, in Crawford County. In Wyandotte Cave they gather by the thousands and in the many caves, large and small, which I have entered, not one has been without bat inhabitants in winter. During the summer they leave the caves and become scattered over wide areas. Temporary dwellings are found in hollow trees, attics and deserted buildings.

Bats differ from most of the higher animals in that they never construct or occupy any sort of nest or den. Any cranny where the light is not too intense and the temperature is moderate, serves them for a temporary abode. They do not even trouble themselves to return to the same place on successive days.

The young are fairly well developed when born. They cling to the mother's fur and are carried about by her, at least while very young. Some species, and perhaps all, later leave their offspring in some secluded nook and return for them when they have finished feeding. The number of young differs for different species. For *Myotis lucifugus* it is probably one or two. They are born some time in June and grow rapidly, maturing before the end of September.

Mating occurs in November (perhaps in October and December also), but the ova are not fertilized until the bats leave the cave in April. The spermatozoa remain alive in the uterus of the female throughout the winter.

The food of bats consists wholly of insects. So many of these are eaten by each individual and the animals themselves are so numerous that they are almost as beneficial to man as birds. The feeling of detestation which most people have for them is therefore wholly without warrant. They never become noxious except when, as sometimes happens, they gather in great numbers in the attic of a dwelling. At such times the odor becomes very offensive. They are also infested by many parasites, of which the bedbug is one, and these sometimes overrun a house which the animals inhabit. It is, however, comparatively easy to get rid of them by covering the holes by which they enter with screen wire. The fumes of formaldehyde or bisulphide of carbon will drive them away if the attic is reasonably tight.

There is no reason to believe that bats have decreased in number since the country was first settled. Their nocturnal habits protect them well from man. Birds and beasts of prey cannot get them easily because they hide away in inaccessible places when at rest and their swift, erratic flight makes it difficult for even the owls to catch them, while hawks and other diurnal birds of prey get them only by accident. So greatly has their freedom from danger modified their habits, that the feeling of fear is almost lacking.

MYOTIS SUBULATUS (Say).

THE SAY BAT.

Vespertilio subulatus Say, Long's Exped. to the Rocky Mts., Vol. 2, p. 65 footnote, 1823.

Vespertilio gryphus lucifugus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 134, 1894.

Myotis subulatus Miller, N. Am. Fauna, No. 13, p. 75, 1897.

Diagnostic characters.—Resembles the preceding species in size and often in color; ears longer and more slender, reaching beyond the tip of the nose when laid forward; tragus longer and more pointed (fig. 28, b); skull more slender and with the braincase rising more abruptly from the rostrum.

Description.—Hair dusky at the base; hairs of the back usually smoky brown, seldom tipped with glossy brown; after moulting in late summer, often having a dull golden tinge; hairs of under surface seldom brownish or yellow, generally silvery white. Fur denser and softer than that of *M. lucifugus.* Ears and membranes more grayish than those of the preceding species.

The ears are long and slender, reaching two millimeters or more beyond the nose when laid forward. The posterior border tapers more uniformly than *lucifugus* and the point is less blunt. The tragus is long, slender, nearly straight and uniformly tapering to the narrowly pointed tip.

The membranes are thinner and paler than in *lucifugus,* but in all other respects similar. Calcar longer, more slender and ending indistinctly in the membrane.

Measurements.—Average of ten from Mitchell: Total length, 87.9 mm. (3½ in.); tail, 37.6 mm. (1½ in.); hind foot, 9.9. mm. (6/16 in.); forearm, 37.6 mm. (1½ in.); tibia, 17.4 mm. (11/16 in.); ear, 12.7 mm. (½ in.).

Skull and teeth.—The differences in the skulls of the two species are sufficiently characterized under *M. lucifugus.* Average measurements of ten individuals from Mitchell: Greatest length, 15.3 mm. 10/16 in.); length of palate, 7.3 mm. (5/16 in.); maxillary tooth row, 7.3 mm. (5/16 in.); greatest width of braincase, 7.1 mm. (5/16 in.); depth of braincase over audital bulla, 7.4 mm. (5/16 in.).

Range.—*Myotis subulatus* is found over practically the whole of North America east of the Rocky Mountains. In Indiana it occurs throughout the State, but is much less abundant than the preceding species. In the caves I have explored, I have found the proportion to be about one of this species to 20 of *M. lucifugus.*

Habits.—The present species, like the preceding one, is a cave inhabiting bat. In most of the published records of this State the common cave bat is erroneously called *Myotis subulatus.* As a matter of fact, the records are for *lucifugus,* while the present species has been entirely overlooked because of its close resemblance to its congener.

The habits of the two species are very similar and the statements made above as to food, breeding habits and relation to man apply, as far as known, with equal force to both. The Say bat begins to return to the caves earlier than the little brown bat, and outnumbered the latter in the Shawnee cave during August, 1907. In captivity the present species appears to be somewhat the more active and intelligent.

The ability of all of the cave inhabiting species to find their way through the tortuous passages of the caves where darkness is absolute, is one of the most remarkable things to be found in the mental makeup of animal. Experiments made by the author show that they do not depend upon sight for guidance. The animals were able to avoid wires stretched in a room, as well when the eyes were covered as when open. Removing the external ears was also without effect. But when the auditory meatus was stopped, their ability to avoid obstacles was greatly diminished. Covering the body hairs and membranes with a sticky substance, thus rendering them less sensitive, also had a marked effect.

It is probable that the flying bats perceive objects through the medium of the ears when the air between the moving animal and some solid body is condensed. The condensation of the air also stimulates the delicate organs of touch which are located about the base of the hairs on the body and membranes.

Bats have great agility in the air and can alight on a vertical wall or other object which is not perceived until they are within a couple of inches of it. This agility enables them to escape injury by striking head on, against the sides of the cave.

These animals quickly learn to go to a definite location for food or to escape confinement. A *Myotis subulatus* which I had in captivity, readily learned to go to a certain spot in its cage marked by a piece of white cloth. When the cage was turned so that the cloth was on the west side instead of the east as before, the bat still went to the east side instead of to the cloth. This experiment and others like it show that the animals do not depend on sight, hearing, smell or taste for orientation. They have a sense of direction apart from the other senses. This may be truly a sixth sense, located in the muscles and joints or in the semicircular canals; or it may be due to the ability of the animals to quickly render an act automatic, as a blind man learns, after long experience, to go about places with which he is familiar.

MYOTIS GRISESCENS Howell.

GRAY BAT.

Myotis grisescens Howell, Proc. Biol. Soc., Washington, Vol. 22, 1909.

Myotis velifer Miller, N. Am. Fauna, No. 13, p. 56, 1897.
Hahn, Proc. U. S. Nat. Museum, Vol. 35, p. 580, 1908.

Diagnostic characters.—Easily distinguished from any other *Myotis* known to occur in the eastern United States by its large size. The forearm measures 40 mm. (1 2/3 in.) or more.

Description.—The color does not differ markedly from that of other species belonging to this genus. The back is light sepia in color and the belly much paler. In a specimen from Mitchell there are white hairs about the mammæ and along the middle line of the belly, and blackish spots on the shoulders.

The ears (fig. 28, c)[a] are rather short, narrow and pointed, reach-

[a]This figure was inserted when it was supposed that the species under consideration was *M. velifer.* Howell has recently described it as *grisescens,* but the ears are similar in the two species.

ing to or slightly past the level of the nostril when laid forward. The anterior border is very convex except near the tips, where it is slightly concave. Tragus long; the anterior edge straight, the posterior convex for the basal two-thirds, then suddenly tapering to the narrow, rounded tip.

The membranes are very sparsely haired, thick and leathery, and about the color usually found in *M. lucifugus*. Calcar slender and longer than the free border of the interfemoral membrane.

Measurements.—From a single adult female taken at Mitchell: Total length, 97 mm. (4 in.); tail, 40 mm. (1 10/16 in.); hind foot, 10 mm. (6/16 in.); forearm, 44 mm. (1 13/16 in.); ear, 12 mm. (½ in.).

Skull and teeth.—The skull is large and heavily built, resembling *M. lucifugus* in form, but easily distinguished by its larger size. Measurements of one skull from Mitchell: Greatest length, 16 mm. (11/16 in.); length of palate, 8 mm. (5/16 in.); maxillary tooth row, 7 mm. (¼ in.); greatest width of braincase, 8.5 mm. (6/16 in.); depth of braincase over bullae, 7.5 mm. (5/16 in.).

Range.—Known only from Tennessee, Missouri and Indiana. In Indiana but one specimen has been taken. It was an adult female captured in Twin Cave at Mitchell on August 9, 1907. The condition of the mammæ showed that the animal had nursed during that summer. It was sent to Mr. A. H. Howell, of the Biological Survey, who identified it as *Myotis velifer,* and it was so recorded by the writer (loc. cit.). Later Howell mentions this specimen in his description of *M. grisescens* from Nickajack Cave, Tennessee.

Habits.—Nothing is known of the distinctive habits of this species. As far as I am aware, it has never been found far from caves, and it is characteristically a cave dweller.

Genus Lasionycteris Peters.

Dental formula.—I, $\frac{2-2}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{2-2}{3-3}$; M, $\frac{3-3}{3-3} = 36$.

Generic characters.—Ears and tragus short and broad, the former with a large basal lobe; color blackish; interfemoral membrane furred on top on the basal half. The skull (fig. 29) is broad and flat, the rostral portion being very broad in proportion to the size of the skull. The braincase rises gradually from the muzzle and its dorsal profile is nearly straight.

The genus contains but one species which is distributed throughout the United States and southern Canada. Its dental formula differs from that of any other bat found in this State with the exception of *Corynorhinus,* which, however, has enormous ears, nearly equalling the entire body in length, whereas the ears of *Lasionyteris* are short and barely reach to the nostril when laid forward along the head.

LASIONYCTERIS NOCTIVAGANS (Le Conte).

SILVER-HAIRED BAT.

Vespertilio noctivagans Le Conte, McMurtrie's Cuvier, Animal Kingdom, Vol 1, p. 31, 1831.

Lasionycteris noctivagans Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 134, 1894.

Lasionycteris noctivagans Miller, N. Am. Fauna, No. 13, p. 86, 1897.

Diagnostic characters.—Color blackish, many of the hairs being tipped with silvery white; ears short and broad; interfemoral membrane partly furred.

Description.—The name silver-haired bat may lead the novice to mistake one of the species of *Lasiurus* for the present one. The silver-haired bat is always to be distinguished from those by its dental formula, by the incomplete furring of the interfemoral membrane, and by the fact that the hairs are dark brown or black except for the white tips on some of them, whereas in *Lasiurus* the hairs have a broad light band near the middle. No other bat in this region resembles it in color and in the short ears and tragi.

The ears are short and nearly as broad as long, reaching barely to the nostril when laid forward. The tragus is short and broad; its posterior edge very convex; anterior edge nearly straight; tip rounded. The interfemoral membrane is partly covered with hair on the dorsal side.

Measurements.—Average of ten specimens from Sing Sing, New York (copied from Miller, N. Am. Fauna, No. 13): Total length, 105.8 mm. (4 3/16 in.); tail, 42.4 mm. (1 11/16 in.); hind foot, 7.9 mm. (5/16 in.); forearm, 41.1 mm. (1 11/16 in.); tibia, 17.1 mm. (11/16 in.); ear (from meatus), 15.9 mm. (10/16 in.).

Skull and teeth.—The skull (fig. 29) is rather long and slender, with braincase and palate broad, and the rostrum pinched and narrow. The dorsal outline is nearly straight, the braincase being elevated but little above the face.

Range.—North America as far south as Nebraska and Pennsylvania, and in the mountains to North Carolina. In Indiana I have never encountered it in the southern part of the State. The localities are Franklin County, Indianapolis, Michigan City. In the northern part of the State it seems to be one of the commonest bats. It has been taken frequently in Chicago and there are several in the collection of the Chicago Academy of Sciences.

Habits.—The writer has never made the personal acquaintance of this bat. It is a tree dweller and is not known to winter in caves. It is known to migrate southward in winter and probably does not stay in the southern half of this State during the summer.

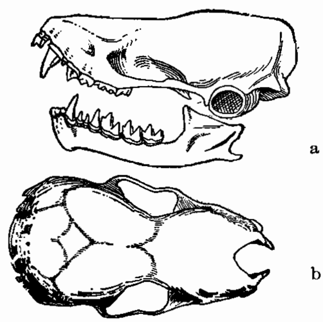


FIG. 29.—Skull of *Lasionycteris noctivagans*: a, lateral view; b, dorsal view. After Miller. N. Am. Fauna No. 13, Bureau of the Biol. Sur., U. S. Dept. of Agri.

Dr. Merriam, in his "Mammals of the Adirondacks," says of it: "Like many other bats it has a decided liking for waterways, coursing up and down streams and rivers, and circling around lakes and ponds. At some places its habit of keeping directly over water is very marked. * * * Several that were wounded and fell into the water at a distance of fifteen or twenty feet from the bank, swam ashore. They swam powerfully and swiftly, for the current was there quite strong and would otherwise have carried them down stream."

Dr. Merriam tells about finding thirteen young in a deserted crow's nest. They were naked and the eyes were closed. The young are generally two in number and are born about the first of July. They commence to fly when three weeks old. The same author gives an account of the finding of an immense colony of these bats in a hollow tree in the edge of Lake Umbagog on June 18, 1880.

Genus Pipistrellus Kaup.

Pipistrellus Kaup, Skizzirte Entwick. Gesch. u. natürl. Syst. d. europ. Thierw., I, p. 98, 1829.

Dental formula.—I, $\frac{2-2}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{2-2}{2-2}$; M, $\frac{3-3}{3-3} = 34$.

Generic characters.—The American species of this genus are small and weak. The ears (fig. 25, d) are proportioned much as in *Myotis*, but the tragus is bent forward at the tip. The Indiana species further differs from any of the *Myotis*, in this region, in that the forearm and fingers are paler in color than the wing membranes about them.

The skull is small and weak, but broad for its size and rounded. The genus can always be distinguished from our other bats by its dentition, the formula being different from that of any other American genus.

The genus is of almost world-wide distribution, though not known from South America. The single species occurring in Indiana is the smallest of our bats and one of the smallest mammals known.

PIPISTRELLUS SUBFLAVUS (F. Cuvier).

GEORGIAN BAT.

Vespertilio subflavus F. Cuvier, Nouv. Ann. Mus. d'Hist. Naturelle, Paris, p. 17, 1832.

Vesperugo carolinensis Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 135, 1894.

Pipistrellus subflavus Miller, N. Am. Fauna, No. 13, p. 90, 1897.

Diagnostic characters.—The smallest bat found east of the Mississippi and the only one having the dental formula given above. Color, light yellowish brown, the hairs being darker at the tips, but these are too short to hide the predominant tint.

Description.—The color is pale golden brown, overlaid on the back by the darker chestnut tips of the hairs. On the under side the general color appears paler because the darker tips are lacking. The hairs are everywhere plumbeous at the base. Ears and membranes blackish, but the forearms and fingers of the living animals are always yellowish brown in contrast to the darker membranes surrounding them.

The ears (fig. 25, d) are of moderate length, reaching to, or slightly beyond the nostril when laid forward. In shape they bear a strong resemblance to *Myotis lucifugus*, but the tip is more bluntly rounded. Tragus short and broad with the posterior border strongly convex at the base; tip blunt; anterior border straight, but considerably bent forward.

The membranes are thin and delicate, with a few short hairs scattered over their surfaces. The wing membrane is attached at the base of the toes; the interfemoral at the tarsus. Calcar very slender and short; thumb proportionally large.

Measurements.—Average of ten from Mitchell: Total length, 78.4 mm. (3 2/16 in.); tail, 35.3 mm. (1 7/16 in.); hind foot, 8.8 mm. (5/16 in.); forearm, 33.3 mm. (5/16 in.); ear, 9.5 mm.

Skull and teeth.—The skull (fig. 30) is small and light, with a narrow muzzle and very convex braincase; teeth small; the average

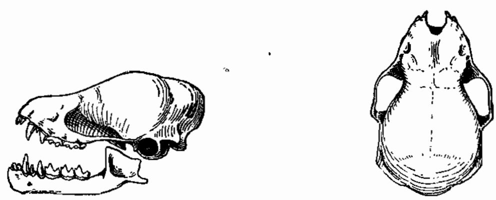


FIG. 30.—Skull of *Pipistrellus subflavus*: a, lateral view; b, dorsal view. After Miller, N. Am. Faunt No. 13, Bureau of the Biol. Sur., U. S. Dept. of Agri.

cranial measurements of ten specimens from Mitchell are: Greatest length, 13.4 mm. (½ in.); length of palate, 5.5 mm. (3/16 in.); maxillary tooth row, 5.6 mm. (3/16 in.); greatest width of braincase, 7.2 mm. (5/16 in.); depth of braincase over bulla, 6.4 mm. (¼ in.).

Range.—Eastern United States, from southern New York to Iowa and south to Texas and Alabama. In Indiana it is apt to occur all over the State, but the only records are from the southern half. Next to *Myotis lucifugus,* it is the most abundant bat in the caves of Monroe and Lawrence counties. It has also been recorded from Franklin County. A specimen taken at Mitchell on November 16, 1906, resembles the northeastern form, *Pipistrellus subflavus obscurus* Miller, in its darker and duller coloration.

Habits.—The habits of this species resembles those of the other cave bats. They leave the cave later in the spring and the majority return later in the fall than do the species of *Myotis.*

Mating takes place about the end of November and the young are probably born in July. The single pregnant female which I have examined contained three very small embryos on the 6th of June.

In flight this species is readily distinguished by its small size and the weak fluttering of its wings which makes it resemble a butterfly rather than a bat. The animals are so small and weak that they certainly can not capture and eat large beetles or other large insects. Their food probably consists chiefly of small diptera and moths. The species usually flies high over the open fields when feeding. These bats readily learn to eat fresh meat when in captivity.

The Georgian bat usually clings to the side walls of the higher passages while in the caves. It is less active than the other species of cave bats. Observations in the caves at Mitchell during the winter of 1906-7 showed that *Myotis lucifugus* rarely stayed in one spot more than a week, while *Pipistrellus* often slept in one spot for a month. Hibernation is not uninterrupted in either species, however.

Genus EPTESICUS Rafinesque.

Eptesicus Rafinesque, Annals of Nature, p. 2. 1820.

Dental formula.—I, $\frac{2-2}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{1-1}{2-2}$; M, $\frac{3-3}{3-3} = 32$.

Generic characters.—Size large (in American species); muzzle broad; ears and membranes thick and leathery, the former of moderate length and rather narrow; tragus broad, but pointed. The skull is very large and heavy, broad and flat on top, with a nearly straight dorsal profile; teeth large and strong.

The bright brown color, large size and heavily built body serve to distinguish this genus from any other found in this region. The strong, flat skull and the dental formula also differ from those of any other bat of this region.

This genus has been generally called *Vespertilio* by the more recent writers. Miller* has, however, restricted the latter name to two European species. Under his arrangement, *Eptesicus* contains about 45 species of very general distribution. One species, with five subspecies, is North American.

EPTESICUS FUSCUS (Beauvois).

LARGE BROWN BAT.

Vespertilio fuscus Beauvois, Catalog Peale's Museum, p. 14, 1796.

Adelonycteris fuscus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 134, 1894.

* Families and genera of bats, Bulletin 57 of the U. S. National Museum, p. 208.

Vespertilio fuscus Miller, N. Am. Fauna, No. 13, p. 96, 1897.

Eptesicus fuscus Miller, Bull. 57, U. S. Nat. Mus., p. 208, 1907.

Diagnostic characters.—Size large (four inches or more). Color bright glossy brown; skull very broad, massive and low.

Description.—The color of the back is always a rich glossy brown, although the shade varies considerably. The underside is paler, the belly being sometimes a yellowish gray, oftener light brown; the throat and upper part of the breast usually darker than the belly. The muzzle is covered with short, blackish hairs.

The ears are of moderate length, reaching to the level of the nostrils when laid forward; anterior edge distinctly thickened and the whole ear conch very thick and leathery; anterior edge convex its whole length; posterior concave just below the broadly rounded tip; tragus rather short and blunt at tip. The membranes are thick and blackish. The forearm and fingers are paler on the under side and contrasting strongly with the membrane. Calcar about equal to free edge of interfemoral membrane and, like the limbs, rather strong. Wing membrane arising from the base of the toes; interfemoral from the tarsus.

Measurements.—Adult male from Mitchell: Total length, 107 mm. (4¼ in.); tail, 47 mm. (1 14/16 in.); hind foot, 11 mm. (7/16 in.); forearm, 45 mm. (1 13/16 in.); ear, 11 mm. (7/16 in.).

Skull and teeth.—The skull (fig. 31) is very large and flat; the braincase is somewhat wedge-shaped; the interorbital constriction

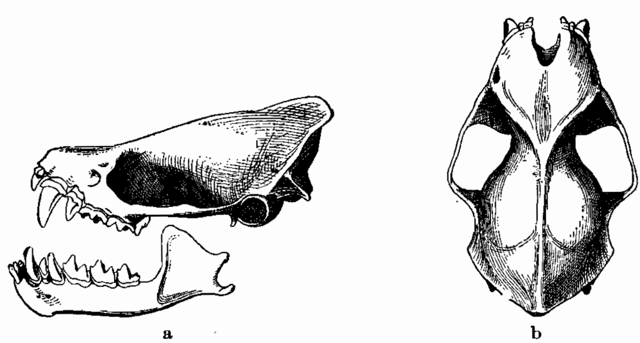


FIG. 31.—Skull of *Eptesicus fuscus*: a, lateral view; b, dorsal view. After Miller, N. Am. Fauna No. 13, Bureau of the Biol. Sur., U. S. Dept. of Agri.

is deep; in old individuals there is a prominent median ridge which divides at the interorbital constriction and runs forward as two fronto-maxillary ridges. There is a marked depression on either side of the median line of the rostrum; braincase flat. The jaws are strong and the teeth large. Cranial measurements of an adult male are as follows: Greatest length of skull, 20 mm. (13/16 in.); length of palate, 9 mm. (6/16 in.); maxillary tooth row, 9 mm. (6/16 in.); greatest width of braincase, 10 mm. (7/16 in.); depth of braincase over bulla, 8 mm. (5/16 in.).

Range.—North America, from Mexico to the colder regions of Canada. In Indiana it doubtless occurs all over the State, although it has been reported only from Vigo, Lawrence and Monroe counties in the southwestern part. It is not abundant in the caves of southern Indiana, but individuals are seen not infrequently.

Habits.—This bat lives well in captivity, and will eat any kind of meat. It goes to a dish for food or picks it up from the floor more readily than any of the smaller species. Its large teeth and powerful jaws would seem to fit it for a carnivorous diet, but there is no evidence that it feeds on anything except insects.

The large brown bat is, perhaps, less truly a cave dweller than the species of *Myotis* found in this region. Among some thousands of the latter which the writer has observed in Indiana and Kentucky caves, only ten of this species were found. It is frequently seen flying in summer and the figures above, probably do not represent the correct proportion of the species in our fauna. All of the ten individuals collected were near the entrances of the cave where daylight reaches. It would seem, therefore, that many individuals migrate in winter. In common with other bats, they live in trees and buildings in summer and resort to caves rarely, if at all. Witmer Stone says of it: "About Philadelphia this is our commonest species. The large brown bat is always distinguished on account of its size, which, in the uncertain twilight, is often exaggerated. * * * It is seen late in autumn and on mild evenings in midwinter, and not infrequently enters houses during the latter season."

Genus LASIURUS Gray.

Lasiurus Gray, Zoological Miscellany, No. 1, p. 38, 1831.

Dental formula.—I, $\frac{1-1}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{2-2}{2-2}$; M, $\frac{3-3}{3-3} = 32$.

Generic characters.—Size medium or large; ear and tragus very short, blunt and broad, the latter bent forward, the former furred over most of its outer surface; interfemoral membrane densely furred over all its upper surface. The skull is broad, short and deep, the rostrum being broader than long. The single upper incisor distinguishes the skulls of this genus from any other known to occur within the State; the genus *Nycticeius,* of probable occurrence, has but one incisor, but it has one less premolar than *Lasiurus.* Externally, the thickly furred interfemoral membrane is the best distinguishing character.

The genus is represented by about twelve species, and is found in both Americas and west to Hawaii. Two species are found in Indiana. They may be distinguished by the following characters:

Size large; forearm 50 mm. (2 in.) or more; color brown, overlaid with white. *cinereus.*

Size smaller, forearm not over 42 mm. (1 11/16 in.); color distinctly red, with white tipped hairs. *borealis.*

LASIURUS BOREALIS (Müller).

RED BAT.

Vespertilio borealis Müller, Natursystem, Suppl., p. 21, 1776.

Atalapha noveboracensis H. Allen, Monog. Bats, N. Am., p. 142. Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 134, 1894.

Lasiurus borealis Miller, N. Am. Fauna, No. 13, p. 105, 1897.

Diagnostic characters.—Color bright reddish, overlaid with gray tipped hairs; interfemoral membrane densely furred on dorsal side.

Description.—The hair is dark chocolate brown at the base with a broad band of light yellowish following. Next comes a rather narrow band of the characteristic color which is a sort of chestnut or rufous red. Most of the hairs on the back are minutely tipped with whitish, which gives the coat a frosted appearance. The red is paler on the head and belly. Breast the same color as the back. Hairs of face yellowish, without the white tips, as are those of the belly and interfemoral membrane. There is whitish patch in front of the shoulder.

The ears (fig. 25) are very short, not reaching to the nostril when laid forward. The tips are very broadly rounded; dorsal surface heavily, and inner surface scantily furred. The tragus is short, very broad and bent forward, the anterior edge concave; the posterior edge convex, with a shoulder which sometimes is so prominent as to give the dried specimens the appearance of having a bifid tip. The membranes are rather thin and of a dark chocolate brown color. The fingers and forearm are light reddish brown. Hair extending on the wing membranes for about half an inch and covering the entire dorsal surface of the interfemoral membrane and feet; wing membrane densely furred on the under side along the forearm and base of the fifth finger.

Measurements.—Three specimens from Bloomington average: Total length, 104.3 mm. (4 3/16 in.); tail, 53 mm. (2 2/16 in.); hind foot, 7.3 mm. (5/16 in.); forearm, 41 mm. (1 11/16 in.); tibia, 20 mm. (12/16 in.); ear (from meatus), 11 mm. (7/16 in.).

Skull and teeth.—The skull (fig. 32) is short and heavy. The braincase is high, but slopes evenly to the muzzle; zygomatic arches

a b

FIG. 32.—Skull of *Lasiurus borealis*: a, lateral view; b, dorsal view. After Miller, N. Am. Fauna No. 13, Bureau of the Biol. Sur., U. S. Dept. of Agri.

prominent; palate broad; rostral region with a median depression. The teeth are large, the molars having very large grinding surfaces and the canines being thick and strong. The skull is one of the most easily recognized of our bats. Measurements of a skull from Winona Lake: Greatest length, 14 mm. (13/16 in.); length of palate, 6 mm. (4/16 in.); maxillary tooth row, 5 mm. (3/16 in.); greatest breadth of braincase, 8 mm. (5/16 in.); depth of braincase over audital bulla, 8 mm. (5/16 in.).

Range.—From Florida and Texas to the colder parts of British America. In Indiana it is a common bat throughout the State, although not taken as often as some of the other species because it does not frequent caves. It is recorded from Winona Lake, Wabash, Carroll, Vigo and Noble counties, and from Mitchell, Bicknell, Richmond, Denver and Bloomington; also from Chicago, Illinois.

Habits.—The red bat is an inhabitant of the forest, where it lives in hollow trees and among the leaves and branches. Stone states that they congregate in caves in immense numbers, and Merriam also speaks of them entering caves. The writer has had extensive acquaintance with the cave fauna of Indiana and Kentucky, but has never met with this species living in the caves. Dr. A. M. Banta, who has studied the cave fauna of this region extensively, has had the same experience.

However, there is evidence that these bats once frequented caves. In a large chamber of Shawnee Cave at Mitchell, more than two hundred skulls of the red bat were found among the masses of fallen stone that cover the floor. A few were also found in Upper Spring Cave at Mitchell. In the same chamber, only about twenty skulls were found of the three species which now congregate there by the hundred. The red bat was sometimes seen flying about in this vicinity in the early twilight of the summer evenings, and it is quite common at Bloomington. Its absence from the caves can not be attributed to its absence from the region. The facts indicate that the habits of the species have been changing and that it has abandoned the cave dwelling habit (at least in this region) in recent times.

This is one of the species of bats said to have a seasonal migration. It has never been found in northern latitudes in winter, and has been taken in southern localities at that season, from which it is absent in summer.

The females of this species have two pairs of teats, whereas most bats have but a single pair. In correlation with this structural peculiarity, they bear a larger number of young than most bats. The most frequent number is, perhaps, three. Two are quite frequent and there are two instances on record of females containing four embryos.

A female dissected at Bloomington contained three embryos about two millimeters in length. The young are probably born about the middle of June. They are darker in color than the adults.

Godman relates an incident which shows the maternal instinct to be strong in these animals. "In June, 1823, the son of Mr. Gillespie, keeper of the city square, caught a young red bat which he took home with him. Three hours afterward, in the evening, as he was conveying it to the museum in his hand, while passing near the place where it was caught, the mother made her appearance, followed the boy for two squares, flying around him, and finally alighted on his breast, such was her anxiety to save her offspring. Both were brought to the Museum, the young one firmly adhering to its mother's tail."

Coues and Yarrow state that this species mates in the air while flying, but this statement needs confirmation, as all other species of bats whose mating habits are known mate while at rest.

LASIURUS CINEREUS (Beauvois).

HOARY BAT.

Vespertilio cinereus Beauvois, Catalog Peale's Museum, p. 14, 1796.

Atalapha cinerea Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 135, 1894.

Lasiurus cinereus Miller, N. Am. Fauna, No. 13, p. 112, 1897.

Diagnostic characters.—The largest bat found in Indiana; length over five inches; forearm two inches, color grizzled gray; interfemoral membrane densely furred above.

Description.—The arrangement of the color bands of the hair is like that of *L. borealis*. However, the band next to the hoary tips is dark chocolate, instead of red, and the white tips are longer and more numerous. On the head, the white tips are shorter and the next band is yellowish brown. On the belly it is very dark and the white tips are mostly absent.

The ears are similar in form to those of the red bat. The inner surface is thickly covered with short hairs except at the edge. The tragus is also quite hairy on the outer side. The tragus is rather more slender in proportion to its height than in *L. borealis.* The membranes are similar to those of the preceding species and are furred in the same way.

Measurements.—A single adult female from Bloomington measured as follows: Total length, 130 mm. (5 3/16 in.); tail, 54 mm. (2 2/16 in.); hind foot, 11 mm. (7/16 in.); forearm, 53 mm. (2 2/16 in.); tibia, 23 mm. (15/16 in.); ear (from meatus), 17 mm. (11/16 in.).

Skull and teeth.—The skull (fig. 33) and teeth resemble those of *L. borealis* in form, but are noticeably larger. Miller gives the following measurements for the skull of an adult female from Minnesota: Greatest length, 17 mm. (11/16 in.); zygomatic breadth, 12 mm. (8/16 in.); upper tooth row, 9 mm. (5/16 in.).

Range.—Found throughout North America, but probably not occurring in the Southern States in summer. Miller states that the species does not breed south of the boreal zone. However, a female with two half-grown young were taken in this State at Bloomington in June, and C. F. Fite has taken specimens at Denver, Miami County, on June 20 and 31. Other Indiana records are: Lake, White, Franklin, Lawrence, Monroe, Jefferson, Wayne and Wells counties.

Habits.—Like *Lasiurus borealis*, the present species is chiefly an inhabitant of the forest, and migrates southward in winter. It has never been reported as living in the caves, but two skulls were found in the Shawnee Cave at Mitchell, along with those of the red bat previously mentioned.

Little is known of the peculiarities of its breeding or feeding habits. In southern Indiana the young are apparently born early in June. Dr. A. M. Banta took a female with two young in June;

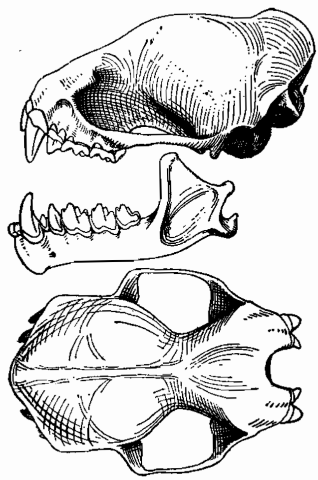


FIG. 33.—Skull of *Lasiurus cincreus*. After Miller, N. Amer. Fauna No. 13. Bureau of the Biol Survey, U. S. Dept. of Agri.

they are preserved in the collections of Indiana University. The young were still clinging to the mother, but are two-thirds grown. They measure 110 mm. in total length; forearm, 45 mm. The family were chased out of a tree by a robin and fell to the ground in front of the zoological laboratories of Indiana University.

This species does not fly until late in the evening, when it is not easily distinguished, and this fact doubtless accounts for the small number of records. It can be recognized by its large size, swift flight and pointed, hawk-like wings.

APPENDIX.

PEROMYSCUS NUTTALLI (Harlan).

GOLDEN MOUSE.

Arvicola nuttalli Harlan, Month. Amer. Journ. Geol. and Nat. Sci., Phil., p. 446, 1832.

Hesperomys nuttalli Baird, Mam. N. Amer., p. 467, 1857.

Calomys aureolus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 139, 1894.

Peromyscus nuttalli Bangs, Proc. Bost. Soc. Nat. Hist., Vol. 28, p. 197, 1898.

Osgood, N. Am. Fauna No. 28, p. 224, 1909.

Diagnostic characters and description.—Size of *P. leucopus,* but both young and adults are of a bright golden brown color above and the under parts are yellowish instead of white. In addition to these general color differences, this mouse is distinguished from *P. leucopus* in having no distinct line of demarcation between the color of the dorsal and ventral surfaces and in having the color of back extending down the limbs to the feet. The ears are also smaller, but there is no very striking difference in the skulls of the two species.

Range.—This species was first described from Norfolk, Virginia. Its range extends along the Atlantic coast from Chesapeake Bay to Florida and in the west to Missouri. It has never been recorded from Indiana and certainly is not common in any part of the State. However, it is not improbable that it will be found in the southwest portion as it occurs in Illinois.

Habits.—Kennicott, who collected the species at several points in southern Illinois, says that it is an inhabitant of the forest, although it is also found among the hazel thickets at the edge of the prairie. He states that it builds its nest in the branches of small trees and the tops of hazel bushes. The nests resemble those of birds, but are roofed over and have a small opening on the side. It probably does not burrow, though its nest has been found under a log, where it was made of fine bark and fibres and was placed on top of the ground with no underground burrow leading to it. It is strictly nocturnal in habit and its food consists of various kinds of seeds and nuts.

In the east it seems to frequent low ground and has been found to be abundant in the Dismal Swamp.

Genus Reithrodontomys Giglioli.

Reithrodontomys Giglioli, Richerche intorno alla distrib. geogr. gener., p. 60, 1873.

The mice of this genus resemble the house mouse and white-footed mice in form, but are generally a little smaller. They can always be distinguished from the other slender, longtailed mice by the grooves in the upper incisors. In this respect they resemble *Synaptomys,* but they differ from the species of that genus in having slender bodies and long tails.

REITHRODONTOMYS LECONTII (Audubon and Bachman).

HARVEST MOUSE.

Reithrodontomys lecontii Audubon and Bachman, Journ. Acad. Nat. Sci. Phil., Vol. 8, pt. 2, p. 307, 1842.

Ochetodon humilis Evermann and Butler, Proc. Ind. Acad. Nat. Sci. for 1893, p. 139, 1894.

Description and range.—Color russet brown above, somewhat darker on the head and middle of the back; beneath grayish white; tail dusky above and whitish beneath. The ears are shorter than in the white-footed mice and the incisor teeth are grooved. The species is smaller than any other mouse in the eastern United States.

There is no record of the harvest mouse from Indiana, but species of the genus occur in West Virginia and others in Kansas and Nebraska. It is, therefore, possible that the species may be found in this State. It is said to live in old fields overgrown with tall grass and trees.

Genus Oryzomys Baird.

Oryzomys Baird, Mamm. N. Amer., p. 58, 1857.

Form similar to that of the house rat, but size smaller; molar teeth with tubercles in two rows; incisor teeth orange colored and without grooves; skull with distinct ridges over the orbits; tail long, scantily haired; belly grayish.

ORYZOMYS PALUSTRIS (Harlan).

RICEFIELD MOUSE.

Mus palustris Harlan, Amer. Journ. Sci. and Arts, Vol. 31, p. 386, 1837.

Calomys palustris Evermann and Butler, Proc. Indiana Acad. Sci. for 1893, p. 139, 1894.

Description and range.—The generic characters given above distinguish this mouse from any other likely to occur in our State.

The species was described from New Jersey and extends south along the Atlantic coast, being replaced in Florida and Texas by closely related forms. According to Evermann and Butler the species was recorded from Hamilton County, Ohio, by Langdon, in 1876. I have not been able to verify this record.

Mr. E. J. Chansler, of Bicknell, has written me as follows: "There is a kind of water rat found about ponds and streams. It is perhaps smaller than the house rat, has short front legs and long hind ones. The hind feet look to be somewhat webbed. Color light gray with dark reflections. Our boys caught some last winter while trapping for mink and muskrat along Flat Creek. They have usually been found among water lilies or about drift along Flat Creek."

Mr. Chansler does not attempt to identify this animal farther than to call it a "water rat," but the description he has given applies fairly well to the rice-field mouse. I consider him too good a naturalist to confuse young muskrats or house rats with this animal, and his statement that they have been taken in winter would also indicate that they were not young animals. In the absence of specimens I can not give a positive record for the species, and indeed there are no known facts concerning its distribution, other than those given above, which would lead us to expect it in the State. Mr. Chansler states that none of the rats have been seen for several years and he thinks they may have disappeared since the draining of Montour's and other ponds.

Genus NEOTOMA Say and Ord.

Neotoma Say and Ord, Journ. Acad. Nat. Sci. Phil., Vol. 4, pt 2, p. 345, 1825.

The rats of this genus are generally about the size of the house rat, but they have tails less scaly, the fur is softer and denser, the eyes and ears are large and the molar teeth have the enamel folded into loops and triangles much like those of the voles (*Microtus*).

NEOTOMA PENNSYLVANICA Stone.

ALLEGHENY WOOD RAT.

Neotoma pennsylvanica Stone, Proc. Acad. Nat. Sci. Phil., p. 16, 1893.

Neotoma floridana Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 139, 1894.

Description.—Size of the house rat; eyes and ears large; tail thickly covered with long, soft hairs. The color is slaty black with a sprinkling of yellowish brown, which is brightest on the sides; belly pure white; tail the color of the back above and white below. The hairs are long and dense enough to obscure the scales which are so prominent on the tail of a house rat and the fur is everywhere softer and denser than in the house rat.

Range and habits.—The Allegheny wood rat is found in the mountains of southern New York, Pennsylvania and the Virginias. The species has also been found in Mammoth Cave, Kentucky. It is an inhabitant of caves and limestone hills and ledges. There is much territory suited for its habitation in southern Indiana, and it could easily reach this region from central Kentucky. Indeed it is rumored that these rats lived in Wyandotte Cave before the cats which now inhabit the cave, exterminated them. I have not been able to confirm the rumor and know of no record from the State. The occurrence of the species in Indiana is not improbable, however.

In Mammoth Cave they live at some distance from the entrance and hide away in the inaccessible clefts. Although they probably never see daylight their eyes are in no way degenerate. In Pennsylvania Mr. Rhoads has found them barricading the clefts in which they live with the bones of animals and other debris. In the Virginia caves they are said to build globular nests as large as a bushel basket on the cave floor.

Genus Evotomys Coues.

Evotomys Coues, Proc. Acad. Nat. Sci. Phila., 1874, p. 186.

Dental Formula.—I, $\frac{1-1}{1-1}$; C, $\frac{0-0}{0-0}$; Pm, $\frac{0-0}{0-0}$; M, $\frac{3-3}{3-3}=16$.

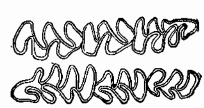


Fig. 34.—Enamel pattern of molar teeth of Evotomys. After Miller, N. Am. Fauna No. 12, Bureau of the Biol. Sur., U. S. Dept. of Agri.

Generic characters.—Size and proportions, about as in *Microtus;* color of back reddish; ears somewhat larger than in *Microtus;* upper incisors without grooves; molars rooted in adult, the crowns narrow, with the angles of the enamel rounded (fig. 34).

EVOTOMYS GAPPERI RHOADSI Stone.

REDBACKED MOUSE.

Evotomys gapperi rhoadsi Stone, Am. Naturalist, Vol. 27, p. 55, 1893. Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 127, 1894.

Description.—Color bright reddish chestnut on the back, this color being somewhat overlaid with longer black hairs; sides yellowish; belly light gray, often with a tinge of yellowish; skull (fig. 35) short and rounded.

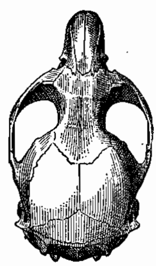


FIG. 35.—Skull of *Evotomys*. After Miller, N. Am. Fauna No. 12, Bureau of the Biol. Sur., U. S. Dept. of Agri.

Distribution and habits.—The limits of this subspecies are not known, but it, or closely related forms, occur in the woods and bogs from Quebec to the Carolinas. Evermann and Butler included it, with an interrogation, in their list under the name of *Evotomys rutilus gapperi.* They mention a specimen from Montmorenci in the collection of C. L. Reynolds, "which seems to belong to this species." I have been unable to obtain any other record from the State, and do not consider this one sufficiently well established to repeat, except in the appendix.

Rhoads states that this form inhabits the cold bogs in New Jersey. This is also true of Stone's lemming, which, however, we find in the grassy uplands in Indiana and the occurrence of the red-backed mouse in this State is by no means an impossibility. It should be looked for especially in the sphagnum bogs and tamarack swamps of the northern half, although it might also be found in other situations.

LEPUS AMERICANUS PHAEONOTUS Allen.

MINNESOTA VARYING HARE.

Lepus americanus phaeonotus Allen, Bull. Amer. Mus. Nat. Hist., Vol. 12, p. 11, 1899.

Description.—Much larger than the cottontail, with longer feet and ears. In summer the color is brighter brown on the back than in the common rabbit and the ears are tipped with blackish; in winter the color becomes clear white.

Distribution and habits.—According to Mr. Hartley Jackson, this hare "is not uncommon in most sections of northern Wisconsin." Kennicott records the killing of one (under the name of *L. americanus*) in 1824 on the present site of Chicago.

I have been led to include the species in this doubtful list principally upon the statement of Mr. I. N. Lamb, now of Richmond, who was familiar with the Kankakee Valley from 1870 to 1875. He speaks of large rabbits which he says "resemble the western jack rabbit, but is not so large; really they look more like the Wisconsin rabbit." It is very probable that a few varying hares may have occurred in all parts of northern Indiana in the early day, but their habits are very retiring and they would not readily attract notice. It is not improbable that the animal which Messrs. Evermann and Butler have recorded as a jack rabbit was really a varying hare.

It is hardly probable that any representatives of the species are living in the State at the present time. It is impossible to say, in the absence of any specimens, whether the form from this region is subspecies *phaeonotus* or subspecies *virginianus,* but the former seems more probable.

LEPUS CAMPESTRIS Bachman.

JACK RABBIT.

Lepus campestris Bachman, Journ. Acad. Nat. Sci. Phil., Vol. 7, p. 349, 1837.

Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 125. 1894.

Diagnostic characters.—Distinguished from other rabbits found east of the Mississippi by its large size, the total length being about 24 inches.

Description.—Color yellowish gray, with some brown hairs intermingled; underparts white; tail also white, with no black border. In winter, in the northern part of its range, it becomes pure white all over. Ears very long ($4\frac{1}{2}$ inches from crown), tipped with blackish; inner surface white excepting a band which is the same color as the back; fur dense and soft.

Range.—From Saskatchewan to southern Kansas, west to the Sierra Nevada and possibly east to Indiana. Evermann and Butler included it in their list of Indiana mammals, saying: "Mr. Chas. L. Reynolds [a taxidermist of Frankfort] informs me that he mounted one that was taken near Chauncey, in the summer of 1888. The specimen is now [1893] in the possession of Mr. Max Spring, a stationer of Lafayette. In the winter of 1876-77, I was told that an unusual rabbit was caught near Prince William in Carroll County."

From recent correspondence with Dr. Evermann I learn that the record was made solely on Mr. Reynolds' statement, and Dr. Evermann himself has some doubts as to the correctness of the identification. I am unable to find the slightest evidence, other than this record, that the species has ever occurred east of the Mississippi, or indeed within two or three hundred miles of the Mississippi. Therefore I can only believe that there was some mistake regarding this Chauncey specimen. It could possibly have been captured and brought east by some one as a pet, or it might have been a varying hare, or more probably still, a Belgian hare.

Skull and teeth.—Skull large, nearly four inches in greatest length, broad and with the dorsal profile strongly arched; post-orbital processes free at either end. Upper incisors with a rather deep groove on the front.

Measurements.—From Baird I copy the following: Total length, $23\frac{1}{2}$ in.; tail, $3\frac{1}{2}$ in.; hind foot, $5\frac{1}{2}$ in.; ear from crown, $4\frac{1}{2}$ in.

Habits.—The jack rabbit is one of the swiftest animals that moves on four feet, at least for moderate distances. It is probable that a coyote, grayhound or antelope can all outrun these rabbits in a course several miles in length, but none are its equal in dodging and hence even the swift grayhound and coyote seldom catch them single handed. The extraordinarily long legs are special adaptations for speed, while the still more disproportionate ears are aids to the sense of hearing, which is very acute.

The nest is said to be simpler than that of the cottontails, being usually a mere mat of grass, covered slightly with fur. The young are from one to six in number and are born with the eyes open. From one to three litters are produced annually.

In some parts of the West these rabbits have been quite destructive to orchards or crops. However, the jack rabbits of California, where the greatest amount of destruction has been done, belong to another group which is characterized by their partially black tails.

PUTORIUS ALLEGHENIENSIS Rhoads.

ALLEGHENY WEASEL.

Putorius allegheniensis Rhoads, Proc. Acad. Nat. Sci. Phil., p. 751, 1901.

Description.—Size small and tail not over one inch in length; color in summer walnut brown above and pure white below, the two colors being abruptly separated. The measurements of the type specimen, as given by Rhoads, are the following: Total length, 199 mm. (8 in.); tail, 19 mm. (¾ in.); hind foot, 20 mm. (4/5 in.).

Range.—This species was discovered in western Pennsylvania less than ten years ago. One specimen was taken along the Ohio River below Pittsburg and several others in the western part of the State. More recently it has been recorded from Oberlin, Ohio, and Jackson includes it in his list of mammals of Wisconsin. I have no evidence of its occurrence in Indiana but the above records show that it may be expected in any part of the State as it might easily be carried down the Ohio from the vicinity of Pittsburg while its northern distribution renders its occurrence in northern Indiana very probable. It can be easily distinguished by the very short tail.

MUSTELA AMERICANA Turton.

PINE MARTEN; AMERICAN SABLE.

[*Mustela*] *americana* Turton, Linnaeus, System of Nature, Vol. 1, p. 60, 1806.

Description.—Size considerably larger than the mink to which it bears some resemblance; tail somewhat bushy; color light, rich brown on the back with light spots on the throat; ears high and pointed; total length about 24 inches.

Range and habits.—The marten was once common in the forests of eastern North America as far south as Pennsylvania and northern Illinois. I have no direct evidence that it was ever found in Indiana, but its range usually extended as far south at least, as that of its near relative, the fisher. It is known to occur in Wisconsin and there is a skeleton in the Chicago Academy of Science said to have been taken in Illinois many years ago. Rhoads says that it prefers deciduous, hardwood forests in Pennsylvania and this would make its occurrence in Indiana in former times all the more probable.

Its habits are much like those of the fisher, but it lives in the tree-tops to an even greater extent. It is very shy and never stays in settled regions nor molests domestic animals. It produces from six to eight young each year and, having few enemies, holds its own fairly well in the unsettled regions of Canada. Macfarlane states that the Hudson's Bay Company sold more than 78,000 skins as the result of a single year's catch no longer ago than 1902.

Genus Parascalops True.

Parascalops True, Proc. U. S. Nat. Mus., Vol. 17, p. 242, 1894.

Dental formula.—I, $\frac{3-3}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{4-4}{4-4}$; M, $\frac{3-3}{3-3} = 44$.

Generic characters.—External form much the same as in the common moles, *Scalops,* excepting the tail, which is short, blunt and densely haired; the size is somewhat less, and the head and feet are less broad. The teeth are more numerous and the dental formula is the same as that of the star-nosed mole.

PARASCALOPS BREWERI (Bachman).

THE BREWER MOLE; HAIRY-TAILED MOLE.

Scalops breweri Bachman, Bost. Journ. Nat. Hist., Vol. 4, p. 32, 1842.

Scapanus americanus Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 139, 1894.

Description.—The Brewer mole bears a general resemblance to the common mole, but may be distinguished from it by the number of teeth and the hairy, club-shaped tail. This organ is somewhat constricted at the base as it is in the star-nosed mole, but it is short (1¼ in.) and bluntly rounded at the tip. The fur usually has more of a brownish tinge than in the common mole. The skull and teeth are similar to those of the common mole but somewhat more slender.

Range and habits.—This mole is limited to eastern North America from the St. Lawrence River to North Carolina and from the Atlantic at least as far west as central Ohio. There are two specimens in the Indiana University collection, correctly identified, cataloged and labeled as coming from Bloomington, Indiana. I do not place much credence in these labels and am not willing to record the species as occurring in the State on the basis of these specimens. But its occurrence is not beyond the range of probability. The species has been taken in Ohio about 60 miles from Cincinnati. Very few moles have been collected in Indiana and the species might be easily overlooked as its appearance does not differ in any striking way from that of the common mole.

The habits of this species are much like those of the other moles. It is said to burrow deeper than the common mole but, like it, prefers the higher ground and is not partial to swamps as is the star-nosed species.

Genus NYCTICEIUS Rafinesque.

Nycticieus Rafinesque, Journ. de Physique, Vol. 88, p. 417, 1819.

Dental formula.—I, $\frac{1-1}{3-3}$; C, $\frac{1-1}{1-1}$; Pm, $\frac{1-1}{2-2}$; M, $\frac{3-3}{3-3} = 30$.

Generic characters.—Size, rather small; ears, small and narrowly rounded at the tip; tragus, short, broad and blunt and much

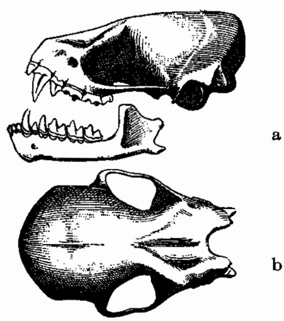


FIG. 36.—Skull of *Nycticeius humeralis*: a, lateral view; b, dorsal view. After Miller, N. Am. Fauna No. 13, Bureau of the Biol. Sur., U. S. Dept. of Agri.

bent forward; membranes and ears very thick and leathery. The skull (fig. 36) is broad and low; in dorsal profile it resembles that of *Eptesicus* except that it is slightly convex at the front of the braincase; braincase more rounded than in *Eptesicus;* the skull of the latter genus also much larger.

The genus is distributed throughout the Gulf states and as far north as Pennsylvania and Kentucky, being represented by but one species; a subspecies is found in Cuba. The dark color, leathery wings and dental formula distinguish this genus.

NYCTICEIUS HUMERALIS (Rafinesque).

THE RAFINESQUE BAT; TWILIGHT BAT.

Vespertilio humeralis Rafinesque, Amer. Monthly Mag., Vol 3, p. 445, 1818.

Nycticeius humeralis Rafinesque, Journ. de Physique, Vol. 88, p. 417, 1819.

Evermann and Butler, Proc. Ind. Acad. Sci. for 1893, p. 139, 1894.

Miller, N. Am. Fauna, No. 13, p. 118, 1897.

Description.—Color dull brown, the hairs being plumbeous at the base but the basal color shades gradually into that of the tip. Under parts somewhat lighter than the back. The ears are small and very thick and leathery; wide at the base and tapering sharply near the middle of the posterior edge; tragus short, blunt, and much bent forward.

The dentition readily distinguishes this species from all other bats of this region. It has but one tooth on each side in front of the large canine (but one incisor) and but one upper premolar. In other respects the skull bears a rather close resemblance to that of the red bat. The occipital crest is less elevated, however, and the skull, on the whole, is less angular.

The present species has never been reported from Indiana. It was originally described from Kentucky, however, and is common in the southern states as far north as Tennessee and central Kentucky. In external appearance it bears a close resemblance to the two species of *Myotis* found in this region and might easily be overlooked among a large number of them. Unless its range is more definitely restricted than that of most other species of bats, it will certainly be taken in southern Indiana sooner or later.

In addition to the characters given above, it may be distinguished from all of our species except the large brown bat, by the tail extending distinctly beyond the interfemoral membrane.

BIBLIOGRAPHY.

The following list of publications is intended to include the papers referring definitely to Indiana mammals, the monographic revisions of some of the groups represented, records of value from near-by states and a few of the more general publications on mammals. The list is not exhaustive and the citations are generally only those with which the author is familiar. In addition to the list of papers following, the histories of 36 counties have been examined for possible information. With the exception of a few of these which are mentioned in the text, no definite information was obtained although the accounts given have aided in forming a picture of animal life as it existed in the days of the early settler. In all cases these histories are compilations, and in many of them not even the names of the editors are given. For this reason it seems unnecessary to give a detailed list of them in this place.

Allen, Harrison.—A Monograph of the Bats of North America. Bull. U. S. Nat. Mus., No. 43, 1893.

Allen, J. A.—American Bisons, Living and Extinct. Mem. Geol. Surv. Kentucky, Vol. I, Pt. II, 1876.

—— On Seasonal Variations in Color in *Sciurus hudsonius*. Bull. Amer. Mus. Nat. Hist., Vol. 3, pp. 41-44, 1890.

—— Revision of the Chickarees or North American Red Squirrels (Subgenus *Tamiasciurus*). Bull. Amer. Mus. Nat. Hist., Vol. 10, pp. 249-298, 1898.

Audubon, J. J. and *John Bachman.*—Quadrupeds of North America, 1851.

Bailey, Vernon.—Revision of the American Voles of the Genus Microtus. N. A. Fauna, No. 17. Publication of the Bureau of the Biol. Surv., U. S. Dept. Agr., 1900.

Baird, Spencer F.—The Mammals of North America. Vol. 8 of the Pacific Railroad Reports, 1857.

Ball, T. H.—History of Lake County, 1884. Animals of Lake County, by Edwin Dinwiddie, pp. 150-153, 1884.

Bangs, Outram.—Revision of the Squirrels of the Eastern United States. Proc. Biol. Soc. of Washington, Vol. 10, pp. 147-166, 1896.

Banta, A. M.—The Fauna of Mayfield's Cave. Publication No. 6 of the Carnegie Institution, Washington, D. C., 1907.

Blatchley, W. S.—The Fauna of Indiana Caves. Twenty-first Report Ind. State Geol., Mammals, pp. 176-181, 1896.

Brayton, A. W.—Report on the Mammals of Ohio. Report of the Geol. Surv. of Ohio, Vol. 4, Zoology and Botany, 1882.

Butler, A. W.—Observations on the Muskrat. Amer. Nat., Vol. 19, pp. 1044-1055, Nov., 1885.

Butler, A. W.—Observations on Faunal Changes. Bull. Brookville Soc. Nat. Hist., No. 1, pp. 5-13, 1885.

—— Our Smaller Mammals and Their Relation to Horticulture. Trans. Ind. Hort. Soc., Vol. 31, pp. 117-123, 1891.

—— On Indiana Shrews. Proc. Ind. Acad. Sci. for 1891, pp. 161-163.

—— The Mammals of Indiana. Proc. Ind. Acad. Sci. for 1894, pp. 81-86, 1895.

—— Indiana: A Century of Changes in the Aspects of Nature. Proc. Ind. Acad. Sci. for 1895, pp. 31-42, 1896. (See also under Evermann, Barton W., and Quick, Edgar R.)

Caton, John D.—The Antelope and Deer of North America, 1877.

Coues, Elliott.—Fur-bearing Animals. A Monograph of the North American Mustelidae. U. S. Geol. Surv. of the Territories, Miscel. Pub. No. 8, 1877.

Coues, Elliott and *J. A. Allen.*—Monograph of the North American Rodentia. Report of the U. S. Geol. Surv. of the Territories, Vol. 11, 1877.

Cox, Ulysses O.—List of the Birds and Mammals of Randolph County, Ind., Ornithologist and Oologist, Vol. 18, pp. 2-3, 1893.

Elliot, Daniel Giraud.—Synopsis of the North American Mammals. Field Columbian Museum, Pub. II, Zool. Ser., 1901.

—— A Check List of the Mammals of the North American Continent, the West Indies and the Neighboring Seas. Field Columbian Museum Pub. 105, Zool. Ser., Vol. 6, 1905.

—— A Catalogue of the Collection of Mammals in the Field Columbian Museum. Field Columbian Museum Pub. 115, Zool. Ser., Vol. 8, 1907.

Evermann, Barton W.—The Occurrence in Indiana of the Star-nosed Mole. Amer. Nat., Vol. 22, p. 359, 1888.

Evermann, B. W. and *A. W. Butler.*—Preliminary List of Indiana Mammals. Proc. Ind. Acad. Sci. for 1893, pp. 120-139, 1894.

Flower and *Lydekker.*—Mammals, Living and Extinct. (The best general work on the structure and relationships of the families and orders of mammals.) London, 1891.

Godman, John D.—The American Natural History, 1826.

Hahn, Walter L.—Notes on the Mammals of the Kankakee Valley. Proc. U. S. Nat. Mus., Vol. 32, pp. 455-464, 1907.

—— The Mammalian Remains of the Donaldson Cave. Proc. Ind. Acad. Sci. for 1906, pp. 142-144, 1907.

—— Habits and Sensory Adaptations of Cave-inhabiting Bats. Biol. Bull., Vol. XV, pp. 135-193, August and September, 1908.

—— Notes on the Mammals and Cold-blooded Vertebrates of the Indiana University Farm, Mitchell, Indiana. Proc. U. S. Nat. Mus., Vol. 35, pp. 545-581, 1908.

Haymond, Rufus.—Mammals found in Franklin County, Indiana. Ind. Agr. and Geol. Rep., pp. 203-208, 1869.

Hornaday, William T.—The Extermination of the American Bison. Rep. U. S. Nat. Mus. for 1886-'87, pp. 369-548, 1889.

Howell, Arthur H.—Revision of the Skunks of the Genus Chinca. N. A. Fauna No. 20. Pub. of the Bureau of the Biol. Surv., U. S. Dept. Agr., 1901.

Howell, Arthur H.—Revision of the Skunks of the Genus Spilogale. N. A. Fauna, No. 26, 1906.

—— Description of a New Bat from Nickajack Cave, Tennessee. Proc. Biol. Soc., Wash., Vol. 22, pp. 45-48, 1909.

Jackson, Hartley H. T.—A Preliminary List of Wisconsin Mammals. Bull. of the Wis. Nat. Hist. Soc., Vol. 6, pp. 13-34, 1908.

Kennicott, Robert.—The Quadrupeds of Illinois Injurious and Beneficial to the Farmer. U. S. Patent Office Report for 1856, pp. 52-110, 1857.

Langdon, F. W.—The Mammalia of the Vicinity of Cincinnati. Journ. of the Cin. Soc. Nat. Hist., 1881, pp. 297-313, 1881.

Lantz, David E.—Coyotes in Their Economic Relations. Bull. No. 20 Biol. Surv., U. S. Dept. Agr., 1905.

—— The Rabbit as a Farm and Orchard Pest. Reprint from Yearb. U. S. Dept. Agr. for 1907, 1908.

Lyon, Marcus Ward, Jr.—Classification of the Hares and Their Allies. Smithsonian Misc. Coll. (Quarterly Issue), pp. 321-447, 1904.

Macfarlane, Robert.—Mammals of the Northwest Territories. Proc. U. S. Nat. Mus., Vol. 28, pp. 673-764, 1905.

McAtee, Waldo L.—List of Mammals, Reptiles and Batrachians of Monroe County, Indiana, Proc. Biol. Soc. of Washington, Vol. XX, pp. 1-16, 1907.

Merriam, C. Hart.—Mammals of the Adirondack Region. Trans. Linnaean Soc. of N. Y., Vols. I and II. Also privately published, 1884.

—— Revision of the Shrews of the Genera Blarina and Notiosorex: Synopsis of the American Shrews of the Genus Sorex. N. A. Fauna, No. 10, 1895.

—— Monographic Revision of the Pocket Gophers, Family Geomyidae. N. A. Fauna, No. 8, 1895.

—— Synopsis of the Weasels of North America. N. A. Fauna, No. 11, 1896.

—— Life Zones and Crop Zones of the United States. Bull. 10, Biol. Surv., U. S. Dept. Agr., 1898.

Miller, Gerrit S., Jr.—The Long-tailed Shrews of the Eastern United States. N. A. Fauna, No. 10, 1895.

—— Genera and Subgenera of Voles and Lemmings. N. A. Fauna, No. 12, 1896.

—— Revision of the North American Bats of the Family Vespertilionidae. N. A. Fauna, No. 13, 1897.

—— Key to the Land Mammals of Northeastern North America. Bull. N. Y. State Mus., No. 38, Vol. 8, pp. 61-160, 1900.

—— Directions for preparing Study Specimens of Small Mammals. Part N. of Bull. No. 39 of the U. S. Nat. Mus., 1901.

—— Families and genera of Bats. Bull. 57 U. S. Nat. Mus., 1907.

Miller, G. S., Jr. and *J. A. G. Rehn.*—Systematic Results of the Study of North American Land Mammals to the close of 1900. Proc. Boston Soc. Nat. Hist., Vol. 30, pp. 1-352, 1901.

—— Systematic Results of the Study of North American Land Mammals during 1901 and 1902. Proc. of the Boston Soc. Nat. Hist., Vol. 31, pp. 61-145, 1903.

Nelson, E. W.—Revision of the Squirrels of Mexico and Central America. Proc. Washington Acad. Sci., Vol. I, pp. 15-106, 1899.

Osgood, Wilfred H.—Revision of the Mice of the American genus Peromyscus, N. Am. Fauna No. 28, 1909.

Plummer, John T.—Some Quadrupeds about Richmond, Indiana. Amer. Journ. Science and Arts, Vol. 46, pp. 245-249, 1844.

Preble, Edward A.—Revision of the Jumping Mice of the Genus Zapus. N. A. Fauna, No. 15, 1899.

Quick, E. R.—Hesperomys leucopus Leconte. Journ. of the Cin. Soc. Nat. Hist., Vol. 4, p. 337, 1881. (Records an albino specimen from Brookville.)

—— Mammals Found in Franklin County, Indiana. Atlas of Franklin County, pp. 9-10, 1882.

Quick, Edgar R. and *A. W. Butler.*—The Habits of Some Arvicolinae. Amer. Nat., Vol. 19, pp. 113-118, 1885.

Rhoads, Samuel N.—Contributions to the Zoology of Tennessee, Mammals. Proc. Acad. Nat. Sci. Phil., pp. 175-205, 1896.

—— The Mammals of Pennsylvania and New Jersey. (Contains much information on the history, extermination and distribution of mammals in these two states.) Privately published, 1903.

Roosevelt, Theodore and others.—The Deer Family. (An excellent account of the habits and distribution of the American species of deer. 1902.)

Schaeffer, Theo. H.—The Pocket Gopher. Bull. 152, Kansas State Agr. Exp. Station, Manhattan, Kansas, February, 1908.

Stone, Witmer and *W. E. Cram.*—American Animals. The Nature Library, Doubleday, Page & Co., 1903. (The best popular account of American Mammals.)

True, Frederick W.—The Puma or American Lion. Report U. S. Nat. Mus. for 1888-89, pp. 591-608, 1891.

—— A Revision of the American Moles. Proc. U. S. Nat. Mus., Vol. 19, pp. 1-111, 1896.

Wied-Neuweid, Prince Alexander Maximilian.—Reise in das innere Nord America—Coblenz, 1839-1841. (Contains a record of the Prince of Wied's travels and of his stay at New Harmony during the winter of 1832-1833. Mammals about New Harmony are mentioned.)

—— Säugethiere aus Nord America.

GLOSSARY.

Arboreal, tree dwelling.

Audital bulla, the swelling of the tympanic bone just within the meatus of the ear.

Bifid, divided into two parts.

Calcar, the bone extending from the tarsus along the posterior edge of the interfemoral membrane of bats.

Canines, the tearing teeth or "eye teeth" of mammals, absent in the order *Glires* and some others.

Congener, belonging to the same genus.

Cusp, in mammals, the projections on the crowns of the teeth.

Dimorphic, having two forms differing greatly in color and appearance, within the same species; e.g., black and gray squirrels.

Dorsal, the back as opposed to the belly.

Ear, measurements of the ear are taken from the point where it joins the crown of the head on the inner side.

Fossorial, burrowing.

Hastate, spear shaped.

Hind foot, measurements of the hind foot as used in this paper are from the dorsal side of the heel joint to the tip of the longest claw. (See Fig. 1.)

Incisors, the front teeth (see Figs. 2 and 3).

Interorbital, the region between the eyes.

Mammæ, the teats.

Molars, the teeth which come into the jaw behind the region of the milk teeth.

Osteological, pertaining to the skeleton.

Pelage, the hair or fur.

Plantigrade, with the entire sole of the foot, from toes to heels, applied to the ground in walking.

Postorbital, behind the region of the eyes.

Premolars, the teeth in the sides of the jaw between the canines and the molars; they replace the milk teeth of the jaw.

Retractile, capable of being drawn back, as the claws of a cat which are not exposed when the animal is at rest.

Rostrum, the anterior part of the skull, made up of the nasal and part of the premaxillary and maxillary bones.

Sagittal crest, a sharp ridge along the middle dorsal region of some skulls. (See Fig. 2.)

Tail, measurements of the tail are taken from the point of its junction with the trunk, to the end of the bony part, *not to the end of the hairs.* (See Fig. 1.)

Total Length, measurements from the tip of the nose to the end of the tail vertebrae. (See Fig. 1.)

Tragus, a slender detached lobe in the ears of bats. (See Fig. 25.)

Tubercle, one of the cusps or prominences on the crowns of the teeth.

Ventral, the lower or belly side of an animal.

Zygomatic arch, the slender arch of bone which forms the lower part of the orbit of the eye. (See Figs. 2 and 3.)

INDEX TO MAMMALS OF INDIANA.

(Orders and Families in Capitals; Genera and Species in Italics; common names in Roman.)

Page

Badger, American 577
Bat, big-eared 617
  cave 621
  Georgian 629
  gray 625
  hoary 637
  large brown 631
  little brown 621
  red 634
  Say's 623
  silver-haired 627
  twilight 649
Bear, black 592
Beaver 487
Bibliography of mammals 650
Bison bison 452
Bison, American 452
Blarina brevicauda 598
  carolinensis 601
  parva 602
Bob cat 545
BOVIDAE 452
Buffalo 452
Canada lynx 453
CANIDAE 547
Canis latrans 561
  occidentalis 557
Carolina beaver 487
Castor canadensis carolinensis 487
CASTORIDAE 487
Catamount 545
CERVIDAE 454
Cervus canadensis 454
Chickaree 468
Chipmunk 471
CHIROPTERA 615
Citellus franklinii 478
  tridecemlineatus 475
Civet cat 575
Condylura cristata 613

Page

Corynorhinus macrotus 617
Cottontail, prairie 534
Cougar 540
Coyote 561
Deer, Virginia 457
DIDELPHIDAE 448
Didelphis virginiana 448
Elk, American 454
Eptesicus fuscus 631
Erethizon dorsatum 531
ERETHIZONTIDAE 530
Evotomys gapperi rhoadsi 643
FELIDAE 539
Felis cougar 540
FERAE 539
Fiber zibethicus 417
Fisher 587
Flesh-eating animals 539
Flying squirrel 485
Fox, gray 548
  red 552
GEOMYIDAE 524
Geomys bursarius 524
GLIRES 460
Glossary of mammalian terms 654
Gnawing animals 460
Gopher, eastern pocket 524
  gray 478
  striped 475
Ground hog 480
  squirrel 471
Gulo luscus 579
Hare, Minnesota varying 644
  water 538
Hoofed animals 545
INSECTIVORA 597
Introduction 419
Lasiomycteris noctivagans 627
Lasiurus borealis 634
  cinereus 637
LEPORIDAE 533
Lepus americanus phæonotus 644
  aquaticus 538
  campestris 644
Lutra canadensis latacina 566
Luteola vison lutreocephalus 581
Lynx canadensis 543
  ruffus 545
Mammal, definition of 421

Page
Mammalia, economic importance of 422
geographic distribution of 422
relation to environment of 423
structural and zoological position of 421
Mammals of Indiana, table of species of 431
Mammals, classification of 440
key to orders, families and genera 442
methods of collecting and preserving 436
Marmota monax 480
Marten, pine 646
MARSUPIALIA 447
Material and acknowledgment 419
Mephitis mesomelas avia 574
putida 569
Microtus ochrogaster 509
pennsylvanicus 506
pinetorum auricularis 512
pinetorum scalopsoides 516
Mink 581
Mole, brewers 647
hairy-tailed 647
prairie 610
star-nosed 613
Mouse, deer 496
golden 639
harvest 640
house 491
jumping 528
meadow 506
mole 516
northern white-footed 497
prairie white-footed 502
red backed 643
stone lemming 522
white-footed 496
wood 496
MURIDAE 490
Muskrat 517
Mus musculus 491
norvegicus 492
rattus 494
Mustela americana 646
pennanti 587
MUSTELIDAE 565
Myotis grisescens 625
lucifugus 621
subulatus 623
Neotoma pennsylvanica 641

Page
Nycticeius humeralis 649
Nyctomys decolorus 504
Odocoideus virginianus 457
Opossum 448
Otter 566
Oryzomys palustris 640
Painter 540
Panther, American 540
Parascalops breweri 647
Peromyscus leucopus 496
noveboracensis 497
maniculatus 502
nutalli 639
Pipistrellus subflavus 629
Porcupine 531
PROCYONIDAE 588
Procyon lotor 589
Puma 540
Putorius allegheniensis 646
noveboracensis 585
Rabbit, common 534
jack 644
Raccoon 589
Rat, allegheny wood 641
black 494
common or Norway 492
red 504
Reithrodontomys lecontii 640
Sable, American 646
Scalops aquaticus macrinus 610
SCIURIDAE 460
Sciuropterus volans 485
Sciurus carolinensis 461
carolinensis leucotis 464
hudsonicus loquax 468
niger rufiventer 466
Shrew, carolina short-tailed 601
large 598
long-tailed 604
mole 598
short-tailed 598
small 602
southern 607
Skunk, alleghenian spotted 575
eastern 569
Illinois 574
Sorex longirostris 607
personatus 604

	Page
SORICIDAE	597
Spermophile, Franklin's	478
striped	475
Spilogale putorius	575
Squirrel, flying	485
fox	466
gray ground	478
ground	471
northern gray	464
pine	468
prairie	478
red	468
southern gray	461
thirteen-lined	475
Sylvilagus floridanus mearnsi	534
Synaptomys cooperi stonei	522
TALPIDAE	608
Tamias striatus	471
Taxidea taxus	577
UNGULATA	451
Urocyon cinereoargentatus	548
URSIDAE	592
Ursus americanus	592
VESPERTILIONIDAE	616
Virginia deer	457
Vole, blue-grass	512
common	506
prairie	509
Vulpes fulvus	552
Wapiti	454
Weasel, allegheny	646
common	585
Wildcat	545
Wolf, gray	557
timber	557
prairie	561
Wolverene	579
Woodchuck	480
ZAPODIDAE	527
Zapus hudsonicus	528

GENERAL INDEX.

	Page
Accidents to coal miners	222
mine property	267
Adams County, petroleum industry in	364
Alluvial soils 282, 299, 308,	328
Analyses of Indiana coals 37, 40,	144
Ashley, George H., paper by	13
Assistants, list of	6
Barnett, V. H., paper by	393
Blackford County, petroleum industry in	363
Blatchley, W. S., paper by	359
Block coal, lower	113
upper	112
Brazil Block Agreement	173
British Thermal Unit, or B.T.U.	38
Cannelton-Shoals coal	115
Clay County, coals of	123
Climate of southwestern Indiana	283
Coals of Indiana, chemical properties of	35
combustion of	37
commercial and economic character of	41
distribution of by counties	20
domestic use of	47
experimental tests of by U. S. Government	43
fuel value of	38
kinds of	33
physical properties of	34
quantity of 135,	138
smokeless combustion of	45
ultimate analysis of	35
weathering of	53
Coal VII	97
VI	101
V	103
IV	106
III	107
II	109
Block, upper	112
Minshall	109
Coal beds of Indiana, stratigraphic chart of	145
cost of Indiana	24
deposits of Indiana	13
general facts concerning	17

Page
industry in Indiana, history of 26
market for Indiana 24
measures in Indiana 54
miners, tables of 159, 205
accidents to 222
mining legislation 257
mines, abandoned, list of 189
directory of 211, 270
production in Indiana, summary of for 1908 156
quantity of in Indiana 23
statistics of by counties 182, 191
tons produced in Indiana in 1908 10
trade in Indiana, conditions of in 1908 158
Corniferous rock petroleum in Indiana in 1908 373
Crawford County, coals of 128
soil survey of 316
Daviess County, coals of 65, 127
soil survey of 343
Delaware County, petroleum industry in 366
Directory of coal mines 211, 270
Dubois County, coals of 128
soil survey of 285
Epperson, James, State Mine Inspector, report of 153
Fertilizer requirements for southern Indiana 333
Fountain County, coals of 118
Fuels, relative cost of various kinds 48
Gas, natural, report of State Supervisor of 385
producer, relative value of 50
Gibson County, coals of 130
Glacial soils 295
Grant County, petroleum industry in 362
Greene County, coals of 59, 125
Hahn, Walter L., paper by 417
Huntington County, petroleum industry in 363
Huron formation 279, 304, 325
sandstone, petroleum in 380
Indiana coal measures 54
Indiana petroleum industry in 1908 359
Indiana mammals, descriptive catalogue of 417
Introductory 9
Jay County, petroleum industry in 365
Kindle, E. M., paper by 393
Kinney, B. A., paper by 385
Knox County, coals in 55, 128
Laurel limestone, fauna of 408
Legumes, value of 336
Lines, Edward F., paper by 13
Louisville limestone, fauna of 411
Mammals of Indiana, descriptive catalogue of 417

Page
Mansfield sandstone 280, 291, 306, 326
Minshall coal 109
Miners, coal, table of 159
Mitchell limestone 277, 320
Natural gas, report of State Supervisor of..................... 385
Oil, crude, paper on 359
Orange County, coal in 128
Owen County, coal in 123
Parke County, coal in 120
Perry County, coal in 130
soil survey of 301
Petroleum industry in Indiana in 1908 359
corniferous rock, in Indiana in 1908 373
Petroleum, table showing total production in Indiana 383
Pike County, coal in 66, 129
petroleum industry in 374
Posey County, coal in 131
Princeton oil field 380
Producer gas 49
Putnam County, coal in 123
Randolph County, petroleum industry in 366
Shannon, Chas. W., paper by 275
Snider, L. C., paper by 343
Soils, alluvial 282
glacial 295
Soil survey of Crawford County 316
Daviess County 343
Dubois County 285
Perry County 301
Spencer County, coal in 130
State Mine Inspector, report of 153
Strikes in coal mines in 1908 161
Sullivan County, coal in 59, 126
Terre Haute Agreement 163
Trenton rock petroleum industry in Indiana in 1908 ....362, 368
Vanderburgh County, coal in 131
Vermillion County, coal in 122
Vernon, section at old tunnel mill 399
Vigo County, coal in.. 124
petroleum industry in 373
Waldron fauna, composition and distribution of.................. 403
list of in southern Indiana 404
stratigraphy of 395
Warren County, coal in 117
Warrick County, coal in 66, 131
Wells County, petroleum industry in 364
Wildcat bores in Indiana in 1908 384