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The Influence of Floods upon Animals

D. M. Brumfiel
The State University

THE INFLUENCE OF FLOODS UPON ANIMALS

D. M. BRUMFIEL.

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INTRODUCTION.

The attention of the writer was first called directly to this problem by certain observations made along the White Water river, in southeastern Indiana, at the time of the great flood which swept that section of the country in the spring of 1913—generally known as the Dayton Flood. The writer was attempting to make collections of insects in the bottom lands of this small tributary of the Ohio river between the downpours of rain on Monday, March 24, 1913, at the time when that particular stream overflowed its banks. The observation that certain forms of animal life were destroyed outright, and others were forced to flee before the rising water, while still others were carried along on floating driftwood and other debris by which they might be introduced into new regions led to analysis of the influence of such floods upon animal life.

This analysis is based upon the study of the limited portion of the White Water valley with which the writer is the most familiar, in occasional visits to the region in the two years following March, 1913, together with a careful review of the changing conditions which have been noticed since the largest previous flood, that of 1898. Having analyzed these changes and their underlying causes the writer had hoped to follow this with a careful survey, verified by actual collections to substantiate the conclusions and illustrate the statements made. Having not been able to spend sufficient time in the region at times when extensive collections were possible, and for the same reason being unable to follow the intermediate and successional changes between floods, it has been considered advisable to present this brief paper in order to record the observations made and also in order to call the attention of other workers to this interesting

problem in the hope that some one, more favorably located, may care to continue the work by more intensive studies.

The photographs were all taken by the author, April, 1915, unless otherwise stated.

GENERAL DISCUSSION OF THE REGION STUDIED.

The limited region under observation consisted of a small por-

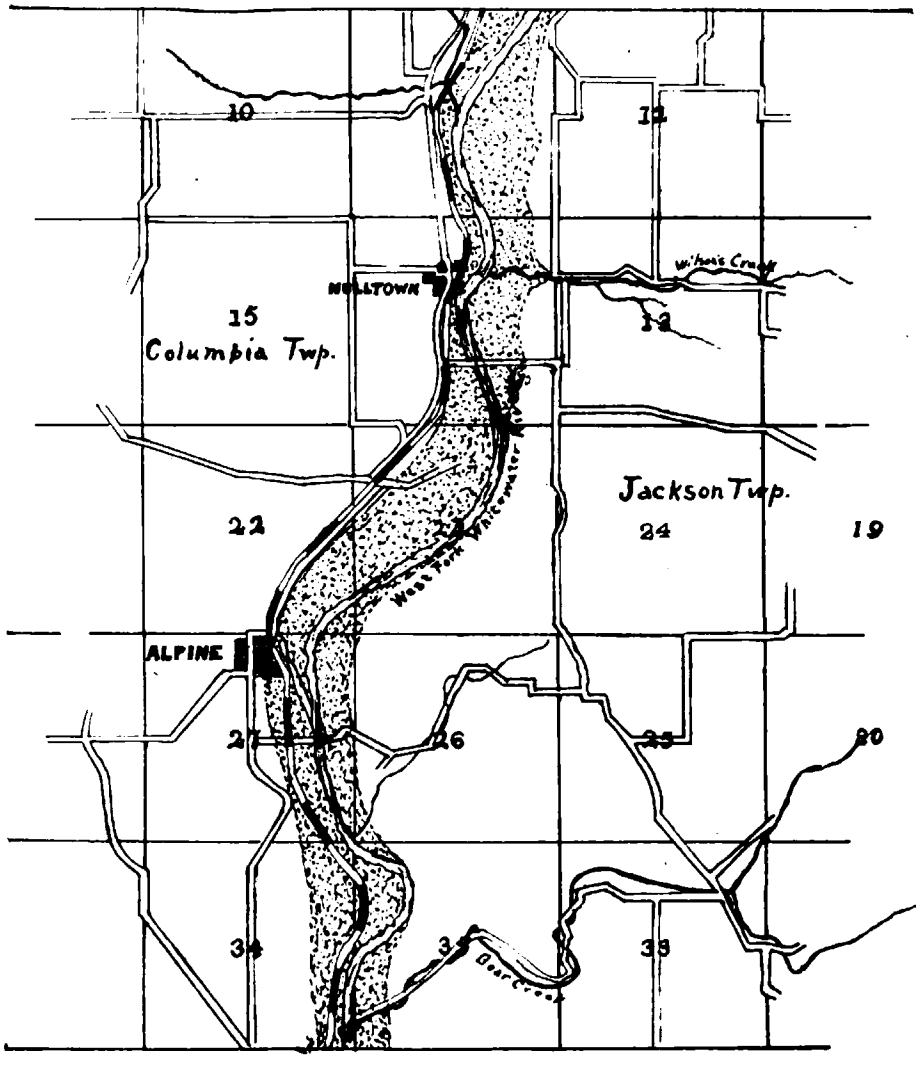

FIG. 15—A portion of Jackson and Columbia townships, Fayette county, Indiana. The course of the West Fork White Water river with stippling to indicate the area covered at high water. Map by H. M. Trusler and the author.

tion of the extreme western edge of Jackson and the extreme eastern edge of Columbia township, Fayette county, Indiana, about five miles south of the county seat, Connersville. The West Fork of the White Water river forms the boundary line

between these two townships, claiming a narrow portion of each for its flood plain. The stream itself, when normal, varies from perhaps fifty to a few hundred feet in width and from eighteen inches to a maximum depth of about twelve feet. As

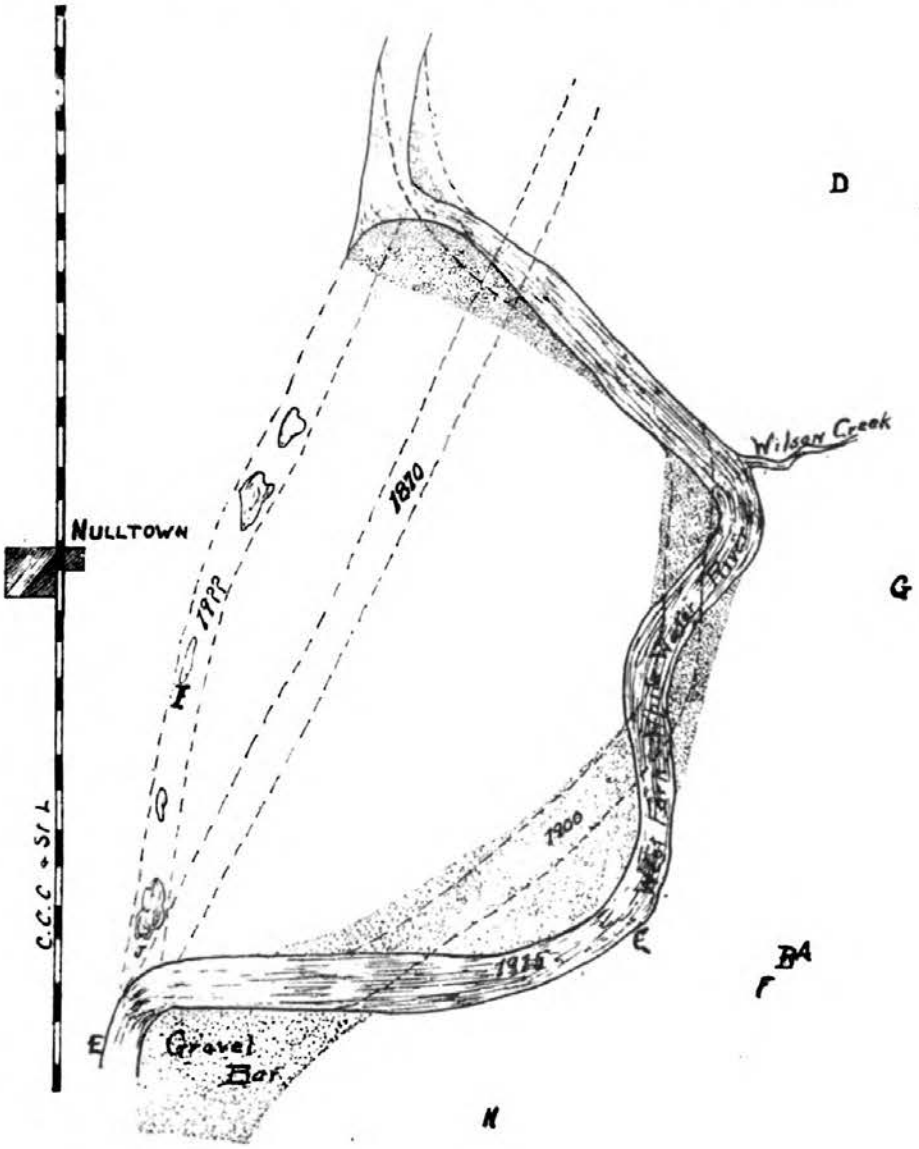

FIG. 16.—Small portion of the region shown in figure 15 on a larger scale, showing changes in the course of the stream and the location of the most prominent gravel bars. The separate letters correspond to the letters of certain of the following figures and mark the locations from which the photographs were made. Map by H. M. Trusler and the author.

with all streams of this size in this region, it flows rapidly, has well defined alternating pools and rapids, and has for the most part a gravelly bottom. It is subject to annual freshets and

usually overflows its banks at least yearly. In such a flood as that of 1913 it attains a width of nearly a half mile, altering its course, sculpturing its flood-plain, and sweeping away fences, crops and even buildings during its brief period of devastation. Figure 15 shows a mapping of its course for five miles with the area covered at high water indicated in shading.

The most careful study was given to that portion near the mouth of Wilson's creek and this has been given in an enlarged mapping (figure 16) to show greater detail and a careful approximation of the changes in the course of the stream over this area. The separate letters indicate the places from which were taken the photographs that serve to illustrate the physiographical and vegetational features.

WAYS IN WHICH THE FLOODS INFLUENCE ANIMAL ASSOCIATIONS.

In analyzing the ways in which floods affect the local distribution of animals, that is, animal associations, it is at once recognizable that all of the efforts are carried out in one of two general ways: viz., first, by abruptly changing the habitats of the animals topographically; and second, by directly changing the composition of the associations themselves without necessarily affecting the physical habitat.

Of the foregoing, topographical changes may be brought about in several ways: (1) the course of the stream may be directly altered, (2) the character of the stream may be altered, that is the local habitats within the stream itself may be subject to physical disarrangement, and (3) changes may be brought about in the physiography of the flood-plain.

It is too obvious to need elaboration that in the alteration of the course of a stream areas which were once the abode of wholly terrestrial forms come to harbor only those which are aquatic, and likewise aquatic habitats are transformed into those which can support only terrestrial forms of life. The map comprising figure 16 is an enlarged sketch of the aforementioned portion of the stream near the mouth of Wilson's creek, on which an attempt has been made to show the changes in the course of the river in recent years. Dotted lines indicate the approximate bed of the river in 1870 (from data gathered from men who have spent upwards of fifty years in the immediate vicinity), in 1900 and in new channel which the stream is cutting for itself and in

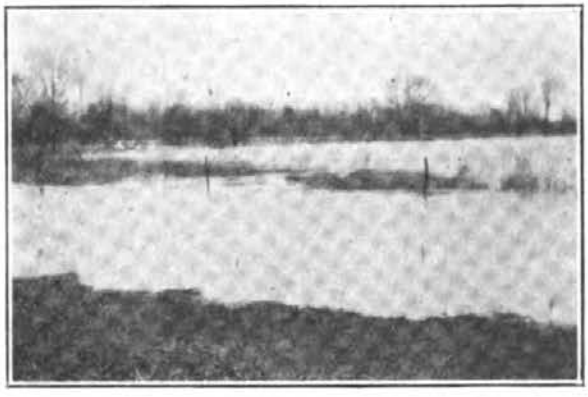

FIG. 17.—The rising water in the flood-plain, March, 1913. It was at this point that the writer took the caterpillars from the grass blades and weed stems. Location A, figure 16.

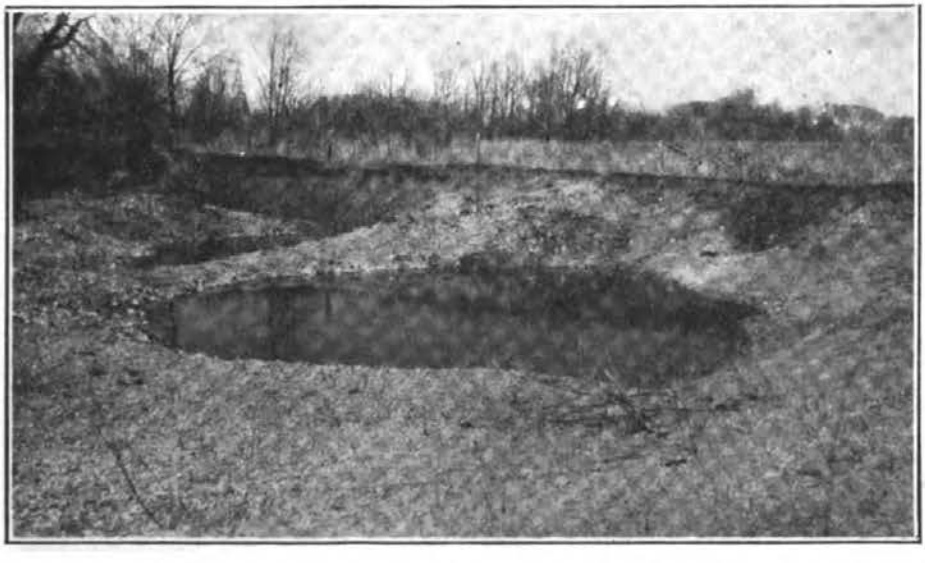

FIG. 18.—Permanent pool in the bottom of a large washout. The ground upon which the writer stood in taking the photograph for figure 17 was taken away in the formation of this washout. The same line of fence posts shows in both figures. Location B, figure 16.

FIG. 19.—Looking up White Water river. The low gravel bar opposite the steep soil bank into which the stream is cutting is shown. In 1900 the right hand bank of the stream at this place was several rods to the left of the edge of the photograph. Location C, figure 16.

FIG. 20.—The flood assisting to protect against itself. The young forest, mostly elm, has been planted in the last few years on the flood-plain by seeds carried by the high water and the wind. Location D, figure 16.

which it promises to be established within a very few years. The actual course of the stream in 1915 is represented by continuous lines. The cutting of the new channel and the permanent pools established there (shown also on the map) come properly under the discussion of the flood-plain and will be considered there. The stippled sections represent gravel bars and directly opposite each the stream flows against a relatively high soil bank into which it is rapidly cutting at these points.

In the changing of the course of a stream there are other effects which incidently influence the animal life beside the important one noted. Of these the features perhaps the most deserving of notice are the oxbow lakes or ponds which are left isolated from the stream, except in the flood season, as cut-off depressions in the old channel. Many of these contain water throughout the year, their bottoms being below the level of the water in the stream, and may persist for a number of years before they are finally filled by the deposition of material and the growth and decay of aquatic and amphibious plants. In such formations are found persisting those forms of animal life from the original stream which are adapted to existence in quiet water. Later purely pond forms may be introduced and become established.

Changes within the stream itself may be many. Deep, quiet pools may be created where there were none by the scooping out of material from the bottom or by partial damming by the piling up of stones and gravel to form a new rapids, increasing the depth of water above that point. Sand bars, shoals, or mud flats may be built up. Rapids may be cut down through the action of successive floods. The sorting of the soil materials may decidedly alter the character of the bottom leaving sand where there was mud or flat stones where there was formerly sand, etc. Each of these changes results in a change in the kinds of animals which are to be found there. The deep, quiet pools will provide a home for larger fish and different species of fish than could exist permanently in the shallow water or in the rapids. The stony bottom and stony rapids provide shelter for many crustaceans and insect larvæ such as May flies (Ephemerida) and Stone flies (Plecoptera) while the mud bottoms abound in worms and molluscs, *e.* g. the common species of fresh water mussel, all being forms that do not thrive in other conditions. The stony rapids, shown in figure 21, have been a favored habi-

tat for the last several years of numbers of the small yellow catfish, (no specimens were secured but they possess strong similarity to the stone cat *Noturus flavus* Rafinesque, in habits and appearance except that they seldom attain more than eight inches in length) and Neuropterous larvæ (*Corydalis cornuta* Linneus). *Necturus maculosus* Rafinesque has also been taken here occasionally. Needham and Lloyd (Needham, J. G., and Lloyd, J. T., 1916) record similar data from their observations on Fall creek, Ithaca, New York.

Hand in hand with the above mentioned changes in the bottom of the stream occur changes in the nature of its banks which may be abrupt and cut in clay (see figure 19) or rock, or gradual and consist of sand (see figure 19), gravel or mud, crowded with vegetation or swept bare, depending upon the action of the stream at flood time. Each of these conditions brings about corresponding variations in the character of the animal life that is in predominance. In portions of the Ohio river valley the presence of muskrats (*Fiber zibethicus* Linneus) and the location of their burrows along the banks bears evidence to this fact. Figures 29 and 30 show the above-water entrance to one of these burrows in a soil bank.

In general the topography of the flood-plain is altered in two ways—by the removal of material and by the deposition of material. The removal of material most commonly results in what are known as "wash-outs." These may be of varying size and depth from mere cuplike excavations where the water has swept about some obstruction to great holes many feet deep and in some cases of acres in extent. The smaller of these are permanently dry, containing water for only a few hours or days after the recession of the flood, while many of the larger ones are of sufficient depth that they mark the location of permanent pools and contain associations of animals adapted to quiet aquatic life. Such washouts are shown in figures 18, 23, 24, 25 and 26. The pool shown in figure 18 is at the bottom of a washout of more than an acre and the water persists with a depth of four to five feet throughout the year although it is several hundred yards from the stream. From such pools the writer has taken crayfish, water beetles, turtles *(Chelydra* and *Chrysemys)* and several species of fish, including *Cyprinus carpio* Linneus of two and three pounds in weight, common sucker *Catostomus commersonii* Lacepede, hogsucker *Catostomus nigri-*

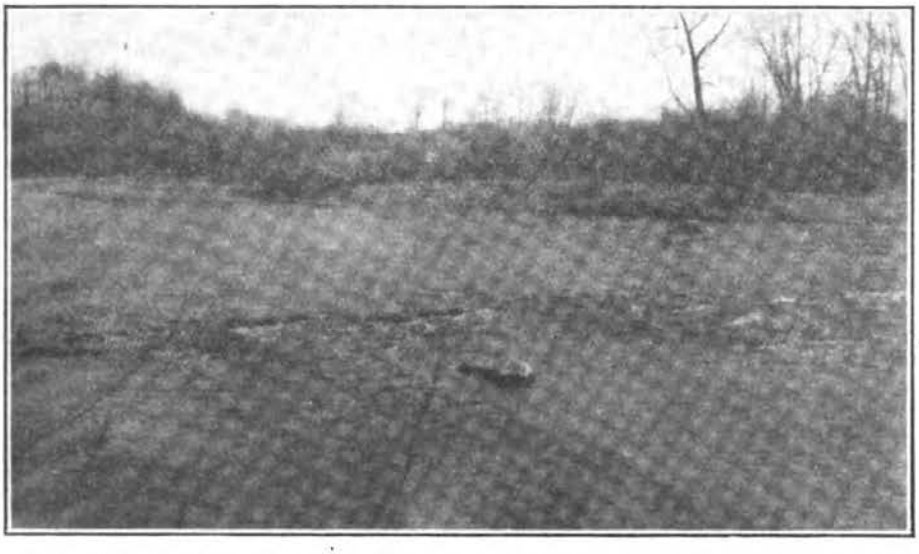

FIG. 21.—Shallow, stony rapids. The home of *Corydalis cornutus* larvæ, etc. Location E, figure 16.

FIG. 22.—Dried plants of *Melilotus alba*, having become established upon the gravel bar during the previous year. This is one of the most important pioneers in revegetation of such areas. Location F, figure 16.

FIG. 23.—A washout made by the flood of 1913 in a cultivated field. The dark areas in the bottom of the excavation mark the extent to which revegetation had been carried on in two years. Location C, figure 16.

FIG. 24.—A washout made by the flood of 1898. It has not only become completely resodded but trees are thriving in what was once the soilless gravel bottom. Location H, figure 16.

cans Le Sueur, red-horse *Moxostoma* sp. (?), and bullheads *Ameiurus natalis* Le Sueur, several weeks and even months after the recession of the flood. Coker (1915) calls attention to the fact that the number of fish is diminished by young fish being carrier away from the stream during overflow.

The cutting of new channels is to be considered under the sculpturing of the flood-plain at least until such are claimed by the stream when in its normal condition. The cutting of one such channel is indicated on the map, figure 16. Figures 25 and 26 show scenes viewed from the bottom of the cut.

The deposition of material upon the flood-plain is almost invariably the direct result of the washouts just mentioned. The soil materials scooped out to form these holes in the flooded plain are capable of being carried in inverse proportion to their coarseness, the gravel and sand usually being deposited immediately below the washout while the soil proper, loam, clay, etc., is often carried in suspension by the water for a much longer distance. This has its most important effect upon animal life indirectly through its alterations made in the character of the vegetation. All animal life, we know, depends either directly or indirectly upon plant life, and many animals are limited to a small number of plant species for food. Even certain of the predaceous animals are limited to a relatively small number of animal species for prey and the parasitic forms naturally depend upon one particular host. The flood-plain is especially rich in mesophytic plants with a corresponding wealth of animal species. In the case of cultivated fields the animal life is more or less distinct, depending upon the nature of the plants under cultivation. The materials deposited by the floods may be roughly classified in this relation as (1) sterile, i. e., sand and gravel, and (2) fertile, i. e., silt. Gravel bars built up in the midst of the fertile flood-plain (figures 27 and 28) are in some cases for years practically barren of both plant and animal life. A deposition of silt may have either of two effects. It may be laid upon a stretch of gravel rendering, in the course of a few months, an area, sterile and waste, into a tangle of grasses and herbaceous plants with most complex animal associations being developed and maintained. On the other hand, cultivated fields, blue grass pasture lands or waste places in which a great wealth of native plants have become established may receive this layer of silt and the area will be obliged to undergo a complete suc-

cession of plant changes before the original condition is again reached. In the region under observation one of the first plants to invade a new area, either fertile or sterile, is the common sweet clover, *Melilotus alba* Desr., which is shown in figure 22 as having become established during the previous year on a gravel bar. Clements (1907) gives a brief statement concerning plant succession on flooded soils. Each stage in this series of plant changes must present a related change in the character of animal life present.

It is of no little importance that floods influence animal associations directly without actually affecting either the physiographical or vegetational environment. This is in turn, upon analysis, seen to be capable of accomplishment in two ways: (1) by destroying or removing forms already in existence and (2) by providing a means of dispersal, i. e., carrying forms into new regions.

While the writer was collecting at the edge of the advancing water he observed great numbers of subterranean caterpillars, many of which do much damage to agriculture. These larvæ were seen to climb grass blades and weed stems to keep out of the water which forced them from beneath the soil or from their places of refuge at the surface of the soil, only to be overtaken at the uppermost tip of the plant and eventually drowned. Of thirty-nine specimens taken, twenty-five were the common army worms, *Heliophila unipuncta* Haworth, two were *Noctua c-nigrum* Linneus, one *Prodenia ornithogalli* Guenee, ten *Apantesis virgo* Linneus, and one *Apantesis phyllira* Drury.

Higher forms of animal life were affected by the floods in being forced to flee. Woodchucks, (*Marmota monax* Linneus) were driven from their burrows to take to trees, etc., for temporary safety and numbers of field mice *(Microtus sp. (?)* were seen swimming for refuge to higher points of land. Wood (1910) records having seen voles clinging to stumps above water and Shelford (1913) speaks of mammals as climbing trees under such circumstances. It is most probable that great numbers of these and other mammalian forms also perished during the period of inundation. Wood (1910) thinks that in spite of the fact that they can swim readily, many of these small mammals perish with each flood. Russell (1898) tells of seeing the dead bodies of drowned rabbits hanging in the willows on the delta of Mackenzie river.

FIG. 25.—This photograph, taken from the bottom of the new channel which is being cut, shows the depth of the channel and one of the permanent pools which lie in it. From this pool were taken three of the species of fish mentioned on page 162. Location I, figure 16.

FIG. 26.—This pool lies only a short distance above the outlet of the new channel. Beside certain of the other fish mentioned small specimens of the small mouth black bass, *Micropterus dolomieu*, were found to be able to maintain themselves. Location J, figure 16.

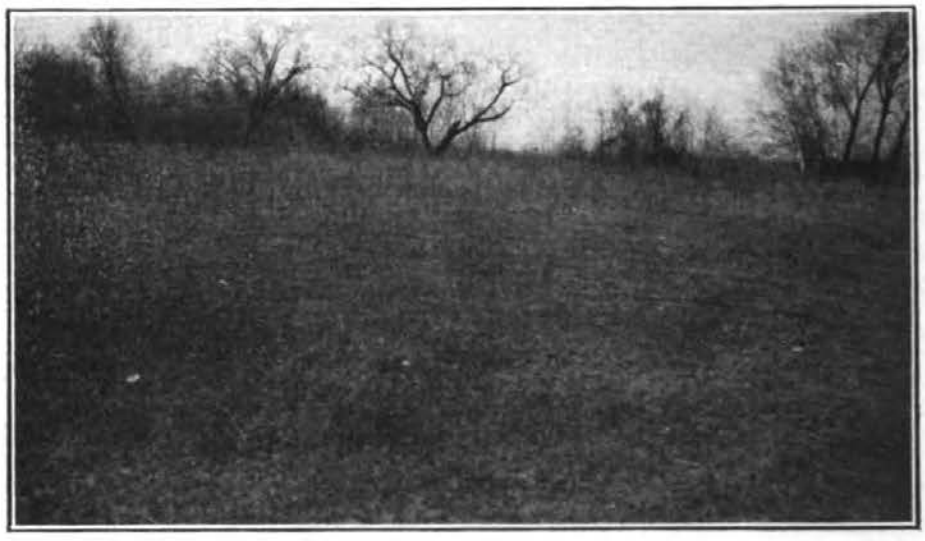

FIG. 27.—Blue grass pasture land on the flood-plain of White Water river. This and the succeeding figure serve to illustrate change in the nature of the flood-plain by the deposition of gravel upon fertile areas.

FIG. 28.—Gravel bar thrown down upon blue grass pasture land. This and the preceding photograph were taken from the same spot by merely facing the camera in another direction.

Of these higher forms, the field mice, and even a specimen of the common cottontail rabbit, (*Lepus nutalli mallurus* Thomas) were seen riding upon the floating driftwood. From such rafts as the writer was able to reach were taken Rhyncophorid, Carabid and Chrysomelid beetles, among other insect forms, and spiders. Shelford (1913) has also recorded having observed insects upon nettles and driftwood. This part, played by the flood, in dispersal of animal life is of considerable possibility and may account, in part at least, for the wide distribution of many of our common forms.

ACKNOWLEDGMENTS AND LITERATURE.

For determination of the lepidopterous larvæ listed in this paper I am indebted to Dr. Stanley B. Fracker, of the University of Wisconsin. I am under especial obligation to Dr. Chas. C. Adams, of Syracuse University, Syracuse, New York, and Professor Gilbert L. Houser, of this institution, for many aids to me in the preparation of this paper and for criticism of the manuscript. I wish, also, to particularly acknowledge my indebtedness to Mr. H. M. Trusler, of Indianapolis, Indiana, for his assistance to me in the preparation of the maps.

As this particular field has practically remained untouched up to the present, there is little available literature on the subject as such. To be sure, there are, no doubt, hundreds of individual references pertinent to the subject, not only in zoological, but botanical and physiographical publications as well. However, to the best of my knowledge, this is the first attempt to bring any of these together in an American publication. I realize that the following list contains but few of the many possible references but it is my intention to give only those titles which I personally consulted in connection with this paper. Inasmuch as many of these are but incidental references, I have included an explanatory paragraph with each title.

Antipa, Gregor, 1912.

Die Biologie des Inundationsgebietes der unteren Donau und des Donaudeltas. Verhand VIII. Inter. Zöol. Kongresses zu Gras, 1910. pp. 163-208.

This article consists of a description of the biological conditions on the flooded lower Danube and its delta. He includes in his discussion, for example, observations concerning the modified nesting habits of birds in response to the flooded conditions of the region. This is the most pertinent article on the subject that has come under my notice.

Garman, H., 1890.

A Preliminary Report on the Animals of the Mississippi Bottoms near Quincy, Illinois, in August 1888, Part I.

Bulletin of the State Laboratory of Natural History; Vol. III, Article IX, pp. 123-184.

He treats of the topography of the flood-plain with a detailed discussion of the forms of animal life taken, the emphasis being laid upon the normal fish fauna.

Alvord, J. W., and Burdick, C. B., 1915.

Report of the Rivers and Lakes Commission on the Illinois River and Its Bottom Lands with Reference to the Conservation of Agriculture and Fisheries and the Control of Floods. 139pp.

While this article contains no direct reference to the subject proper, the comparative treatment of the agriculture and fisheries of the region, data of past floods, and estimates of future inundations, together with the discussion of remedies, serve to make it a paper of importance.

Clements, F. E., 1907.

Plant Physiology and Ecology. 315 pp. Holt & Co., New York.

Paragraph 300 on page 280 gives a brief statement concerning plant succession on flooded soils.

Needham, J. G., and Lloyd, J. T., 1916.

The Life of Inland Waters. 438 pp. Comstock Publishing Company.

On page 42, in the chapter on the Nature of the Aquatic Environment, "The rate of settling (of silt) is dependent upon the rate of movement of the water and on the size of the particles," as illustrated by certain features of Fall creek, Ithaca, New York.

In the chapter on Types of Aquatic Environment the authors discuss the formation of flood-plain lakes and ponds, page 67. On pages 84 to 85 the effect of silt upon organisms is brought out.

In the same chapter, pages 87 to 88, in the discussion of high and low waters, high waters and the inconstancy of water level are recorded as disturbing the adjustment of the vegetation and causing migration of the larger animals.

In the chapter of Aquatic Societies the authors treat of the varieties of bottom formation and the consequent faunal variations, pages 356 to 367.

Shelford, V. E., 1913.

Animal Communities in Temperate America. The Geographical Society of Chicago, Bulletin 5. Univ. of Chicago Press.

On page 105, under the discussion of special stream problems, the author gives a list of species taken at the side of the bank at high water. He makes the statement that in times of flood the fresh and quiet water forms become mixed. On page 106 he advances the idea that large floods crush swift water forms beneath moving stones. The migration of Mollusca upstream during floods is recorded, pages 106 to 107.

On page 202 the author records having observed insects on nettles above the rising water and upon driftwood. In this same connection, mammals are spoken of as climbing trees, page 203.

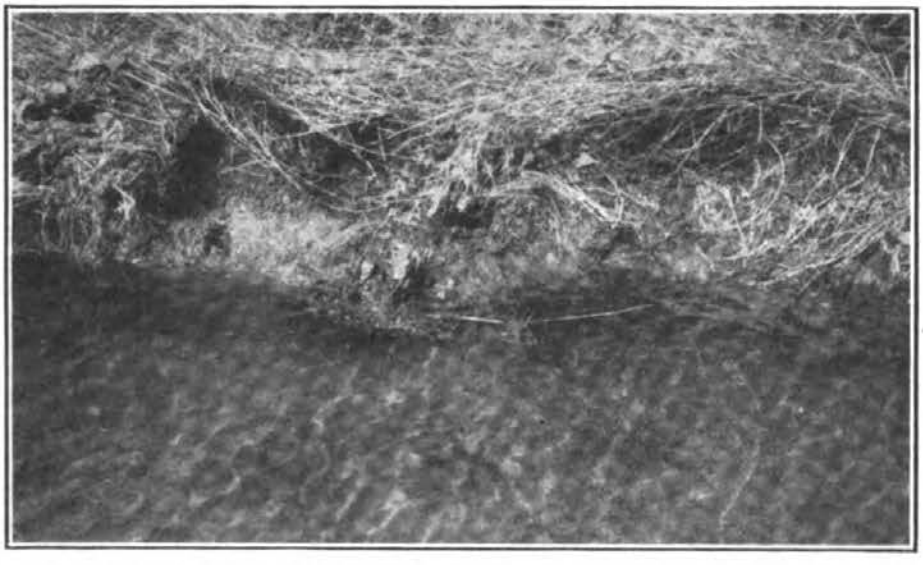

FIG. 29.—The above-water entrance to burrow of muskrat, *Fiber zibethicus*, in soil bank of White Water river.

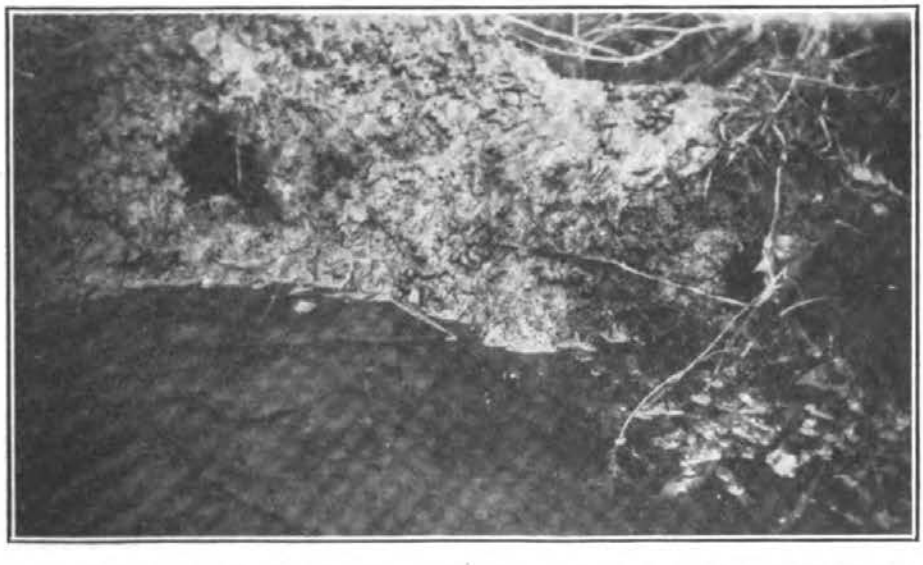

FIG. 30.—A nearer view of the entrance to the burrow shown in figure 29.

Coker, Robert E., 1915.

Water conservation, Fisheries, and Food Supply. Popular Science Monthly, July, 1915.

Under the heading "Floods and Fishes," pages 93 to 94, the author speaks of the diminution of the number of fish by floods as taking place in the following ways: (1) young fish being left away from the stream by the overflow, (2) recently laid eggs prevented from hatching, (3) the deoxygenation of the water for the young fish by turbidity.

Reynolds, R. V. R., 1911.

Grazing and Floods. A study of conditions in the Manti National Forest, Utah.

Bulletin 91. Forest Service, United States Department of Agriculture, 16 pp. map and 5 pl.

Under the heading "Damage from Floods" the statement is made that floods have resulted in the destruction of many fish. All of the streams of this region were formerly of cold, clear water, which never became turbid, and were well stocked with trount. These fish have been killed in the thick mud brought down by floods and are now very few in numbers.

Cameron, A. E., 1913.

General Survey the insect fauna of the soil within a limited area near Manchester (England); a consideration of the relationship between soil insects and the physical conditions of their habitat.

Journal Economic Biology, Vol. VIII, 159-204.

On page 190, under the topic of "Soil Insects and Soil Moisture" the author discusses the practice of artificially flooding fields as a means of combatting insect pests, and states that certain wire worms can live six days in water.

Chittenden, F. H., 1904.

Insects Injurious to the Basket Willow. Bureau of Forestry Bulletin ..o. 46, pp. 63 80.

On pages 63 to 64 the writer emphasizes the desirability of planting basket willows in land that is subject to complete inundation for several days at a time as the injurious insects rise to the surface and are swept away.

Webster, F. M., 1904.

The Suppression and Control of the Plague of the Buffalo Gnats in the Valley of the Lower Mississippi River, and the Relations thereto of the Present Levee System, Irrigation in the West, and Tile Drainage in the Middle West.

Proceedings of the Twenty-fifth Annual Meeting for the Promotion of Agricultural Science, 1904, pp. 53-72.

The author shows how the extensive flooding of the lower Mississippi flood plain makes it possible for these insects, *Simulium venustum* Walker, to develop in large numbers over wide areas attached to drift wood, floating logs, growing bushes, etc., in the flood water.

Wood, F. E., 1910.

A Study of the Mammals of Champaign County, Illinois. Bulletin of the Illinois State Laboratory of Natural History, Vol. VIII, Article V.

On page 512 the author records having seen voles clinging to stumps above the water, and having been told that in high water of the Illinois river white footed wood mice take to the trees above the water. He thinks that in spite of the fact that they can swim readily, many of these small mammals drown with each flood.

McIlhenny, E. A., 1914.

The Wild Turkey and Its Hunting. 245 p, 19 pl.

Doubleday, Page and Company.

In the chapter on Enemies and Food the author tells of the turkeys resorting to tree tops during the overflow of the extensive bottom land forest and feeding almost exclusively upon the buds of the trees at such times. He records one instance of two months' duration, pages 143 to 149.

Russell, Frank, 1898.

Explorations in the Far North. State University of Iowa, 1898.

The author observed the dead bodies of rabbits suspended from the willows on the delta of the Mackenzie river. These had been drowned during the overflow of the stream. Page 139.

THE STATE UNIVERSITY.