A FAUNAL SURVEY OF SHEBOYGAN MARSH

by

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INTRODUCTION

Of a necessity, Americans have become conservation minded even though the awakening in many instances is too late. The history of the Sheboygan Marsh affords an excellent cross-sectional study of the development of the conserving idea in Sheboygan County, Wisconsin.

The Sheboygan Marsh is located in the extreme northwest corner of Sheboygan County. At the present time it consists of about 12,000 acres of partly inundated grass and wood land. Of this Sheboygan County owns the strategic part. Deeds (1) filed in the register of deeds office at the courthouse at Sheboygan, Wisconsin, show that the county owns approximately 6,346 acres. All of this land is located in Township 16 North, Range 20 East.

An item in the Sheboygan Press in 1927 (2) stated that a government map drawn in 1837 shows a lake having irregular shorelines, extending north and south for a distance of approximately five or six miles and for a similar distance east and west. This map can now be found in the office of the Jerry Donohue Engineering Company, Sheboygan, Wisconsin.

The Geographical and Historical Atlas of Sheboygan County (3) indicated that direct Indian trails existed between ancient Shebowegan Lake and the region around the outlet of the Sheboygan river into Lake Michigan (Fig. 1). Bulletin 180 of the Department of Agriculture and Markets (4) showed that the Menominee Indians laid claim to the land along the Lake Michigan

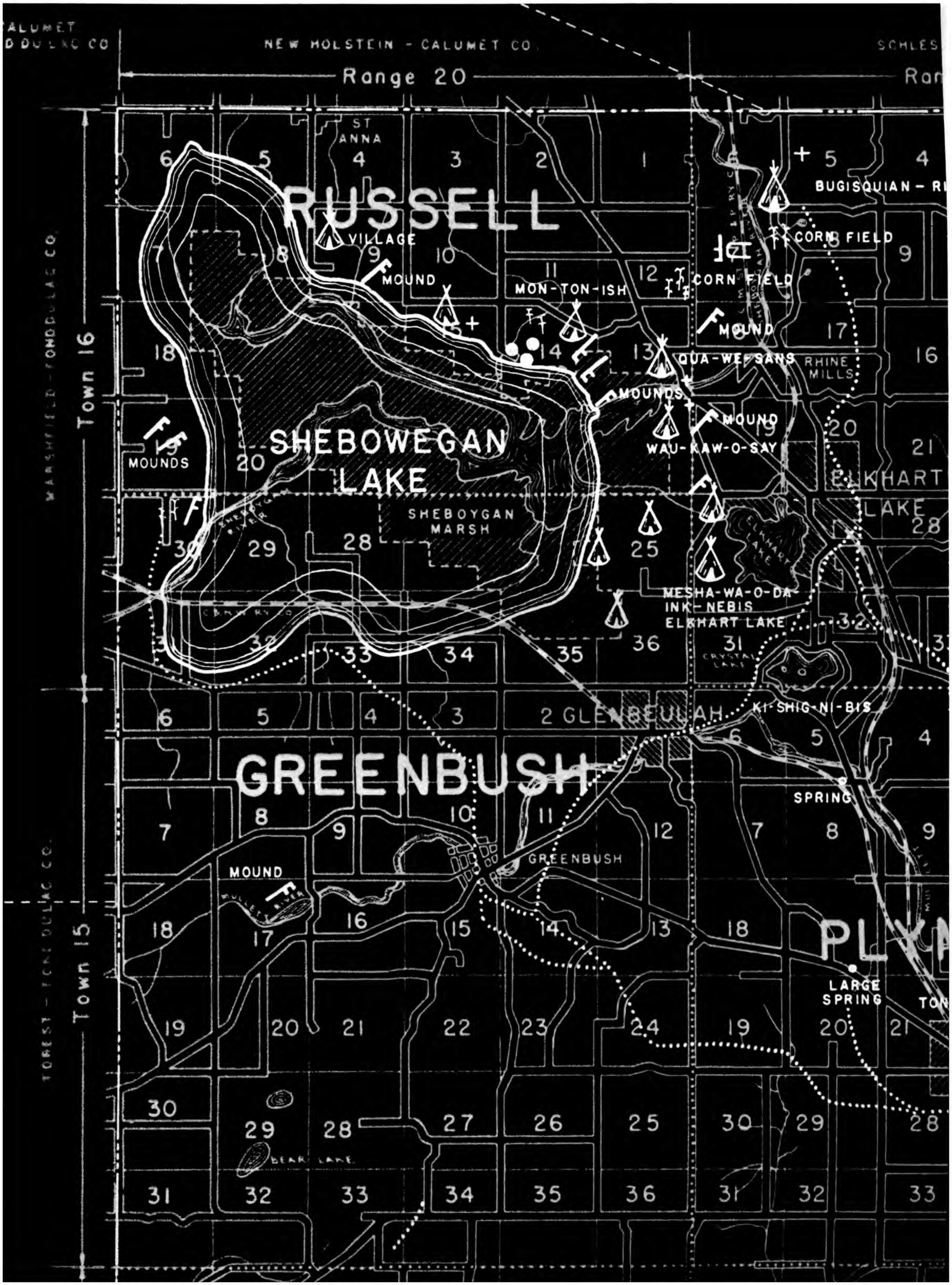


Fig. 1. Historical map of Sheboygan County as it appeared under Aboriginal possession. Note ancient Shebowegan Lake superimposed on present day Sheboygan Marsh.

Trails .... Mounds Village Cornfield Burials + +

shore in which was located the present area of the Sheboygan Marsh. The Potawatomi, the Winnebago and perhaps even the Chippewa occasionally made hunting trips into this region.

At a treaty held in Washington in February, 1831, the Menominee Indians ceded a large area of land on the Lake Michigan shore to the government. The Geographical Atlas previously mentioned further records that the survey of this tract was completed in 1833 and the results published in 1837. Notes and maps on this survey are still available.

Paxson (5) stated that Governor Dodge in 1837 convened the Chippewa and the Sioux, and two treaties, concluded that autumn, opened much of Northern Wisconsin territory to white entry.

> The farmer was slow in following the retiring Indians north of a line drawn from Fort Winnebago to Fort Snelling, but the lumbermen rushed in to establish a new frontier of their own and to lay the foundations of the first large private fortunes that the far Northwest produced. (5)

This migration left its imprint on Sheboygan County where some clearing and cultivating of land had already transpired.

In 1848 Wisconsin became a state and the cheap farming lands then available brought a flood of immigration from Germany, Scandinavia, Switzerland and France. Thrifty German settlers who laid claim to the land in the vicinity of the marsh had come from a land where one had to be a good farmer. Applying their methods in the new land, the surrounding territory was soon denuded of its trees and silt began to move into the already shallow lake. These immigrants at an early date began to have visions of draining the area and tilling the good soil that must lie beneath.

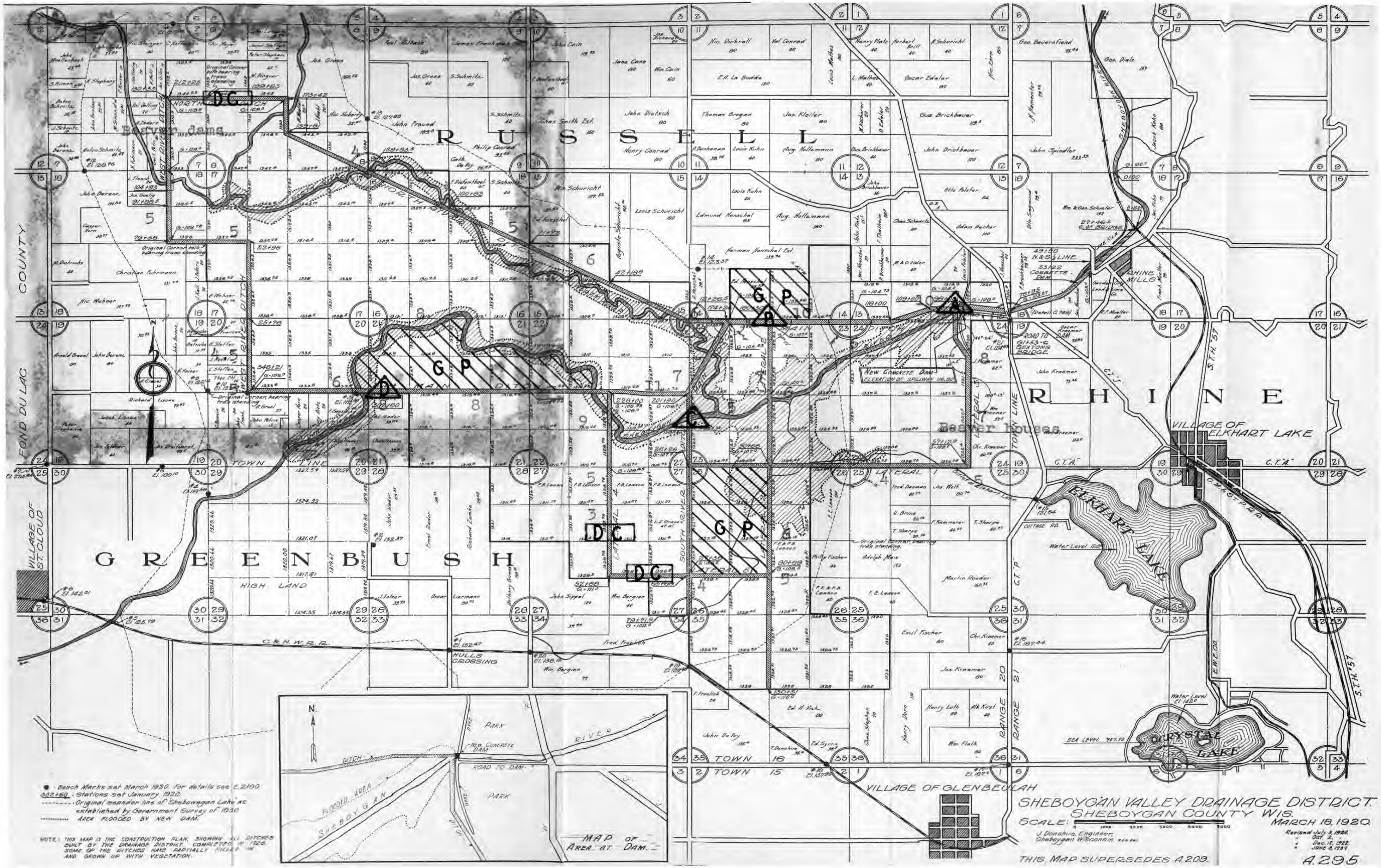
Peterson and Sinz (6) expressed their attitude and that of their predecessors by stating that too little had been done in the reclamation of a vast amount of land in the United States which was lying idle and worthless because of a water-logged condition. They extolled the virtue and progress typified by the drainage of such areas in Holland and in Ireland. To quote their opinion:

> The Sheboygan Marsh is an example of many acres of land that do no good whatever to the owners the year around. In the condition that it now is, it cannot even be used for pasturing purposes, because of the danger of the cattle becoming mired in soft and water-soaked soil.

A description of the marsh as they saw it in 1905 is interesting.

> It is an irregular shaped tract of land, being about six miles long and four miles wide, containing about ten thousand acres. Half of this tract is covered by tamarack woods which are located mostly around the outer edge of the swamp. Around the swamp there are steep hills on the north side, gently sloping hills on the south and west sides. The eastern side slopes away from the swamp. As the swamp comes to a point on this side it is only about a half a mile long. The Sheboygan river enters the swamp at the extreme western side, and runs through the northern half in an easterly direction. The channel of the river is very tortuous and varies in depth from six inches to two feet. (Fig.2)

Peterson and Sinz were engineering students and showed by maps how the marsh could be drained. Their report shows that from a geological standpoint the marsh was due to the existence of a limestone ledge on the east side, which impounded the water of the Sheboygan river. Since the last glacial era there had been an accumulation of what they considered undesirable peat. Under the peat was a huge layer of marl due to the decay of



A, B, C, D,--Stations
D.C.--Ditches Clogged

G.P.--Game Preserve
Depths in Arabic Numerals

EXPLANATION OF PLATE I

Fig. 3. Sheboygan Marsh seen from 14,000 feet (2.67 miles) in the air. Photograph taken in 1937, prior to construction of new dam. Area now flooded 1,500 acres. Photograph used by permission of Jerry Donohue Eng. Co., Sheboygan, Wisconsin.

Plate I

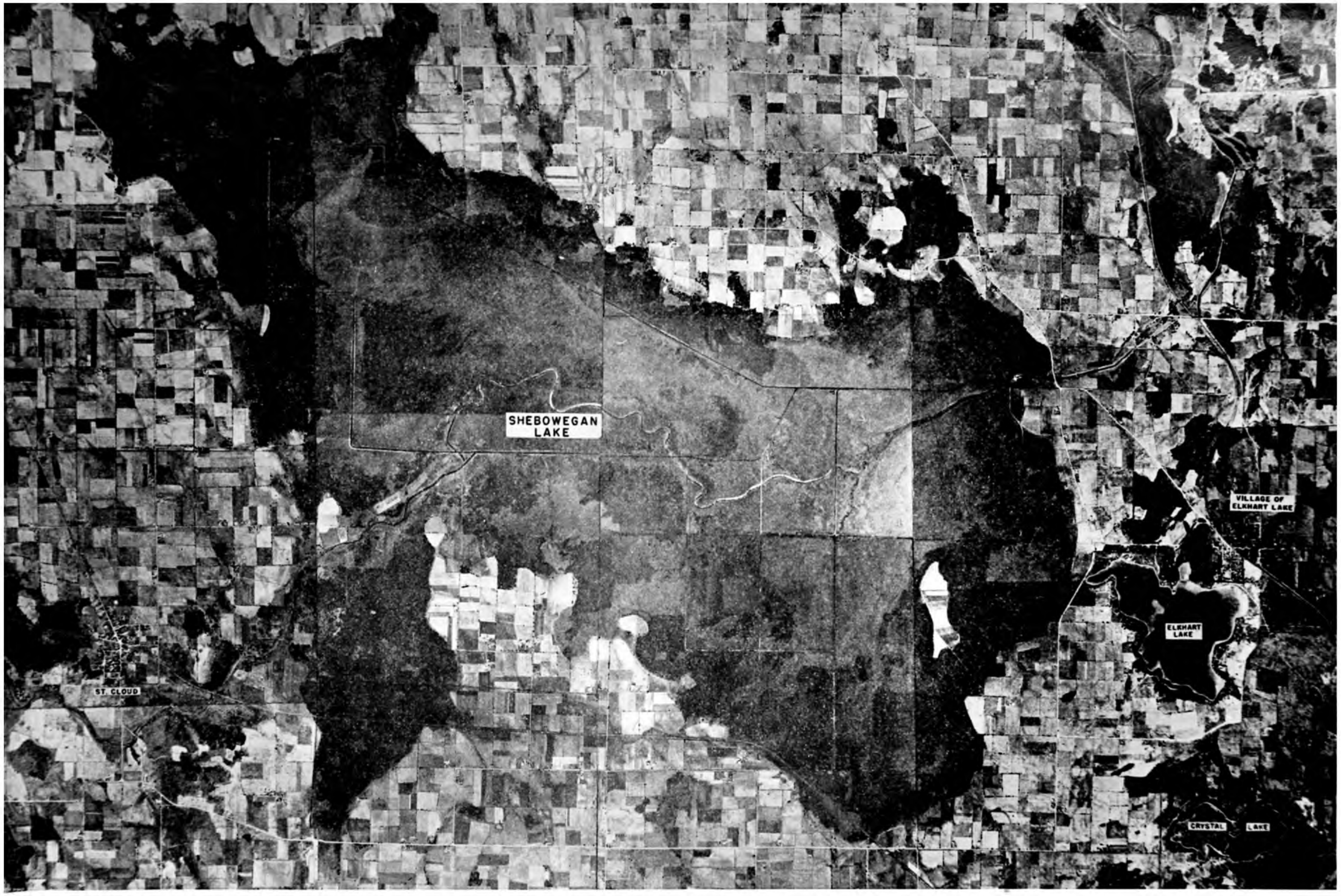

SHEBOWEGAN LAKE
VILLAGE OF ELKHART LAKE
ELKHART LAKE
ST. CLOUD
CRYSTAL LAKE

Fig. 3

shells and crustacea. From ten to forty feet below the surface of the swamp, they reported a layer of clay.

These writers further state that John Bertzschy in 1868 attempted to realize a profit from the potential value of the swamp. It seems that this project was initiated by Bertzschy borrowing $25,000 and the state legislature voting an equal amount. The problem of drainage seemed simple enough not to require the employment of a skilled engineer for guidance. As Bertzschy saw it, the river leading out of the marsh was not low enough to carry off the water and he proceeded to blast the limestone ledge that hemmed it in with charges of black powder. Simultaneously, a drainage ditch was started that was to cut into the main part of the marsh and draw the water towards the outlet. Bertzschy was unable to blast out all of the limestone ledge with black powder and soon found himself without funds. The area remained partially drained for over thirty years. According to Peterson and Sinz (6), Bertzschy lowered the east end of the ledge about three feet while the west end was lowered about six or eight inches and the damming up of the river was nearly as complete at the end of the work as before. From the reports of local residents this partial drainage did not ruin the region for wildlife, and the fauna of the region should not have been seriously affected.

Peterson and Sinz (6) described the efforts of others during the years from 1900 to 1905 to reap some profit from the marsh. A. G. and William Mauer attempted to use marl to make Portland cement. Options were obtained on the best marl beds but the plan failed when the proper clay for mixture was not found in sufficient quantities. They next turned their attention to peat manufacture but this venture also failed. Peterson and Sinz (6) in their work made a study of the average rainfall during the years 1902, 1903 and 1904 and gave data on the depth, width, length and slope of ditches necessary to drain the marsh successfully.

Finally, the Garden City Land and Lime Company was organized by New York promoters. This company eventually drained the marsh. The promoters envisioned a beautiful new city springing up where the marsh then was. Maps were drawn showing streets with buildings and churches. A conversation with Jerry Donohue, in charge of the engineering company from Sheboygan employed to do the job, disclosed that a $200,000 bond issue had been floated and about $160,000 worth of stock had been sold. This drainage project began in 1912 and reached its completion on September, 1921. The drainage was completed but no gardens were forthcoming; thousands of dollars were lost. Some fifty years after men had first dreamed of reclaiming this land, these dreams were realized. The drainage project lowered the water some ten feet and drained the terrain thoroughly.

To the great disappointment of the promoters, no one wanted the land. After the war, land prices had suffered a severe reversal. For many years the marsh was dry. When rain fell the water poured out of it through the drainage ditches.

The Sheboygan Press of Aug. 1, 1927 (2) recorded that tax delinquency began in the year 1923, and by 1927 the county held tax certificates totaling $117,149.28.

The area having been drained, fires began to break out in the parched grasses. Two years later, the Sheboygan Press (7) gave an account of the county skies being reddened by fires and darkened by smoke attracting tourists to the blaze. The marsh fires were now occurring annually and burning brightly for a long time.

In 1931, 1,000 acres of the marsh were destroyed by the fires (8). These were alluded to as the great fires of 1931 in which cattle were killed and many farm buildings endangered. People in the vicinity were now becoming aroused to the fire hazard. Pawlisch (9) stated that as if by magic a dam appeared one night in 1932 where the old limestone ledge had been. This dam was illegally constructed, not having been authorized by the Public Service Commission. Presumably some citizens thought that action spoke louder than words. This dam marked the beginning of the return of the former wildlife haven. The force of the pent up waters was too much for this first crude structure and another dam had to be built in the spring of 1933. Since no violent objectors appeared, this more substantial dam was built in broad daylight by popular subscription and effort.

The citizens became intensely interested in acquiring the marsh for the county, especially since much of the property was tax delinquent. The complete area became tax delinquent

EXPLANATION OF PLATE II

Fig. 4. Marsh as it appeared drained 1931-
devastating peat fires.

Fig. 5. Another result of drainage-1931.
Charred tamarack and white cedar.

Plate II

Fig. 4

Fig. 5

on November 27, 1936 (10). Interested citizens had paved the way for county acquisition of the property. At a public sale for taxes on March 5, 1937, the county acquired 6,000 acres or the major part of the marsh (11). This made them sole possessors. The County Board voted to appropriate $5,000 as the county's share in building a new permanent dam (12) which was approved in July of that year by the Public Service Commission (13). On October 6, 1937, the Federal Government approved the marsh as a W. P. A. project and promised an allottment of over $20,000 (14). With this appropriation work started immediately.

Much credit must be given to Mr. Charles Broughton, editor of the Sheboygan Press, for forestalling any legal technicalities that might have arisen by deeding to the county 80 acres of land which he had purchased previously and which represented the key site of the dam. The way was now clear for the erection of a new permanent dam. To pour concrete in the dead of winter was problematical but work was begun. That spring saw unusually early thaws with accompanying high water. It appeared that the work was predestined for failure. A crew of more than a hundred volunteers by working day and night warded off the waters successfully at the crucial hour.

On March 12, 1938, the Sheboygan Press (15) announced the successful termination of a long hard fight. On that day the new dam was completed and the impounded waters were permitted to roar over it. In a short time, there appeared a rejuvinated marsh of about 12,000 acres (Fig. 2).

This marsh appeared to present an ideal study of the

EXPLANATION OF PLATE III

Fig. 6. The temporary dam of 1932.

Fig. 7. Temporary dam of 1933.

Plate III

Fig. 6

Fig. 7

adjustment made by plants and animals to such a changed habitat, with special emphasis to be made on the conservation import of any findings.

Since the state of Wisconsin is intensely interested in its fishing waters and because of encouragement and interest manifested by the Biology Division of the Wisconsin Conservation Department, it was decided at an early date to put considerable emphasis on water analysis. Since it appears that all other factors hinge more or less directly on water, the universal solvent, such factors as oxygen content, free carbon dioxide, fixed carbon dioxide, methyl orange alkalinity and temperature were considered as important indices in this study.

The purpose of this thesis was primarily to determine what types of wild life are found in the Sheboygan Marsh and to ascertain types that give promise of maintaining themselves in the marsh.

REVIEW OF LITERATURE

In making a faunal survey of an area as vast as the Sheboygan Marsh, it would be almost impossible to exhaust all the related literature. Therefore the literature which was primarily related to the problem was considered. It was felt that the ecological implications should be stressed and the literature dealing with that field was given more attention.

An immense amount of current literature dealing with the ecology of fresh waters has appeared in recent years. Birge

EXPLANATION OF PLATE IV

Fig. 8. Permanent dam of 1938. Courtesy Jerry Donohue Eng. Co.

Fig. 9. Water level today as caused by 1938 dam. Note Blue-winged teal in background.

Plate IV

Fig. 8

Fig. 9

and Juday (16) have dealt with the dissolved gases of water and their biological significance. This was an important work, for water is a basic substance to all life. No specific studies appear to have been made on the waters of marshes but it would seem that the same methods employed by Birge and Juday on lakes could be applied to marshes.

In Michigan considerable work has been done on the ecological study of bogs by such workers as Coburn, Dean and Grant (17) and Goe, Erickson and Woollett (18) the major emphasis being on plants.

According to Needham and Lloyd (19) the composition of a marsh, a swamp and a bog are different:

> In general we may speak of a marsh as a meadow-like area overgrown with herbaceous aquatic plants, such as cattail, rushes and sedges; of a swamp as a wet area overgrown with trees; and a bog as such an area overgrown with sphagnum or bog-moss, and yielding under foot.

From the above, the Sheboygan Marsh can correctly be called a marsh.

Among the many workers in limnology, the plankton studies of Juday (20) and Wiebe (21) were found especially valuable. They emphasized the necessity of plankton and discussed conditions that were favorable to its increase. Allen and Nelson (22) made an interesting study on the artifical culture of marine plankton which was found helpful in the study of fresh-water forms.

Welch (23) in his comprehensive work dealt with special types of lentic environments and their faunal characteristics.

Fish were considered as an important unit in this study.

The work of Gutsell (24) stressed the influence of certain water conditions, especially dissolved gases on trout. Clausen (25) found that there were fluctuations in the amount of oxygen consumed by fish. Greene's monograph (26) was used as an authoritative source on the distribution of Wisconsin fishes. Cahn (27) emphasized the effect of carp in waters suitable for their propagation. For information on the conditions of existence and life history of fish, it was thought profitable to make some scale studies.

Various methods have been employed for determining the age of fish. The size or weight and the length and the age of the fish have to be considered. The size can easily be determined but the age is more difficult to ascertain. Van Oosten (28) concurred in the general agreement that a study of the scales gives the best results. If the fish has no scales such structures as vertebrae, otoliths and opercula can be used with a degree of accuracy that varies with individual skill.

Van Oosten (29) conducted an interesting study of whitefish that were hatched and reared in a New York aquarium. These fish were nine years old and he determined that the annuli were of the same number as the age of the fish in years. Hence, he assumed that the annuli were winter marks formed by the retardation of growth in late summer and winter and were completed when growth began again in spring. Food and sexual maturity seem to be factors in annular formation. Schneberger (30) and Jobes (31) clearly outlined methods in determining growth of the yellow perch. These papers also were helpful sources in making growth studies. Hubbs (32) prepared material on life histories, habitat preferences and identification of minnows. Davis (33) gave instructions for conducting stream and lake surveys that proved indispensable.

In the study of amphibia, Wright (34) was a great aid in identification. Ditmars (35) and Pope (36) were found useful in reptile study.

Bird life in the marsh was found to be abundant. Clements and Shelford (37) gave useful suggestions on how best to determine the species of birds in an area. Van Deventer (38) made a study of a winter bird community in western New York. His methods were found applicable in the study of the winter birds of the marsh. Chapman (39) gave many practical helps.

Elton (40) was useful in the study of composite animal ecology, while in the study of American mammals, Hamilton (41) was found informative. Fassett's (42) manual gives the importance of the major aquatic plants to their chief consumers. This was one of the best sources on aquatic plants. No work of biological significance appears to have been done on the Sheboygan Marsh.

PHYSICAL FEATURES

The Sheboygan Marsh has an area of approximately 12,000 acres. Of this about 1,500 acres are covered by water and the remainder is typical marshy terrain. It is all located in

Township 16 North, Range 20 East, commonly called Town of Russell, Sheboygan County, Wisconsin.

Elkhart Lake and Crystal Lake, both deep spring-fed lakes, are within a radius of two miles. Elkhart Lake drains into the marsh. The shape and area of the Sheboygan Marsh has altered appreciably throughout geological ages. Before the last glacial epoch, what is now the Sheboygan Marsh was a large lake which, in addition to the present marsh, covered over half of the present Town of Russell. It is estimated that this lake was about 45 feet deep. The glaciers brought in their deposits, however, making the lake smaller and more shallow. The lake now was nothing more than a broadening of the Sheboygan river which was partially dammed in on the eastern edge by a limestone ledge (Figs. 1,2). The surrounding country consists of steep hills on the northern side and gently sloping hills on the south and west sides. The eastern side is comparatively level. The uneven topography originated from the glacial deposits. The soil is homogeneous--muck and fibrous peat and underlying marl constituting the whole. Sand, gravel and rock are very uncommon. It has a miscellaneous forest cover of tamarack, white cedar, spruce, poplar, ash, elm and birch. The predominating trees today are tamarack and poplar. The shore line is extremely irregular except where drainage ditches constitute the shore line.

The water inlet from Elkhart Lake and the water coming in from the Sheboygan river are impounded by the dam at the outlet thereby maintaining a fairly constant water level. The maximum depth of the marsh is approximately twelve feet just above the dam. The average depth of the drainage ditches is about six feet (Fig. 2). These ditches become more shallow as one proceeds farther into the marsh. The average depth is fairly constant as the drainage ditches were designed to drain off the water by gravity before the dams were put in.

METHODS AND MATERIALS

Chemical Analysis of the Water

A series of tests was taken periodically over a course of a year at three designated stations "A", "C", and "B" (Fig. 2) with a field set designed for this purpose by the Biology Division of the Wisconsin Conservation Department. The methods of determining the dissolved oxygen, the free carbon dioxide, and the fixed carbon dioxide were taken from the American Public Health Association, "Standard Methods of Water Analysis" (43).

The bottle for dissolved oxygen sample had a capacity of 250 cc and was fitted with a glass stopper. A standard short form model nessler tube was used for carbon dioxide determination. Water samples for determination of alkalinity were measured with a 100 cc volumetric flask into a white porcelain casserole for titration.

Surface samples for dissolved oxygen were collected by tilting the bottle to a horizontal position and allowing the water to flow into it very slowly and with minimum agitation. This is necessary to prevent undue aeration. The bottle was filled so that water was displaced when the stopper was inserted and no air bubbles were left under it. Following a suggestion by Davis (33), air bubbles were "averted to a great extent by first rinsing out the bottle to moisten the interior surface".

The carbon dioxide samples were collected in a similar manner. The water level was accurately adjusted to the 100 cc mark by gently pouring off the surplus without undue agitation. Since no exchange of gas as a rule affects the alkalinity, it was not necessary to exercise as great care in the collection of this sample as in the other ones taken.

To the sample collected in the 250 cc bottle for oxygen determination 1 cc of manganous sulfate and 1 cc of alkaline potassium iodide were added beneath the surface of the liquid. The stopper was carefully replaced preventing the entrapping of air bubbles. The bottle was then shaken vigorously for a few seconds and then the precipitate allowed to settle until it was contained in the bottom half of the bottle. After the precipitate had settled, 1.5 cc of concentrated sulphuric acid was added. The stopper was replaced with the former precautions against trapping air bubbles and the bottle again shaken vigorously to mix the contents. Since three stations were almost invariably visited, sometimes in a canoe and at other times by the aid of a small sled, titration was carried out at each station when weather conditions permitted to avoid carrying too many bottles.

Two-hundred cc of the treated sample were measured out with a 200 ml volumetric flask, into a white porcelain casserole. The sample was then titrated with 40 N. sodium thiosulphate. When the color became a faint yellow after the addition of thiosulphate, 2 cc of starch were added. The titration was then continued until the blue color disappeared. The dissolved oxygen was then recorded in parts per million by weight. Since a 200 cc sample was used the dissolved oxygen was equal to the number of cc of 40 N. thiosulphate required.

The carbon dioxide sample having been taken, 10 drops of phenolphthalein were added. If the sample turned white or was colorless, free carbon dioxide was present. It was then rapidly titrated with N/44 sodium hydroxide until a faint but permanent pink was produced. The free carbon dioxide was then equal to ten times the number of cubic centimeters of sodium hydroxide used.

To determine the alkalinity another 100 ml sample was taken and three drops of methyl orange were added. This was then titrated with N/50 sulphuric acid to color change. The alkalinity in parts per million of calcium carbonate is equal to the total number of milliters of N/50 sulphuric acid used multiplied by 10.

If the carbon dioxide sample became colored upon the addition of phenophthalein, hydroxide or normal carbonates were present indicating a carbon dioxide deficiency. This was then titrated with N/50 sulphuric acid from a burette until the coloration disappeared. The carbonates present or carbon dioxide deficiency was then equal to the number of cc of N/50 sulphuric acid used multiplied by 10. By adding three drops of methyl orange the titration was then continued with N/50 sulphuric acid to pink color change. The total cc used times 10 gave the so-called methyl orange alkalinity.

Plankton

Since in this survey not all aspects of the biota could be dealt with in detail, an effort was made to determine the predominating species of plankton only. Juday (20) gives specific details on limnological apparatus and methods available. Davis (33) suggests that the sample could be collected in a 12-quart pail with a mark to indicate the 10-liter measure. Fifty liters should then be strained by pouring through a 20-mesh silk bolting cloth net partially submerged in water. The sample having been collected, the sides of the net should be carefully rinsed with water to wash all the plankton down where it may be collected in a graduate centrifuge tube at the bottom. It could then be centrifuged at a moderately high speed for several minutes and the volume in cubic centimeters determined for fifty liters of water.

In this study, however, surface plankton drags were made with a Turtox No. 12 plankton net and the plankton washed into centrifuge tube as described above. No attempts were made to determine plankton volumetrically. Plankton forms were preserved by adding $\frac{1}{2}$ cc of formalin to each 10 cc of plankton water. A label was placed in the bottle giving the date, where collected on the marsh and the collector's name.

Fish

Most of the fish used in this study were caught in the fyke or hoop nets of the Wisconsin Conservation Department rough fish removal program during the winter of 1939 and 1940. Some few were caught by hook and line during the summer of 1939. The fish were taken when the nets were lifted for the removal of carp. The fish were weighed and measured and some killed by placing immediately into 50% formalin and these were later injected with 10% formalin and stored in the latter. The weight was taken to the nearest gram and the standard length, the distance from the tip of the snout to the end of the last vertebra or base of the caudal fin rays, was taken in millimeters. These data were recorded on the fish scale sample envelopes furnished by the Wisconsin Conservation Department. On this envelope the following observations were recorded, species, locality, date, length, weight, sex, collector and address.

Professor Chancey Juday, noted Limnologist of the University of Wisconsin, agreed to arrange to have the age of the scales determined. The age groups in tables 1 and 2 were determined by his trained assistants. In order to study the scales only typical scales were selected. The regenerated and irregular ones were discarded. The scales were next soaked in water and the dirt removed by brushing with a small tooth-brush. The scales were then mounted in glycerine jelly as outlined by Van Oosten (28). Schneberger (30) found that they could be mounted in ordinary white Karo syrup with greater ease and with quite satisfactory results. The scales were then projected upon ground glass after the method described by Van Oosten (29). The age of the scale could then be determined by comparing each annulus with the outside circulus.

Amphibia

In the study of the amphibia, the marsh was covered systematically. Different channels and areas were covered at each trip. A long handled device with a small hoop net twelve inches in diameter at one end similar to an insect net was constructed to capture the amphibia. With this the prey could be quickly covered and with a dexterous twist scooped up. Without this device few frogs could be captured. The shores and marshy regions upon which one could walk were carefully searched. Those species that were recognized in the field were released; others were put into a bucket with holes punched in the top for later study and identification. Some few were preserved in 10% formalin after having been injected with formalin of the same strength. Several specimens, including the mud-puppy, were secured in mid winter from nets which the Wisconsin Conservation Department was using to catch carp.

Reptiles

A careful search was made for snakes along the water's edge, under dead trees and fallen logs and in the marsh grass. The specimens were captured alive with a forked stick and since the varieties were few, they were usually released again. The turtles were caught with the aid of a dip net. Again where identification was positive the specimen was liberated. The best time for turtle hunting was on sunny days. On such days the turtles would expose themselves while sunning, thereby expediting their capture. A few snapping turtles were taken on the hook while fishing.

Bird Study

In an area as vast as the Sheboygan Marsh the number of birds of any one species seen could at best be only roughly approximated. The majority of species found therein could be pretty accurately determined. Clements and Shelford (37) say:

> Numbers of birds and larger mammals are usually ascertained by cruising. Only experts are effective in this. The person who can identify most readily reports most. Usually general impressions are underestimates.

Most of the birds were identified while cruising in a canoe. No other method was nearly as effective as this. Occasionally it was possible to glide within fifteen or twenty feet of the bird before it took flight, affording the observer ample time for identification.

Form sheets were devised after the manner used by Prof. George Wagner of the Zoology Department of the University of Wisconsin (Fig. 10). While in the field the species seen were checked and the number approximated. These check lists included all the birds that had been seen in Sheboygan County to date. Two pairs of good field glasses were used, one for close observation giving a clear image and magnifying about four times and another magnifying about ten times for more distant work.

Mammals

In the study of aquatic mammals, the cruising method--paddling slowly and noiselessly in a canoe in a systematic manner over a limited area--was also very efficacious. Study from blinds was occasionally resorted too but this method was less successful. The greatest number of mammals were most always seen at twilight. At that time the nocturnal animals became active, and the diurnal ones had not yet retired. Beaver could be approached at work, sometimes they swam under the canoe; muskrats were everywhere. While cruising into the wind, three young red foxes feeding on crustacea were approached within fifteen feet before they became aware of impending danger. In the woods the method of quiet waiting was employed since the density of the vegetation and soft underfooting made

Fig. 10. Check list of Sheboygan County birds.

....	" Philadelphia*........	Hudsonian**.....
....	" Warbling,...........	Kinglet, Golden-crowned.....
	" Yellow-throated......	" Ruby-crowned........
	" Blue-headed..........	Gnatcatcher, Blue-grey......
Finches, Sparrows, etc.		
Grosbeak, Evening..........	....	Thrush, Wood...............
" Pine..........	....	" Wilson's............
Finch, Purple...............	Warbler, Black and White...	" Grey-cheeked........
Crossbill, American*.......	" Prothonotary*.......	" Olive-backed........
" White-winged*...	" Blue-winged**.......	" Hermit..............
Redpoll....................	" Golden-winged......	" Robin................
Goldfinch..................	" Nashville..........	" Bluebird...........
Pine Siskin................	" Orange-crowned*....	....
Snowflake*.................	" Tennessee..........	....
Longspur, Lapland..........	" Northern Parula....	
" Smith's**........	" Cape May..........	Addenda
....	" Yellow............	....
....	" Black-throated Blue	....
Sparrow, Vesper...........	" Myrtle............	....
" Savanna..........	" Magnolia..........	....
" Grasshopper......	" Cerulean**........	....
" Henslow's*.......	" Chestnut-sided....	....
" Leconte's*.......	" Bay-breasted......	....
" Lark*............	" Blackburnian......	....
" Harris's*........	" Black-poll........	....
" White-crowned....	" Black-throated Green	....
" White-throated....	" Pine..............	....
" Tree.............	" Palm..............	....
	" Oven-bird.........	....

* - Uncommon at Sheboygan, Wisconsin

** - Rare at Sheboygan, Wisconsin

LIST OF ______________________________ ANIMALS

DATE __________ WEATHER __________ TEMPERATURE __________ WIND __________

TIME __________ DISTANCE ____________________ TRIP NO. __________

LOCALITY ______________________________

OBSERVER ______________________________

✓ - easy to be identified now
o - not so easy to be identified now

BIRDS:

Grebe, Horned
" Pied-billed

Loon
" Red-throated*

Gull, Herring
" Ring-billed
" Bonaparte

Tern, Common
" Arctic
" Black

Cormorant, Double crested

Duck, Am. Merganser
" Red-breasted Merganser
" Hooded "
" Mallard
" Mallard Black
" Gadwall*
" Baldpate
" Gr-winged Teal
" Blue-winged Teal
" Shoveller
" Pintail
" Wood*
" Redhead
" Canvasback
" Scaup, Greater
" " Lesser
" Golden-eye
" Ring-necked
" Bufflehead
" Old-Squaw**
" Scoter, white winged
" Ruddy

Geese, Canada

Swan, Whistling*
Bittern, American
" Least
Heron, Great Blue
" Green
" Bl-crowned night
Rail, King
" Virginia
" Sora

Gallinule, Florida
" Coot

Phalarope, Northern*
" Wilson's

Sandpipers and Snipes

Woodcock, American
Snipe, Wilson's
Dowitcher
" Long-billed*
Sandpiper, Stilt**
" Knot**
" Purple**
" Pectoral
" Least
" Semi-palmated
" Red-backed
" Sanderling*
" Godwit, marbled**
" Yellow-legs, Gr
" Lesser
" Solitary
" Spotted

Plover, Black-bellied*
" Kildeer

Plover, Semi-palmated
" Turnstone

Grouse, etc.

Bob-White
Grouse, Ruffed
" Canada Ruffed**
Prairie Chicken

Dove, Mourning
Hawk, Marsh
" Sharp-shinned
" Cooper's
" Goshawk*
" Red-tailed
" Red-shouldered
" Broad-winged*
Hawk, Rough-legged
Eagle, Bald*
Hawk, Duck*
" Pigeon
" Sparrow
" Fish(Osprey)

Owl, Barn*
" Long-eared
" Short-eared
" Barred*
" Screech
" Great-horned
" Snowy*
Cuckoo, Yellow billed
" Black-billed
Kingfisher, ~~Hairy~~ Belted
Woodpecker, Hairy
" Downy
" Yellow-billed sapsucker
Woodpecker, Pileated**
" Red-headed
" Red-bellied*
" Flicker

Whippoorwill
Nighthawk
Swift, Chimney
Hummingbird, Ruby-throated
Flycatcher, Kingbird
" Great Crested
" Phoebe
" Olive-sided
" Pewee
" Yellow-bellied
" Alder
" Least
....

Lark, Horned
" Prairie Horned
Jay, Blue
Raven, Northern**
Crow

Blackbirds and Orioles

Bobolink
Cowbird
Blackbird, Red-winged
Meadowlark
" Western*
Oriole, Orchard*
" Baltimore
Blackbird, Rusty
Grackle, Bronzed
....
....

Finches, Sparrows, etc.

Grosbeak, Evening
" Pine
Finch, Purple
Crossbill, American*
" White-winged*
Redpoll
Goldfinch
Pine Siskin
Snowflake*
Longspur, Lapland
" Smith's**
....
....

Sparrow, Vesper
" Savanna
" Grasshopper
" Henslow's*
" Leconte's*
" Lark*
" Harris's*
" White-crowned
" White-throated
" Tree

Sparrow, Chipping
" Field
" Junco, Slate colored
" Song
" Lincoln's
" Swamp
" Fox
" Towee
" Cardinal*
" Grosbeak, rose-breasted
" Bunting, Indigo
" Dickcissel*
....
....

Tanager, Scarlet
" Summer**
Swallow, Purple Martin
" Cliff
" Barn
" Tree
" Bank
" Rough-winged
Waxwing, Bohemian**
Cedar
Shrike, Northern
Migrant
....

Vireo, Red-eyed
" Philadelphia*
" Warbling
" Yellow-throated
" Blue-headed
....
....

Warbler, Black and White
" Prothonotary*
" Blue-winged**
" Golden-winged
" Nashville
" Orange-crowned*
" Tennessee
" Northern Parula
" Cape May
" Yellow
" Black-throated Blue
" Myrtle
" Magnolia
" Cerulean**
" Chestnut-sided
" Bay-breasted
" Blackburnian
" Black-poll
" Black-throated Green
" Pine
" Palm
" Oven-bird

Warbler, Northern Water-Thrush
" Louisiana thrush**
" Connecticut*
" Mourning
" Maryland Yellow-throat
" Yellow-breasted Chat**
" Wilson's
" Canadian
" Redstart
....
....

Pipit, American*
Mockingbird
Catbird
Brown Thrasher
Wren, Carolina*
" House
" Winter
" Short-billed Marsh
" Long-billed "
....
....

Creeper, Brown
Nuthatch, White breasted
" Red-breasted
Chickadee, Black capped
" Hudsonian**
Kinglet, Golden-crowned
" Ruby-crowned
Gnatcatcher, Blue-grey
Thrush, Wood
" Wilson's
" Grey-cheeked
" Olive-backed
" Hermit
" Robin
" Bluebird
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Addenda

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* - Uncommon at Sheboygan, Wisconsin
** - Rare at Sheboygan, Wisconsin

movement moisy and precarious.

Aquatic Plants

No serious attempt was made to identify many aquatic plants in this study. However, an attempt was made to become acquainted with those plants that are extremely important to animal life. Fortunately Mr. Clyde B. Terrel, Aquatic Plant Specialist of Oshkosh, Wisconsin, was making surveys of the aquatic plants of the marsh and much valuable information was obtained while making the surveys with him. Plants that were gathered later were identified with the aid of Fassett's manual of plants (42).

OBSERVATIONS

Chemical Nature of the Water

When observations of the chemical nature of the water were first started, stations were arranged on a circuit of about nine miles. This circuit was made in a canoe so that a minimum of noise was made and a maximum of marsh inhabitants could be seen. After several trips it became apparent that the original circuit was too extensive for practical observations and in addition no marked differences in the water analysis were manifest at station "D" when compared to stations "A", "C", "B". For those reasons station "D" shown on map (Fig. 2) was abandoned as an observation station.

Great care had to be taken in gathering the samples of water to eliminate possibility of error in the final reading. This was particularily true of the dissolved oxygen determination where improper technique in obtaining sample would give a correspondingly inaccurate reading.

The samples to be tested were all taken from the surface since adequate equipment for taking samples at varying depths was not available. This method, it is true, does not give the complete picture of a body of water at one investigation. However, if tests are carried out at different stations under similar conditions throughout the course of a year, the results gleaned should reveal the nature of that body of water and its possibilities as a fresh water habitat.

Figure 11 shows this relationship of the chemical constituents studied over a period of time. It will be seen in Fig. 11 of water analysis of station "A" that the oxygen line fluctuates. According to Dr. Edward Schneberger[1], water must have at least 5 parts per million of oxygen in it to keep fish alive. Greene (26) asserts that most fishes cannot live in water which contains less than 1 to 3 parts per million of oxygen over rather long periods. Gutsell (24) found that asphyxiation of trout occurred with an oxygen content of 2.5 parts per million. With less than 1.3 all trout were asphyxiated. He also found that carbon dioxide up to 28 parts per million was not markedly harmful.

In figure 3 the four seasonal phases through which most

[1]Correspondence with Dr. Edward Schneberger, Chief Biologist, Wisconsin Conservation Department, Madison, Wisconsin.

large bodies of water pass are well illustrated; the summer stagnation period; the fall overturn, winter stagnation period and spring overturn. With the passing of summer and the approach of early autumn, September 3, 1939 in Fig. 11 declining air temperatures began to cause a cooling off of the surface waters of the marsh. The water so cooled sank and convection currents were set up. Thus in the deeper parts of the marsh, accepting that there was some thermal stratification (see Fig. 2 for depths), the water in the epilimnion or surface layer was equalized and lowered in temperature. This lowering in temperature continued until the epilimnion attained the same temperature as the thermocline; (the layer of rapid fall of temperature) then progressively it finally reached the temperature of the deeper levels of the thermocline. As the process continued it finally dropped to the same temperature level as the hypolmnion or deep layer of relatively constant conditions. The whole marsh then became homothermous. As a result, the water had the same density throughout. The wind circulated the water from top to bottom making the waters of the marsh take on a uniform character from September 30, 1939 to December 27, 1939. At that time the marsh became frozen except for a few spring holes and covered with a heavy blanket of snow. This ushered in the winter stagnation period. Now another form of stratification took place just the reverse of summer conditions. The warmer water sank to the bottom and the colder water remained on top. Eventually the whole marsh,

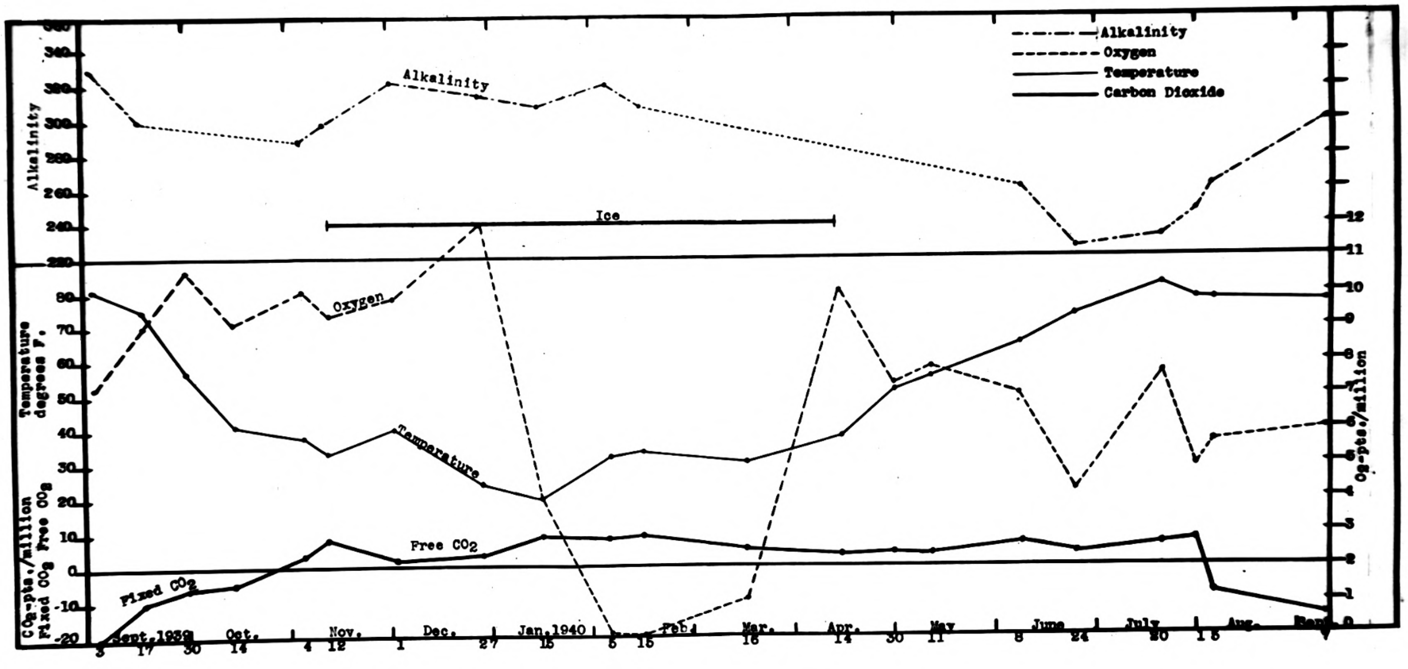

Fig. 11. Chemical analysis and temperature recordings of Station "A" from September 3, 1939, to September 7, 1940.

in a general way, resembled the hypolimnion of the summer period. Various factors now became active in diminishing the amount of oxygen such as the shutting off of light, the dying off of certain plankton forms, and interaction with other gases.

About January 13, 1940, the oxygen content fell below the necessary 5 parts per million and reached the zero mark by February 15, 1940. Thereafter, perhaps due to the seepage of water of melting snow and ice, the oxygen content began to rise again until by the last of March it was above the 5 parts per million mark. Since the readings were taken at the surface, there undoubtedly was a considerable difference in the oxygen content as compared to that below the surface. The breaking up of ice and the wave action hastened the spring overturn which was comparable to the fall overturn--temperatures of water were equalized and became thoroughly mixed. On April 14, 1941, the spring overturn had reached its peak. Warm weather then brought about the thermal stratification of the summer stagnation period in which the surface waters fell below 5 parts per million on June 24, 1940. Rain and windy weather raised the oxygen reading by July 20, 1940. A period of continued warm weather with little wind caused some fluctuation in the oxygen content on August 1, 1940. The graph of Fig. 11 then indicates a gradual approach to the fall overturn condition. For about 90 days therefore the water of the marsh was devoid of oxygen adequate to keep fish alive and healthy at station "A".

It was learned that at station "C" the unfavorable months were the same as at station "A" with the exception of June 24, 1940, when the oxygen at station "C" did not fall quite as low as at station "A". However, on August 1, 1940, there was a slightly lower drop in oxygen at station "C" than at station "A". Station "B" coincided quite closely with station "C", having a higher oxygen reading on August 1, 1940.

The data for all the stations is tabulated in Table 1. The carbon dioxide content remained fairly constant, there being a variation from -20 parts per million of fixed carbon dioxide on September 3, 1939, to 9 parts per million of free carbon dioxide on January 15, 1940 at station "A". The other two stations were very similar. Judging from these surface tests, the quantities were not sufficiently large to produce a detrimental effect. This is supported by Gutsell's (24) findings that carbon dioxide up to 28 parts per million were not markedly harmful. Tests in the hypolimnion would undoubtedly have given a different picture as surface readings taken by chemical tests show rather low free carbon dioxide. But since samples were gathered repeatedly in the same manner over a period of a year, the results should be indicative. During the months of September and October there was a general free carbon dioxide deficiency. This was probably due to strong winds and rapid plant growth. After the ice froze and there was no more surface agitation and very little plant

Table 1. The results of water analyses.

Date	Station	Weather time of day	O_2 p.p.m.	Free CO_2	Alk.	Color	Temp.	Remarks
9/3/39	A	Clear 2:10 p.m.	7.2	-20	330.0	Brown	81.0	
" "	C	P. cloudy 6 p.m.	6.6	-10	347.5	" "	80.0	
" "	B	P. cloudy 6:15 p.m.	6.7	-12	--	" "	79.5	
9/5/39	A	P. cloudy 6 p.m.	10.0	-10	319.0	" "	75.0	After rain
" "	C	P. cloudy 4:45 p.m.	7.2	-18	--	" "	74.0	" "
" "	B	P. cloudy 3:45 p.m.	9.7	-20	--	" "	76.0	" "
9/17/39	A	Clear 12 a.m.	9.0	-10	300.0	" "	75.0	
" "	C	Clear 12:53 p.m.	9.0	- 8	--	" "	72.0	
" "	B	Clear 2:25 p.m.	9.4	- 6	--	" "	75.0	
9/30/39	A	Clear 10:45 a.m.	10.6	- 6	--	" "	57.0	
" "	C	Clear 12 a.m.	11.3	- 6	--	" "	54.0	
" "	B	Clear 11:15 a.m.	11.7	- 8	--	" "	58.0	
10/14/39	A	Clear 10:50 a.m.	9.5	- 5	--	" "	41.0	
" "	C	Clear 10:30 a.m.	9.0	- 3	--	" "	40.0	
" "	B	Clear 11 a.m.	10.2	- 4	--	" "	42.0	
11/4/39	A	P. cloudy 11 a.m.	10.0	3	290.0	" "	38.0	Rain-ice forming
" "	C	P. cloudy 10:35 a.m.	11.0	4	--	" "	38.0	
" "	B	P. cloudy 10 a.m.	10.5	3	--	" "	42.0	

Table 1 (cont.)

Date	Station	Weather time of day	O_2 p.p.m.	Free CO_2	Alk.	Color	Temp.	Remarks
11/12/39	A	Clear 4:15 p.m.	9.3	8	299.0	Brown	33.0	Ice one-inch thick in places
" "	C	Clear 4:30 p.m.	9.0	7	--	" "	32.0	
" "	B	Clear 5 p.m.	10.0	8	--	" "	32.0	
12/1/39	A	Overcast 2:45 p.m.	9.8	2	322.0	" "	40.0	
" "	C	Overcast 3:20 p.m.	10.8	4	--	" "	40.0	
" "	B	Overcast 4 p.m.	10.9	3	--	" "	36.0	
12/27/39	A	P. cloudy 10 a.m.	12.0	3	314.0	" "	24.0	First time completely frozen. Evidence of springs. Heavy snow
" "	C	P. cloudy 10:20 a.m.	12.8	3	--	" "	22.0	
" "	B	P. cloudy 10:40 a.m.	11.5	4	--	" "	24.0	
1/15/40	A	P. cloudy 2 p.m.	4.0	9	308.0	" "	20.0	O_2. falling rapidly. Snow on ice
" "	C	P. cloudy 3 p.m.	3.8	8	--	" "	22.0	
" "	B	P. cloudy 3:30 p.m.	3.4	8	--	" "	20.0	
2/5/40	A	Cloudy 3:30 p.m.	.5	8	320.0	" "	32.0	Ice eighteen inches thick
" "	C	Cloudy 4:30 p.m.	.6	7	--	" "	32.0	
" "	B	Cloudy 5:15 p.m.	.6	13	--	" "	32.0	
2/15/40	A	Clear 10 a.m.	0.0	9	308.0	" "	33.0	Lowest reading
" "	C	Clear 10:30 a.m.	.01	8	--	" "	32.0	
" "	B	Clear 11 a.m.	0.0	8	--	" "	32.0	

Table 1 (cont.)

Date	Station	Weather time of day	O_2 p.p.m.	Free CO_2	Alk.	Color	Temp.	Remarks
3/16/40	A	P. cloudy 4 p.m.	1.0	5	--	Brown	28.0	Water circulating over dam for first time since work began.
" "	C	P. cloudy 4:30 p.m.	2.5	4	--	" "	28.5	
" "	B	P. cloudy 5 p.m.	6.0	6	--	" "	28.0	Spring hole? Test 300 yds. from S."B"
4/14/40	A	Clear 10:45 a.m.	10.0	3	--	" "	38.0	Ice breaking up. Impossible to visit stations "C" and "B".
4/30/40	A	Cloudy 11 a.m.	7.3	4	--	" "	51.0	
5/11/40	A	Clear 10 a.m.	7.8	3	--	" "	58.0	
" "	C	Clear 1:30 p.m.	7.7	4	--	" "	56.0	
" "	B	Clear 10:30 a.m.	7.5	4	--	" "	57.0	
6/8/40	A	Clear 3 p.m.	7.0	3	260.0	" "	65.0	
" "	C	Clear 5 p.m.	6.0	4	--	" "	65.0	
" "	B	Clear 4:45 p.m.	6.5	3	--	" "	64.0	
6/24/40	A	Clear 5 p.m.	4.2	4	225.0	" "	73.0	
" "	C	Clear 3 p.m.	6.1	5	--	" "	72.0	
" "	B	Clear 4 p.m.	6.3	5	--	" "	72.0	

Table 1 (concl.)

Date	Station	Weather time of day	O_2 p.p.m.	Free CO_2	Alk.	Color	Temp.	Remarks
7/20/40	A	Cloudy 3 p.m.	7.6	6	232.0	Brown	82.0	Brisk wind following rain
" "	C	Cloudy 4 p.m.	8.0	4	--	" "	78.0	
" "	B	Cloudy 11:45 a.m.	7.6	7	--	" "	80.0	
8/1/40	A	Cloudy 10:30 a.m.	4.9	8	249.0	" "	78.0	
" "	C	Cloudy 10:15 a.m.	4.0	10	252.0	" "	77.0	
" "	B	Cloudy 11:30 a.m.	4.7	8	--	" "	78.0	
8/5/40	A	Clear 10 a.m.	5.6	- 8	260.0	" "	78.0	
" "	C	Clear 10:30 a.m.	5.2	-10	--	" "	79.0	
" "	B	Clear 12 a.m.	5.0	-12	--	" "	79.0	
9/7/40	A	P. cloudy 2 p.m.	6.0	-14	300.0	" "	76.0	
" "	C	P. cloudy 2:30 p.m.	6.0	-14	--	" "	78.0	
" "	B	P. cloudy 2 p.m.	5.0	-12	--	" "	77.0	

growth, free carbon dioxide was present.

Carbon dioxide occurs in natural waters as free carbon dioxide and Welch (23) added two other important forms, viz.,

> (a) nearly insoluble monocarbonate (such as $CaCO_3$ or $MgCO_3$) and known as fixed, combined, or bound carbon dioxide; and (b) that additional amount required to convert the monocarbonate into bicarbonate [such as $Ca(HCO_3)_2$ or $Mg(HCO_3)_2$] and known as half-bound.

The half-bound carbon dioxide can be considered as intermediate between free and fixed carbon dioxide. Algae can use most of the half-bound carbon dioxide. Wiebe (21) claimed as much as 92 percent was used by algae. Until recently it has been thought that the bound carbon dioxide was not available to plants.

The free carbon dioxide is readily consumed in photosynthesis of plants and therefore fits into the ecological picture.

The alkalinity readings of the marsh were very high ranging from 330 parts per million on September 3, 1939, to 300 parts per million on September 7, 1940. This seems to indicate that there was an abundant supply of available carbon dioxide for plants from the dissolved bicarbonates.

The temperature readings taken of the water fluctuated from 81° F. on September 3, 1939, to a low of 20° F. on January 15, 1940, and an extreme high of 82° F. on June 20, 1940. Temperature effects the quantity of gas which can be absorbed. Welch (23) stated the well known fact that cold water has a greater capacity for gas than warm water. It would seem paradoxical therefore to have the temperature reading drop and at the same time the oxygen reading fall to a negative quantity. Other factors, however, such as lack of light and accompanying plant inactivity, oxidation of decaying plankton, lack of circulation of water and wave activity account for this.

The water was always stained a coffee-brown color throughout the observations. This color is apparently due to the substances contributed by the peat deposits of the bottom of the marsh and its margins. Welch declared that in lakes containing heavily stained waters very little penetration of light waves occurs below a meter in depth. No Secchi disk was used for determinations of turbidity but the color of the water of the marsh is undoubtedly an important factor as concerns plant photosynthesis and possibly other factors.

Plankton

The samples of plankton were sent to Prof. Chancey Juday of the State Geological and Natural History Survey, Madison, Wisconsin, for species determination. He obtained the following results of the bottles collected on August 15, 1940:

Bottle No. 1

1. *Pleuroxus procurvotus*
2. *Hyalella knickerbockeri*--very abundant
3. *Cyclops* (gen.)--a few
4. Ostracoda--fairly abundant

Bottle No. 2

1. Bosmina longirostris--common
2. Diaphanosome brachyurum
3. Ceriodaphnia pulchella--a few specimens
4. Daphnia retrocurva--common

He summarized his report by stating that the Ostracoda and Copepoda were very common.

It is generally conceded that the amount and variety of plankton in a body of water determines to some extent its fertility and productivity. Scientists are of the opinion that the quantity of plankton suitable for fish food should not be so abundant as to produce a large amount of decomposable matter which after settling absorbs large amounts of dissolved oxygen and in so doing makes condition unadaptable to fish life. In brief for maximum production of fish life, the right kind of plankton must be there and in balanced proportions with other factors otherwise plankton can be a serious handicap instead of an asset.

Davis (33) pointed out if there is an abundance of plankton one could expect to find an abundant bottom fauna while if there is a scarcity of the same the opposite could normally be expected. That being the case some method of comparing samples taken by a standard method would have more value than a more intensive survey of plankton fauna in various bodies of water investigated.

The phytoplankton or plant plankton was extremely common and numerous. In summer a great deal of "lake bloom"--chlorophyll bearing plankton covered wide areas. Only

Table 2. Scale study--age, weight, length, comparisons.

Variety	Age group	Weight in g	Length in mm
Perch			
(*Perca flavescens*)	0	28	89
	0	28	90
	0	28	83
	0	28	90
	I	56	122
	I	84	153
	I	56	128
	II	224	203
	II	196	203
	II	252	319
	II	224	203
	II	224	203
	II	196	203
	II	140	194
	II	224	185
	II	336	216
	III	336	242
	III	280	230
	III	224	192
Pickerel			
(*Esox lucius* or			
E. americanus	II	672	459
	II	1680	642
	II	1456	540
	II	1008	483
	II	1876	573
	II	1456	528
	II	672	458
	II	1008	496
	III	2016	560
	IV	2464	680
	V	2352	661
	VI	5824	864
	VI	3024	712
	VI	1792	611
	VII	3360	744
Sunfish			
(*Eupomotis gibbosus*)	0	14	51
	0	14	51
	I	56	96
	II	112	134
	II	56	102
	II	336	140
	II	336	147

Table 2 (concl.)

Variety	Age group	Weight in g	Length in mm
Carp (*Cyprinus carpio*)	I	140	190
	I	224	216
	I	196	203
	II	336	242
	III	672	305
	IV	896	331
L. M. Black Bass (*Micropterus salmoides* or *Huro floridana*)	O	224	178
	I	252	216
	IV	336	223
Wall-Eyed Pike (*Stizostedion* sp.)	O	84	166
	O	84	178
Green Sunfish (*Lepomis cyanellus*)	I	56	115
Crappie (*Pomoxis sparoides*)	I	224	178

Table 3. Yearly average weight and length comparisons.

Variety	Age group	Number of fish	Ave. weight in g	Ave. length in mm
Perch	0	4	28.00	88.00
(*Perca fla-*	I	3	65.33	134.33
vescens)	II	9	223.50	214.30
	III	3	280.00	221.30
Pickerel	II	8	1228.50	522.37
(*Esox lucius*	III	1	2016.00	560.00
or *Esox*	IV	1	2464.00	680.00
americanus)	V	1	2352.00	661.00
	VI	3	3546.60	729.00
	VII	1	3360.00	744.00
Sunfish	0	2	14.00	96.00
(*Eupomotis*	I	1	56.00	130.70
gibbosus)	II	4	210.00	172.00
Carp	I	3	186.00	203.00
(*Cyprinus*	II	1	336.00	242.00
carpio)	III	1	672.00	305.00
	IV	1	896.00	331.00
L.M. Black Bass	0	1	224.00	178.00
(*Micropterus*	I	1	252.00	216.00
salmoides or	IV	1	336.00	223.00
Huro floridana)				
Wall-Eyed Pike (*Stizostedion* sp.)	0	2	84.00	172.00
Green Sunfish (*Lepomis cyanellus*)	I	1	56.00	115.00
Crappie (*Pomoxis sparoides*)	I	1	224.00	178.00

Table 4. The average standard lengths and average weights attained by the Yellow Perch in the Sheboygan Marsh, Lake Erie, and Nebish Lake in each age group.

Sheboygan Marsh (1939-1940)

Age group	Number of fish in group	Length in mm for age groups: 0	I	II	III	Average actual weight in grams
0	4	88				28.00
I	3		134.33			65.33
II	9			214.3		223.50
III	3				221.3	280.00
Lake Erie--Jobes (1932)						
0	(No data)	62*				(No data)
I	176		150.00			81.76
II	815			178.0		115.08
III	98				197.0	151.76
Nebish Lake, Wisconsin--Schneberger (1930)						
0	(No data)	--				(No data)
I	23		67.00*			44.00
II	12			130.0*		110.00
III	5				162.0*	122.00

*Calculated lengths

sucker-mouthed minnows seem to thrive on plant plankton while young game fish thrive on animal forms. From the fish life found in the marsh, the zoo-plankton would appear to be the most important. The algae, however, that make up "lake bloom" play a very important part in lakes for even though certain fish do not eat algae directly, they eat many organisms that feed on algae.

Mollusca

The species of mollusca found in the marsh are limited in number. The four following genera of snails were represented: Limnea, Campeloma, Physa and Planorbis. The most numerous molluscawas a snail belonging to the genus Limnea. This genus is consumed by many species of ducks such as the greater scaup and lesser scaup, bufflehead, baldpate, redhead and canvas-back. Snails are also consumed by turtles and fish.

One bivalve representative of the genus Sphaerium was found in great abundance in the marl beds but no live specimens were discovered. Only in the extreme northwest corner of the marsh were the empty shells of the larger bivalves seen in such places and positions as to permit the assumption that a few larger clams were inhabitants of the marsh.

Fish

The following list represents the species of fish which were observed:

Varieties of Fish and Minnows in Sheboygan Marsh

Common Name	Scientific Name
Large mouth bass	*Micropterus salmoides* (Lac.)
Wall-eyed pike	*Stizostedion vitreum* (Mitchill)
Pickerel, northern	*Esox lucius* (L.)
Black crappie	*Pomoxis sparoides* (Lacepede)
Bluegill	*Helioperca macrochria* (Raf.)
Sunfish, Pumpkin seed	*Eupomotis gibbosus* (L.)
Perch	*Perca flavescens* (M.)
Bullhead	*Ameriurus melas* (Raf.)
German carp	*Carpoides carpio* (Raf.)
Common sucker	*Catostomus commersonnii* (Lac.)
Green sunfish	*Apomotis cyanellus* (Raf.)
Common shiner	*Notropis cornutus* (Agassiz)
Northern red-bellied dace	*Chrosomus eos* (Cope)
Blunt-nosed minnow	*Hyborhynchus notatus* (Raf.)
Mud minnow of mud fish	*Umbra limi* (Kirtland)
Creek chub; horned dace	*Semotilus atromaculatus* (M.)

The Tables 2 and 3 are not exhaustive but are indicative of the age of fish of certain weights. Table 4 compares perch taken in the Sheboygan Marsh with others caught in Lake Erie [Jobes (31)] and Nebish Lake in northern Wisconsin [Schneberger (30)]. Jobes (31) in his preliminary report on the growth of perch from Lake Erie found that the growth is very rapid in the first two years, but that there is a decline in growth rate during the third summer. As concerns this decline Jobes says, "The decided decrease in growth-rate during the third summer may possibly be correlated with the attainment of sexual maturity".

By comparing the average standard lengths and average weights attained by the yellow perch in Sheboygan Marsh taken in the winter of 1939 and 1940 to the ones taken in Lake Erie in 1932 and the ones taken in Nebish Lake in 1930, it was seen that there was a considerable correspondence. That the number of perch taken in the marsh is short of a good average has to be kept in mind. Realizing that deficiency, one may proceed with comparisons. The growth in average standard length and increase in average weight of the perch of the Sheboygan Marsh exceeded that of Lake Erie in all but the second year and exceeded that of Nebish Lake in all years. These comparisons seem to indicate that there is a bountiful supply of food in the marsh and if every other factor were as favorable, perch would do very well.

The pickerel also made a remarkable growth which is proof of the abundant food supply for this species. In none of the scale studies was there any evidence of stunted growth or that food was a limiting factor.

The two species of fish that were found to be most numerous in the marsh were the German carp and the black bullhead. Forbes (44) stated that it was remarkable how often all fishes except the bass and crappie ate duckweed, bloodworms, Hexagenia and sphaerids, Campeloma, mussels, detritus and even mud. The crappie according to Forbes fed on plankton; the bass, however, preyed primarily on the young of other fishes and minnows. The German carp found so numerously in the marsh possesses all the qualities of a climax dominant. Fishermen have often complained of this. Cahn (27) described the effect of carp introduced into an artificial pond formed by a dam in Wisconsin. He related that at the end of a few years, the carp practically removed all rooted vegetation thereby uncovering the silt bottom to which the carp was best adapted. This made it possible for the carp to become the most abundant fish. Such fish that fed upon plants and insects as the basses and sunfishes were seriously depleted as a result. The carp here acted as a dominant, by changing the habitat in which it lived, and thereby changed the composition of the entire community. All fishes that stir up the bottom materials tend to increase the turbidity which is unfavorable to plant growth. Cahn stated: "The introduced carp is capable of changing the entire community composition, bringing about changes as marked as that produced by civilized man on the original vegetation". It is apparent if the carp were not controlled, they would in the course of time take over the marsh. Carp and all other species of fish have had their natural increase checked by the unfavorable oxygen conditions. If this could be improved by plant and bottom stabilization, and if the winters were not too severe, the marsh would become a productive fishing ground. In the present condition, however, the winter kill is too depleting to warrant the planting of game fish.

By referring to the map of the marsh (Fig. 2), it will be seen that the outlet of Elkhart Lake empties into the Sheboygan Marsh. Elkhart Lake is a very deep, spring fed, average-sized lake. The water at the outlet rarely freezes solidly and is relatively high in oxygen content. During the winter of 1939 and 1940, the oxygen in the marsh fell to a low level. The fish began to move about and thousands of carp were caught in nets under the ice. Thousands more swam up the one-half mile stream that connects Elkhart Lake to the Sheboygan Marsh and were there fenced in and removed by the Conservation Department.

A series of chemical tests made on February 17, 1940, revealed 11.6 parts per million of oxygen where the stream ran over rocks at the outlet of Elkhart Lake. Tests taken at intervals down the stream showed readings ranging down to .8 parts per million where the stream entered the marsh. Not all of the fish in need of oxygen were able to swim up the stream and thousands of them died. It appeared that the carp died before the pickerel, bass, perch or bullheads but that may have been due to the fact that there were more carp. After the snow melted and the ice became thin, Warden Forrest Brown reported that he was able to see thousands of dead fish under the ice. Later visiting herring gulls from Lake Michigan fed upon dead fish for weeks. That there are some large fish in the marsh can be explained by the presence of spring holes to which they must retire in winter and by the fact that many fish were reported to have migrated upstream away from the oxygen depleted waters of the marsh. State Warden Forrest Brown said in a conversation that very few fish were caught in the state nets during the winter of 1940 and 1941. Upon investigation he had found large numbers in over-populated areas up the river. Clausen (25) made hourly determinations of the oxygen consumption of several species of fish and found that there were fluctuations in the amount of oxygen consumed by a fish over a measured period of time. Under such conditions, it is possible that a spring hole could support many large fish.

Amphibia

The following list illustrates the amphibia that were identified in the marsh. There are probably more.

Common Name	Scientific Name
American toad	*Bufo americanus* (Holbrook)
Common tree toad	*Hyla versicolor* (Cope)
Northern wood frog	*Rana cantabrigensis* (Baird)
Green frog	*Rana clamitans* (Latreille)
Pickerel frog	*Rana palustris* (Le Conte)
Leopard frog	*Rana pipiens* (Schriber)
Wood frog	*Rana sylvatica* (Le Conte)
Mud-puppy	*Necturus maculosus*

The most common of the amphibia were the leopard and the northern wood frog. The abundance of frogs in all probability served to attract many great blue herons, bitterns and visiting egrets. Frogs were also one of the staple foods of the pickerel and bass.

Reptiles

In the faunal survey of the marsh only two species of turtles were recorded. They were the central painted turtle, Chrysemys picta marginata (Herm.), and the snapping turtle, Chelydra serpentina serpentina (L.). The painted turtle is very abundant as witnessed by the numbers that could be seen sunning themselves on a fair day. Pope (36) pointed out that the painted turtle loved to sun itself and had strong scavenger tendencies which often was the reason they were falsely accused of preying on living vertebrates and large invertebrates. In nature, according to this authority, they have been known to eat dead mammals, dead birds, dead fish, reptiles and clams. The marsh is in need of just such animals to clean up the dead fish destroyed by the winter kill and other dead organisms. This species of turtle in the marsh might well be considered beneficial.

Pope further stated that the stinking musk and mud turtles Sternotherus odoratus and the common snappers Chelydra serpentina serpentina often met an untimely end because they have some habits of the fish which the angler does not appreciate. Such habits as taking a baited hook often prove their undoing. The chief sin of the snappers, Pope continued, was their occasional slaughter of game fishes and of aquatic birds. He credited them, however, as doing some good as scavengers and destroyers of harmful animals. He suggested too that all turtles may eat more destructive insect pests than is now generally known.

One does not see the snappers out of water as often as the painted turtle but the habitat along some of the former drainage ditches should prove ideal for their propagation. The egg shells of this species were observed on the sandy ridges scooped out of the former drainage ditches and from all signs these eggs had been destroyed by either raccoons or skunks. The skunk, it has been found, is a control factor for turtles. Undoubtedly the snapping turtle will never become a serious predator in the marsh unless its natural enemies are destroyed. Turtles can easily be trapped and have some economic value when caught. These features should make turtle control relatively simple.

The only species of snake seen was the common garter snake Eutaenia sirtalis (Linn.). This species was very abundant and preyed on amphibians.

Birds

Almost all of the birds previously seen in Sheboygan county were recorded in the marsh plus a few not previously recorded Fig. 10, namely, the American egret, the yellow-headed blackbird and the turkey vulture. In Table 5 the species are listed in groups. These observations were made over the entire area of the marsh.

Of special interest was the return of the American egrets first reported in 1938 by reliable sources and were seen in the course of this study for the first time on August 15, 1939. When reported to competent ornithologists of the Public Museum at Milwaukee and others at Madison, Wisconsin, the reports were questioned since the egret had not been seen in Wisconsin for years. It was conceded by these authorities that the American egret had formerly visited Wisconsin but they were of the opinion that it could not be in the marsh now. They thought that the egret had been confused with the immature great blue heron which also has a whitish color or perhaps even with the young of the little blue heron which is white. Upon study, however, it was observed that the egret had a yellow bill and black legs while the bills and legs of the immature great blue heron and little blue heron were of a nondescript color. Mr. W. F. Grimmer of the Game Management Division of the Wisconsin Conservation Department visited the marsh and identified the questionable species as definitely the American egret. The reports were thus verified to the satisfaction of all. In 1939 the egrets appeared in considerable numbers until September after which no more were seen. During 1940 none were seen until August 17 when four were sighted. For some unexplainable reason they were much less numerous than the year before and stayed only a short time. It will be of interest to follow the migrations of this species in years to come and attempt to learn its limiting factors.

No nesting sites of the American egret were found. Warden Ferrel reported in 1939 that an adult dead bird had been found in a tamarack woods and that to all appearances the birds were roosting there. Several small rookeries of the great blue heron have been established in the marsh and apparently the black-crowned night heron nests there also; however, the latter fact was not verified.

The activity of the various species of birds in the marsh was found to be closely related to the general weather conditions, an observation also noted by Van Deventer (38) and others. On completely cloudy days without rain, there was little activity. However, on cloudy days when rain or snow was falling, activity increased. The greatest activity was noticed on partly cloudy days. Temperature did not appear to have much effect on activity.

The bird observations are condensed in Table 5. This gives an indication of the numbers of birds of certain species. The table also designates if they are winter, summer or permanent residents or transients and their comparative abundance. It also shows the favorite habitat of a particular species. Some were observed most commonly on the marsh edge, others on the open water or wooded region, still others in the ditches or brushy edges of the ditches.

Under the heading of "Remarks", comments are made that seemed to be of especial interest or import.

Mammals

The following mammals were seen in the Sheboygan Marsh.

Table 5. The birds of Sheboygan Marsh.

Water birds Game birds Land birds	Frequency Common Rare Occasional	Winter resident Summer " Permanent " Transient	Habitat Marsh edge	 Open water	 Wooded region	 Ditches	 Brushy edges at ditches	Remarks
1. Grebe, Horned	(O)	(T)		**		**		
2. " Pied-billed	(C)	(S.R.)		**		**		Apparently breeds in the marsh.
3. Loon	(R)	(T)		**				
4. Gull, Herring	(C)	Permanent visitor	**	**		**		Visitors from nearby Lake Michigan--important scavangers.
5. Tern, Common	(O)	(S.R.?)	**	**				Seen periodically during the summer months.
6. " Black	(C)	(S.R.)	**	**		**	**	This species very abundant--seen all over the marsh.
7. Cormorant, Double crested	(R)	(T)		**				Reported for the first time during the spring of 1941 when several were seen flying with ducks.
8. Duck, Am. Merganser	(C)	(S.R.)		**	**	**		Seen most commonly in spring and fall.
9. " Red-breasted Merganser	(O)	(T)		**				Seen only a few times.
10. " Mallard	(C)	(S.R.)	**	**		**	**	This species stands second in abundance. Breed in marsh.

Table 5. (cont.)

Water birds / Game birds / Land birds	Frequency: Common / Rare / Occasional	Winter resident / Summer " / Permanent " / Transient	Habitat: Marsh edge	Habitat: Open water	Habitat: Wooded region	Habitat: Ditches	Habitat: Brushy edges at ditches	Remarks
11. Duck, Mallard Black	(C)	(S.R.)	**	**		**	**	Not as numerous as the green-head. Breeds in marsh.
12. " Baldpate	(C)	(T)	**	**		**		Most numerous in spring.
13. " Blue-winged Teal	(C)	(S.R.)	**	**		**	**	Most numerous duck in the marsh. Breeds there commonly.
14. " Shoveller	(C)	(T)	**	**		**	**	Seen only during migratory season.
15. " Pintail	(C)	(T)	**	**		**		This species may breed in marsh.
16. " Wood	(O)	(S.R.)	**		**	**	**	This duck is supposed to be rare in Sheboygan county but is commonly seen in the marsh.
17. " Redhead	(O)	(T)	**	**				Migratory species.
18. " Canvasback	(O)	(T)	**	**				Does not breed in the marsh.
19. " Scaup, Greater	(C)	(T)	**	**		**	**	Very numerous in early spring.
20. " Scaup, Lesser	(C)	(T)	**	**		**	**	Does not breed in marsh.
21. " Golden-eye	(C)	(T)	**	**		**		Not observed breeding in the marsh.

Table 5. (cont.)

Water birds Game birds Land birds	Frequency Common Rare Occasional	Winter resident Summer " Permanent " Transient	Habitat Marsh edge	 Open water	 Wooded region	 Ditches	 Brushy edges at ditches	Remarks
22. Duck, Ring-necked	(O)	(T)	**	**				Seen only in spring and fall.
23. " Bufflehead	(O)	(T)	**	**		**		Seen only in spring and fall.
24. " Ruddy	(O)	(S.R.?)	**	**		**		Seen during the breeding season. May breed in marsh.
25. Goose, Canada	(C)	(T)		**				Does not breed in marsh.
26. " Blue	(R)	(T)		**				Very uncommon in marsh at all seasons.
27. Bittern, American	(C)	(S.R.)	**	**	**	**	**	Breeds in marsh.
28. " Least	(C)	(S.R.)	**				**	Numbers in marsh vary annually.
29. Heron, G. Blue	(C)	(S.R.)	**	**	**	**	**	This species has well established rookeries.
30. " Green	(C)	(S.R.)	**		**	**	**	Breeds abundantly.
31. " Black-crowned night	(O)	(S.R.)	**		**		**	Must breed in marsh even no nests were found.

Table 5. (cont.)

Water birds Game birds Land birds	Frequency Common Rare Occasional	Winter resident Summer " Permanent " Transient	Habitat Marsh edge	 Open water	 Wooded region	 Ditches	 Brushy edges at ditches	Remarks
32. Rail, King	(R)	(S.R.?)	**			**	**	No nests found.
33. " Virginia	(O)	(S.R.?)	**				**	No nests found.
34. " Sora	(C)	(S.R.)	**				**	Breeds abundantly.
35. Gallinule, Fla.	(O)	(S.R.)	**					May breed in marsh.
36. Coot, American	(C)	(S.R.)	**	**		**		Breeds abundantly.
37. Egret, American	(O)	(T)	**	**	**	**		This is the first time the egrets were reported for the marsh. Good indicators of favorable habitat.
38. Woodcock, American	(O)	(S.R.)	**		**		**	No nests found.
39. Snipe, Wilson's	(C)	(S.R.)	**			**		No nests found.
40. Sandpiper, Least	(O)	(S.R.)	**			**		No nests found.
41. " Semi-palmated	(O)	(S.R.?)	**			**		No nests found.
42. " Yellow-legs. Gr.	(O)	(S.R.?)	**	**		**		May breed in marsh.

Table 5. (cont.)

Water birds Game birds Land birds	Frequency Common Rare Occasional	Winter resident Summer " Permanent " Transient	Habitat Marsh edge	 Open water	 Wooded region	 Ditches	 Brushy edges at ditches	Remarks
43. Sandpiper, Lesser Yellow-legs	(O)	(S.R.?)	**			**		No nests found.
44. " Spotted	(C)	(S.R.)	**			**	**	Apparently breeds in marsh.
45. Plover, Killdeer	(C)	(S.R.)	**			**	**	Breeds in marsh.
46. Bob-White	(R)	(S.R.?)			**			Typical call heard in the woods.
47. Grouse, Ruffed	(C)	(P.R.)	**		**		**	Found quite abundantly in white cedar fringes of the marsh.
48. Pheasant, Rg.-N.	(C)	(P.R.)	**		**		**	An abundant introduced species.
49. Dove, Mourning	(C)	(S.R.)	**		**		**	Breeds in marsh.
50. Hawk, Marsh	(C)	(S.R.)	**	**	**	**	**	The most common hawk in the marsh. Breeds there.
51. " Cooper's	(O)	(S.R.)	**		**	**	**	May breed in the marsh.
52. " Red-tailed	(O)	(S.R.?)	**		**	**	**	May breed in the marsh.
53. " Red-should	(O)	(S.R.)	**		**	**	**	May breed in the marsh.
54. " Sparrow	(O)	(S.R.)	**		**	**	**	May breed in the marsh.
55. " Fish (Osprey)	(O)	(T)	**	**	**	**	**	Seen usually in early spring and fall

Table 5. (cont.)

Water birds Game birds Land birds	Frequency Common Rare Occasional	Winter resident Summer " Permanent " Transient	Habitat					Remarks
			Marsh edge	Open water	Wooded region	Ditches	Brushy edges at ditches	
56. Vulture, Turkey	(R)	(T)	**	**	**	**	**	The first time this species was recorded in marsh.
57. Owl, Barred	(O)	(P.R.)	**		**	**	**	May breed in the marsh.
58. " Screech	(O)	(P.R.)	**		**	**	**	Breeds in the marsh.
59. " Great-horned	(O)	(P.R.)	**		**	**	**	Breeds in the marsh.
60. Cuckoo, Yel.-bill	(O)	(S.R.)	**		**		**	May breed in the marsh.
61. " Bl.-bill	(O)	(S.R.)	**		**		**	May breed in the marsh.
62. Kingfisher, Belted	(C)	(S.R.)	**	**		**	**	Breeds in the marsh.
63. Woodpecker, Hairy	(C)	(S.R.)			**			Breeds in the marsh.
64. " Downy	(C)	(S.R.?)			**			Breeds in the marsh.
65. Yellow-bellied sap-sucker	(C)	(S.R.)			**			Breeds in the marsh.
66. Woodpecker, Red-headed	(C)	(S.R.)			**			Breeds in the marsh.
67. Flicker	(C)	(S.R.)			**			Breeds in the marsh.
68. Woodpecker, Red-bellied	(R)	(S.R.)			**			Apparently does not breed in marsh.

Table 5. (cont.)

Water birds Game birds Land birds	Frequency Common Rare Occasional	Winter resident Summer " Permanent " Transient	Habitat Marsh edge	 Open water	 Wooded region	 Ditches	 Brushy edges at ditches	Remarks
69. Partridge, Hun.	(O)	(P.R.)	**		**		**	Introduced species occasionally seen.
70. Nighthawk	(O)	(S.R.)	**	**		**	**	Seen flying over the marsh at dusk.
71. Swift, Chimney	(O)	(T)	**	**		**	**	Seen flying over the marsh.
72. Humingbird, Ruby-throated	(O)	(S.R.)	**		**		**	Breeds in the marsh.
73. Kingbird	(C)	(S.R.)	**		**	**	**	Breeds commonly in marsh.
74. Flycatcher, Great Crested	(C)	(S.R.)	**		**		**	Breeds in marsh.
75. Phoebe	(O)	(S.R.)	**					Only a few breed in the marsh.
76. Flycatcher, Least	(O)	(S.R.)	**		**		**	Breeds in marsh.
77. Lark, Horned	(O)	(T)						Does not breed in marsh.
78. Jay, Blue	(C)	(P.R.)	**		**	**	**	One of the few birds that inhabits the marsh in both winter and summer.
79. Crow	(C)	(P.R.)	**		**	**	**	Breeds in marsh.
80. Bobolink	(O)	(S.R.)	**					Breeds on edges of marsh.
81. Cowbird	(C)	(S.R.)	**				**	A parasitic species that deposits its eggs in the nests of warblers, sparrows and vireos.

Table 5. (cont.)

Water birds Game birds Land birds	Frequency Common Rare Occasional	Winter resident Summer " Permanent " Transient	Habitat Marsh edge	 Open water	 Wooded region	 Ditches	 Brushy edges at ditches	Remarks
82. Blackbird, Red-winged	(C)	(S.R.)	**	**		**	**	Breeds abundantly in the marsh.
83. Meadowlark (Eastern)	(O)	(S.R.)	**					May breed in the marsh.
84. Oriole, Orchard	(O)	(S.R.)	**		**			This species is not as rare in the marsh as it was indicated to be in check list.
85. " Baltimore	(O)	(S.R.)	**		**			Breeds in marsh.
86. Grackle, Bronzed	(C)	(S.R.)	**		**			Breeds in marsh.
87. Blackbird, Yellow-headed	(O)	(S.R.)	**	**				Breeds in marsh. Not numerous.
88. Finch, Purple	(O)	(T)	**		**			Does not breed in marsh.
89. Redpoll	(O)	(T)	**		**			Does not breed in marsh.
90. Goldfinch	(C)	(P.R.)	**		**			Breeds in the marsh.
91. Sparrow, Vesper	(C)	(S.R.)	**					Breeds on the edges of marsh.
92 . Sparrow, Savanna	(O)	(S.R.)	**					May breed in the marsh.
93. " White-crowned	(O)	(S.R.)	**		**		**	Breeds in marsh.

Table 5. (cont.)

Water birds Game birds Land birds	Frequency Common Rare Occasional	Winter resident Summer " Permanent " Transient	Habitat Marsh edge	 Open water	 Wooded region	 Ditches	 Brushy edges at ditches	Remarks
94. Sparrow, White-throated	(O)	(S.R.)	**		**		**	Breeds in marsh.
95. " Tree	(O)	(S.R.)	**		**		**	Breeds commonly in marsh.
96. " Chipping	(C)	(S.R.)	**		**		**	Breeds in marsh.
97. " Field	(O)	(S.R.)	**				**	Found chiefly in exposed burned-over areas.
98. Junco, Slate colored	(C)	(P.R.)	**		**		**	One of the few birds that stays in marsh all year.
99. Sparrow, Song	(C)	(S.R.)	**		**		**	Very common sparrow in the marsh.
100. " Swamp	(C)	(S.R.)	**		**		**	Commonly found in marsh.
101. " Fox	(O)	(T)	**		**		**	Breeds farther north than the marsh.
102. Towhee	(C)	(S.R.)	**		**		**	A numerous species of the marsh.
103. Grosbeak	(O)	(S.R.)	**		**		**	Not common in the marsh.
104. Bunting, Indigo	(O)	(S.R.)	**		**		**	Not common in the marsh.
105. Tanager, Scarlet	(O)	(S.R.)	**		**		**	Rather rare in the marsh.
106. Purple Martin	(C)	(S.R.)	**	**				Houses have been put up for this species at the marsh entrance.

Table 5. (cont.)

Water birds Game birds Land birds	Frequency Common Rare Occasional	Winter resident Summer " Permanent " Transient	Habitat Marsh edge	 Open water	 Wooded region	 Ditches	 Brushy edges at ditches	Remarks
107. Swallow, Cliff	(O)	(T)		**				Observed flying over the marsh.
108. " Barn	(C)	(T)		**				Observed flying over the marsh.
109. " Tree	(C)	(S.R.)	**	**	**		**	These were found nesting in woodpecker holes in charred trees.
110. " Bank	(C)	(S.R.)	**	**				Observed nesting in gravel pit south of park entrance.
111. Waxwing, Cedar	(O)	(S.R.)	**		**			Observed in the white cedars.
112. Shrike, Northern	(O)	(T)	**		**			Observed during the winter months.
113. Vireo, Red-eyed	(O)	(S.R.)	**		**			Breeds in the marsh.
114. " Warbling	(C)	(S.R.)	**		**			Breeds in the marsh.
115. " Yellow-throated	(O)	(S.R.)	**		**			Breeds in the marsh.
116. " Blue-headed	(O)	(S.R.)	**		**		**	Breeds in marsh.
117. Warbler, Black and White	(O)	(T. and S.R.)	**		**		**	A few breed in the marsh.

Table 5. (cont.)

Water birds Game birds Land birds	Frequency Common Rare Occasional	Winter resident Summer " Permanent " Transient	Habitat Marsh edge	 Open water	 Wooded region	 Ditches	 Brushy edges at ditches	Remarks
118. Warbler, Nashville	(O)	(T)	**				**	Seen in spring and fall migrations.
119. " Cape May	(O)	(T)	**		**		**	Seen in spring and fall migrations.
120. " Yellow	(C)	(S.R.)	**		**		**	This is the most common warbler in the marsh.
121. " Black-throated Blue	(O)	(T)	**				**	Seen in spring and fall migrations.
122. " Myrtle	(O)	(S.R.)	**		**		**	A few breed in the marsh.
123. " Magnolia	(O)	(S.R.)	**		**		**	Seen breeding in the marsh.
124. " Chestnut-sided	(O)	(S.R.)	**		**		**	A few may breed in the marsh.
125. " Bay-breasted	(O)	(T)			**		**	Seen in spring and fall migrations.
126. " Blackburnian	(O)	(T)			**		**	Seen in spring and fall migrations.
127. " Black-poll	(O)	(T)			**		**	Seen in spring and fall migrations.

Table 5. (cont.)

Water birds Game birds Land birds	Frequency Common Rare Occasional	Winter resident Summer " Permanent " Transient	Habitat Marsh edge	 Open water	 Wooded region	 Ditches	 Brushy edges of ditches	Remarks
128. Warbler, Black-throated Green	(O)	(T. and S.R.)	**		**		**	A few may breed in the marsh.
129. " Pine	(O)	(T. and S.R.)			**		**	A few may breed in the marsh.
130. " Palm	(R)	(T)			**		**	Seen in spring and fall migrations.
131. Ovenbird	(O)	(T. and S.R.)	**		**		**	Quite numerous in the marsh.
132. Northern-Water Thrush	(O)	(T. and S.R.)	**				**	A few may breed in the marsh.
133. Warbler, Maryland Yellow-throat	(O)	(S.R.)			**		**	Apparently breeds in the marsh.
134. " Mourning	(O)	(S.R.)			**		**	Apparently breeds in the marsh.
135. " Wilson's	(O)	(T)			**		**	Seen in spring and fall migrations.
136. " Canadian	(O)	(T)			**		**	Seen in spring and fall migrations.
137. " Redstart	(O)	(S.R.)	**		**		**	Breeds commonly in the marsh.
138. Catbird	(C)	(S.R.)	**		**		**	Very numerous in the marsh.
139. Brown Thrasher	(C)	(S.R.)			**		**	Comparatively abundant in marsh.

Table 5. (cont.)

Water birds Game birds Land birds	Frequency Common Rare Occasional	Winter resident Summer " Permanent " Transient	Habitat Marsh edge	 Open water	 Wooded region	 Ditches	 Brushy edges of ditches	Remarks
140. Wren, House	(O)	(S.R.)			**		**	Observed nesting in old woodpecker holes.
141. " Short-billed Marsh	(C)	(S.R.)			**	**	**	Difficult to distinguish the short-billed from the long-billed wren.
142. " Long-billed Marsh	(C)	(S.R.)			**	**	**	Marsh wrens and their nests are abundant.
143. Creeper, Brown	(O)	(S.R.)			**			Probably breeds in marsh.
144. Nuthatch, White breasted	(O)	(S.R.)			**			Probably breeds in marsh.
145. " Red-breasted	(R)	(T)			**			This is the rarer form.
146. Chickadee, Black-capped	(C)	(P.R.)			**			This bird is found in the marsh throughout the year.
147. Kinglet, Golden-crowned	(O)	(T)			**		**	Seen during spring and fall migrations.
148. " Ruby-crowned	(O)	(T)			**		**	Seen during spring and fall migrations.
149. Thrush, Wood	(O)	(T?)			**		**	Probably breeds farther south.

Table 5. (concl.)

Water birds Game birds Land birds	Frequency Common Rare Occasional	Winter resident Summer " Permanent " Transient	Habitat Marsh edge	 Open water	 Wooded región	 Ditches	 Brushy edges of ditches	Remarks
150. Thrush, Wilson's	(O)	(S.R.)			**		**	May breed in marsh.
151. " Olive-backed	(O)	(T)			**		**	Probably breeds farther north.
152. " Hermit	(O)	(T)			**		**	Probably breeds farther north.
153. Robin	(C)	(S.R.)			**		**	Numerous in the marsh.
154. Bluebird	(O)	(S.R.)			**			Observed to nest in hollow trees in marsh.

Common Name	Scientific Name
Beaver	Castor canadensis (Kuhl)
Muskrat	Ondatra monax (L.)
Woodchuck	Marmota monax (Howell)
Rabbit	Sylvilagus floridanus (Allen)
Ground squirrel	Citellus tridecemlineatus (Mitchell)
Gray squirrel	Sciurus carolinensis (Gapper)
Red squirrel	Sciurus hudsonicus (Erxleben)
Fox squirrel	Sciurus niger (Geoffrey)
Field mouse	Microtus pennsylvanicus (Ord)
House mouse	Mus musculus (L.)
Shrew, Short-tailed	Blarina brevicauda (Say)
Raccoon	Procyon lotor (L.)
Opossum	Didelphis virginiana (Kerr)
Red fox	Vulpes fulva (Desmarset)
Skunk	Mephitis mephitis (Schreber)
Weasel	Mustela cicognani (Bonaparte)
Mink	Mustela vison (Scherber)

Hamilton (41) stated that there are about 25 important fur bearing animals in North America. Of that number seven were commonly seen in the marsh. The muskrat was by far the most numerous and important, in fact, it has long replaced the beaver as the principal fur bearing animal of the fur trade. The marsh makes an ideal habitat for this species. All factors such as aquatic food plants, suitable and adequate range, and protection are in their favor. No trapping is allowed on the game preserves which are designated in Fig. 2. Hence the animals can always radiate from these to adjoining areas that may have been depleted by trapping. Hundreds of dollars worth of muskrat furs are taken from the marsh yearly.

Beaver were found widely distributed over the marsh but were limited in number. In the south drainage ditch or lateral 3 (Fig. 2) they have constructed several wooden houses. On the extreme northern corner of the west river ditch, they have built a series of dams and live in the banks. An abundance of plants commonly used by the beaver were found, such as willows *Salix* sp.; tag alders *Alnus incana* and *Alnus crispa*; trembling aspen *Populus tremuloides*; and big tooth aspen *Populus grandidentata*.

The rest of the animals were seen in varying numbers with the exception of the opossum of which only one specimen was observed.

Aquatic Plants

The following list represents some of the more important and common water plants found in the marsh.

Common Name	Scientific Name
Duck weeds	*Spirodela polyrhiza* (L.)
	Lemna trisulca (L.)
Smartweeds	*Polygonum* sp.
Pond weeds	*Potamogeton* sp.
Wapato	*Sagittaria latifolia* (Willd.)
	Sagittaria heterophylla (Pursh)
Wild celery	*Vallisneria americana* (Miclx.)
Wild rice	*Zizania aquatica* (L.)
Bulrushes	*Scirpus* sp.
Coontail	*Ceratophyllum demersum* (L.)
Bur-reed	*Sparganium* sp.
Cat-tail	*Typha latifolia* (L.)
Yellow pond lilies	*Nymphozanthus* sp.
White water lilies	*Castalia tuberosa* (Paine)
Pickerel-weed	*Pontederia cordata* (L.)
Spike rushes	*Eleocharis* sp.
Sedges	*Carex* sp.
Reed grass	*Scirpus cyperinus* (L.)
Nut-grass	*Chufa* sp.
Sweet flag	*Acorus calamus* (L.)
Blue flag	*Iris versicolor* (L.)

The Sheboygan Marsh has both a variety and an abundance of the larger aquatic plants. Sportsmen living in the vicinity have been interested in increasing the number of these plants to make the marsh an even more attractive habitat for ducks. Sheboygan Press (45) gave a detailed list of the plantings of aquatic foods in the marsh that represented a total cost of four-hundred dollars raised by popular subscription. Aquatic vegetation also provides havens of protection for young fish from the attacks of larger, carnivorous fish. It is here where the small fish forage and hide from the predaceous pike and crappie. A sufficient supply of aquatic vegetation increases fish growth and numbers since these plants are the food of crustacea, bottom-dwelling insect larvae, worms and snails. These organisms are eaten by the small fish, which in turn serve as food for the larger species. Muskrats are primarily herbivorous and eat aquatic and marsh vegetation. Occasionally the rhizomes of the water lily that had been dislodged by the muskrats were observed. Where sufficient material was available, muskrats built their homes from aquatic plants.

DISCUSSION

The vast expanse of 12,000 acres makes the Sheboygan Marsh typically representative of many marshes of Wisconsin. The results obtained in the water analyses of the marsh would undoubtedly find a counterpart in the study of other marshes of corresponding water depths and areas.

The partial and then finally the complete draining of the marsh, thereby exposing the bottom to sun, air and fire caused retrogression. The subsequent natural plant successions have been more or less disturbed and their associations mingled. Normally and undisturbed, the marsh soil should have been composed chiefly of plankton remains, humus and vegetable peat. This badly unbalanced bottom soil has been in the process of stabilization since the partial flooding of the marsh in 1932. The dam of 1932 was washed out in a few months and was replaced by another more substantial one that raised the water level above the line of the first one. But the original shoreline of the marsh was by no means attained. In 1938 the present dam was built and the water level restored; according to the engineer in charge, to about what it was between the years of 1868 to 1921.

By water level was not meant the depth, however. The depths in 1938 were much greater than the ones reported by Peterson and Sinz in 1905. No data were given in the government surveys of 1837 as to the water depths but undoubtedly the marsh was deeper in places in 1938 than it was in 1837. This was due to the filling in with water of the drainage ditches formerly constructed to drain it. The marsh then has been rejuvenated and the animal and plant communities found in the marsh were merely seral stages leading to the climax forms of the region. As concerns the plants, the Sheboygan

Marsh may eventually become a tamarack forest due to the gradual filling in of the region with plant remains and silt.

This recurrent fluctuating of the water levels was very destructive to the aquatic plants and animals. One could compare these fluctuations with droughts which naturally damage fishing conditions because desirable habitats that serve as shelters for fish and spawning grounds, such as former aquatic plant areas, snags and like debris, were all left exposed. Mucky bottoms have more to offer for sustaining life than sandy ones, since muck is usually conceded to be physically and chemically broken down organic matter which furnishes desirable soils for plant life in medium to hard bodies of water.

Chemical tests showed that the marsh has hard water. The hardness or softness of a body of water is directly related to associated conditions which are of basic importance to fish. Canfield and Wiebe (46) stated that in Europe investigators have found that hard water is more productive of plankton. This was also the opinion of Juday and Birge (16). An area of water which produces a generous amount of plankton has one of the prerequisites necessary for fish.

The long, submerged lax stem and leaf plants such as the muskie weed Potamogeton praelongus (Wulf), coontail Ceratophyllum dermersum (L.) and sago pondweed Potomogeton pectinatus (L.) are always associated with game fish because varied animal life lives on these plants and these animals in turn serve as food for the fish. This type of plant is lacking

EXPLANATION OF PLATE V

Fig. 12. Marsh as it appeared in 1902--note profuse vegetation.

Fig. 13. The marsh as it appeared in 1937. Note dearth of vegetation caused by water fluctuations and fires.

Plate V

Fig. 12

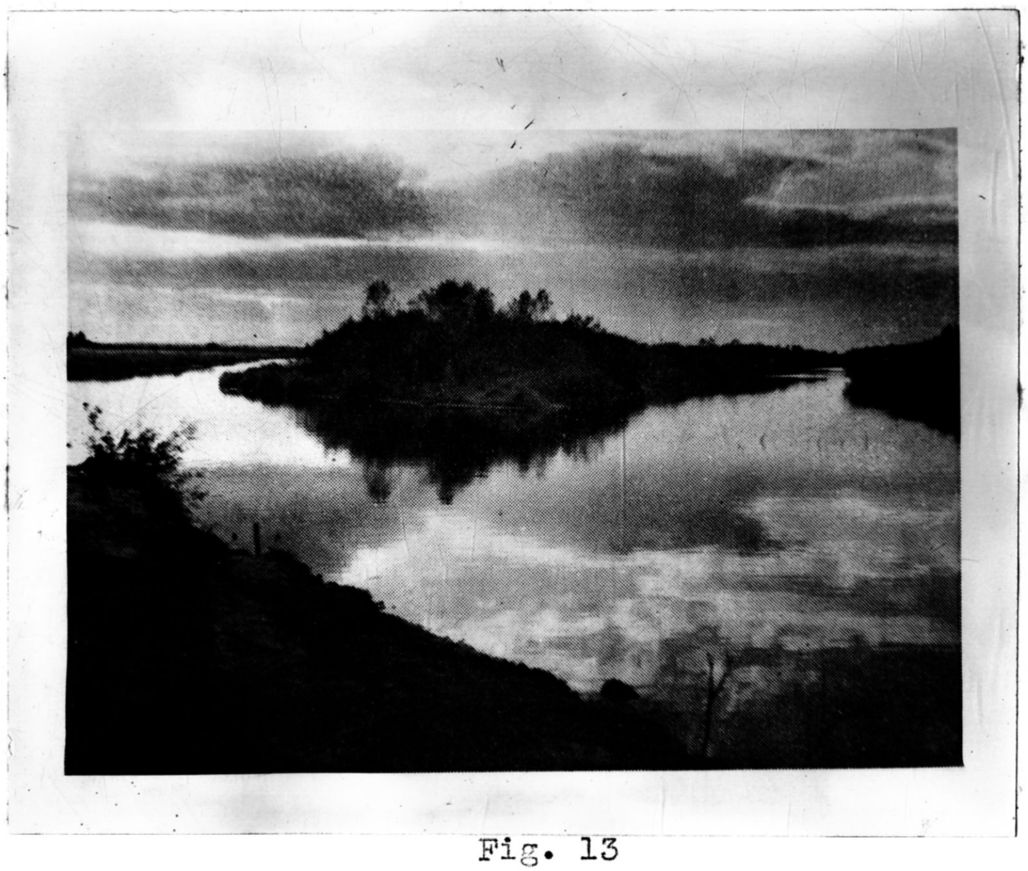

Fig. 13

in soft water lakes. The majority of these plants are also duck foods and waterfowl consume various portions of them. In addition, these plants are oxygenators and effect their environment by liberating oxygen which is essential to aquatic forms. Juday (20) summarized this interrelation between plant and fish life by pointing out that "The complicated chain between plant and animal life may have a dozen links in it". In fact the biome or plant-animal formation does not exist as two separate units in the same area, according to Clements and Shelford (37). Elton (40) showed that plants have a dominating influence upon the distribution of animals in forming special local conditions and that plants produced sharper boundaries to the habitats separating animal communities than they otherwise would be.

Carbon dioxide is an important gas in nature, especially for plants. Where the carbon dioxide is lost by the sinking of decomposed products into deep water below the region of circulation, it is more or less permanently withdrawn from the possibility of being used again. Such lakes find a valuable supply of carbon dioxide available in the dissolved bicarbonates. The marsh contains a large supply of bicarbonates and thereby possesses a source of carbon dioxide which soft water lakes lack and as a result it can support a larger population of plankton.

Birge and Juday (16) pointed out a well known fact that photosynthesis consumed carbon dioxide and liberated a certain amount of oxygen. Since photosynthesis requires sunlight one would expect it to be most active near the surface. The color and turbidity of the water would limit the depth to which this could take place. In the marsh the water is rarely turbid but it is always discolored with plant stains. This would make the zone in which photosynthesis could take place relatively thin. In clear bodies of water, however, it could extend to many feet. The oxygen content of the zone of photosynthesis would fluctuate with the ratio of the oxygen liberated and that absorbed from the air to that consumed by respiration and decomposition.

Birge and Juday in the same paper stated that sources of carbon dioxide were several, namely, from the air, from the ground water and from decomposition of organic matter and respiration and from dissolved bicarbonates of calcium and magnesium. They also spoke of a zone of decomposition. Decomposition takes place at all depths as plants and animals die and sink but the greatest amount takes place in deeper water which they designated as the decomposition zone. Here there is very little oxygen and anaerobic decomposition continues with evolution of carbon dioxide, methane and carbon monoxide. The distribution of the gases varies in intensity and amount to the number of green plants the body of water can produce. This in turn would be the limiting factor of animal life. Since the water in the marsh is shallow, during the time it is unfrozen the entire body of water may circulate.

The carbon dioxide might be used over and over again for plant growth. However, in winter horizontal strata apparently are formed. The definite circulation of the water is reduced, sunlight is cut-off and consequently photosynthesis checked because of the dearth of light and perhaps decrease of carbon dioxide, and a drop in the dissolved oxygen ensues.

In bodies of water where the carbon dioxide becomes locked up in the zone of decomposition, the carbon dioxide available for plants in the dissolved bicarbonates becomes a valuable supply. Lakes then that contain a large amount of bicarbonates have a source of carbon dioxide not available in soft water lakes. According to Juday and Birge (16),

> The reduction of the bicarbonates to monocarbonates gives an alkaline reaction to the upper stratum of the lake. These monocarbonates must take up the carbon dioxide liberated in the upper water by respiration and decomposition, and more will be absorbed from the air than is possible if free carbon dioxide is already contained in the water. Thus the presence of an abundance of dissolved carbonates increases the supply of carbon dioxide for plant use, both directly and indirectly; directly, by the original stock of half-bound carbon dioxide into the bicarbonates; indirectly because the monocarbonates take up more carbon dioxide from the air than would be absorbed without their aid, and also absorb that liberated in the upper water by respiration and decay. Much of this would escape into the air, especially at night, if not so absorbed. In such lakes the epilimnon is permanently alkaline during the summer, which shows that more carbon dioxide is withdrawn from the bicarbonates than is supplied to them from other sources, and more than is made good at night.

The intimate relationship of the productivity of a body of water is inseparably linked to its chemical construction. This in a large part constitutes the environment which the animal forms found in a region must successfully cope with in order to maintain themselves. The marsh is capable of supporting any number of ducks and mammals as attested by the survey but the fish life is still in jeopardy. The oxygen content for fish is far too unstable. In the ecological succession which may follow most of the species of fish desirable to man may be eliminated. Eventually, the marsh if left to "run" according to "nature" will choke with aquatic vegetation and will become populated with mud minnows, carp and bullheads. Game fish require a bottom with little vegetation for spawning. There were some indications that such fish as bass may be restricted through parasites and pickerel may be killed off by gill diseases due to an unnatural habitat. The marsh merits more study in the future.

SUMMARY

1. A survey of the Sheboygan Marsh was conducted from August 15, 1939, to May 19, 1941. Since the construction of a permanent dam in 1938, the water level of the marsh remained relatively stable.

2. Aquatic plants grew in the marsh in great profusion affording an abundant food supply for ducks and muskrats. It was an excellent habitat for water and shore birds.

3. The chemical nature of the water was not satisfactory to aquatic animals. Some fish apparently survived in spring holes or migrated out of the marsh. Winter kills were heavy and undoubtedly will continue to be so.

4. Molluscs were numerous but limited to 4 species.

5. Protection and coverage insured maximum reproduction rates for ducks and fish.

6. Severe winters have had a deleterious effect especially on the fish life since the oxygen was almost reduced to a zero quantity. There is no way apparently of improving the general fish habitat of the marsh. The marsh cannot be profitably restocked or fingerlings planted at the present time. 15 species of fish were classified.

7. Turtle life was relatively abundant but limited in species. 2 species were found.

8. Only one species of snake was observed. This was relatively abundant.

9. 154 species of land birds, water birds, game birds and birds of prey were recorded in the territory. 15 species of ducks were found to inhabit its waters. Of these the blue-winged teal, the black duck, and the mallard were found to nest there.

10. As a restoration of a favorable habitat for wildlife, the reflooding of the marsh has proved to be a marked success.

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LITERATURE CITED

(1) Records of Register of Deeds. Sheboygan County Court House, Sheboygan, Wis. 221: 97-99. 1937.

(2) Sheboygan Marsh abounding with great variety of charm and beauty. Sheboygan, Wis. Sheboygan Press. 20:11. Aug. 1, 1927.

(3) Geographical and historical atlas of Sheboygan County, Wis. Sheboygan, Wis. Jerry Donohue Engineering Co. 104p. 1941.

(4) Wisconsin Dept. of Agr. and Markets. Bul. 180. 62 p. 1925.

(5) Paxson, F. L. History of the American frontier. Boston. Houghton Mifflin. 293 p. 1924.

(6) Peterson, H. W. and Sinz, E. F. Plans for the draining of Sheboygan Marsh. Unpublished thesis. Univ. of Wis. Mech. Eng. Lib. 38 p. 1905.

(7) Marsh fire brightens up county sky. Sheboygan, Wis. Sheboygan Press. 22:1. Nov. 4, 1929.

(8) One thousand acres destroyed in county. Sheboygan, Wis. Sheboygan Press. 24:1. Aug. 22, 1931.

(9) Pawlisch, Otto, V. Sheboygan Marsh is a great lesson in practical conservation. Sheboygan, Wis. Sheboygan Press. 30:30. Sept. 9, 1937.

(10) Seeking to have county acquire marsh. Sheboygan, Wis. Sheboygan Press. 29:1, 4. Nov. 27, 1936.

(11) County acquires Sheboygan Marsh. Sheboygan, Wis. Sheboygan Press. 30:1, 4. Mar. 5, 1937.

(12) Appropiate $5,000 sum for marsh. Sheboygan, Wis. Sheboygan Press. 30:1, 6. May 4, 1937.

(13) Bollenbeck, W. J. Sheboygan Marsh dam is approved. Sheboygan, Wis. Sheboygan Press. 30:1, 3. July 29, 1937.

(14) Marsh project is approved. Sheboygan, Wis. Sheboygan Press. 30:1, 6. Oct. 6, 1937.

(15) Permanent dam used for first time. Sheboygan, Wis. Sheboygan Press. 32:1, 3. Mar. 12, 1938.

(16) Birge, Edward A. and Juday, Chancey. The dissolved gases of the water and their biological significance. Wis. Geol. and Nat. Hist. Survey Bul. 22. 259 p. 1911.

(17) Coburn, H., Dean, D., and Grant, G. M. An ecological study of Bryant's Bog, Cheboygan County, Michigan. Mich. Acad. Sci., Arts, and Letters, Papers. 17:57-65. 1933.

(18) Goe, L., Erickson, E., and Woollett, E. An ecological study of Mud Lake Bog, Cheboygan County, Michigan. Mich. Acad. Sci., Arts, and Letters, Papers. 4:297-310. 1924.

(19) Needham, James G., and Lloyd, J. T. The life of inland waters. Ithaca. Comstock. 438 p. 1916.

(20) Juday, C. The third report on limnological apparatus. Wis. Acad. Sci., Arts, Letters, Trans. 22:299-314. 1926.

(21) Wiebe, A. H. Investigations on plankton production in fish ponds. U. S. Bur. Fisheries Bul. 46:137-176. 1930.

(22) Allen, E. J. and Nelson, E. W. On the artifical culture of marine plankton organisms. Mar. Biol. Assoc. Jour. 8:421-474. 1908.

(23) Welch, Paul Limnology, New York. McGraw-Hill. 471 p. 1935.

(24) Gutsell, James S. Influence of certain water conditions, especially dissolved gases on trout. Ecology 10:77-96. 1929.

(25) Clausen, R. G. Oxygen consumption in fresh water fishes. Ecology 17:216-225. 1936.

(26) Greene, Willard C.
The distribution of Wisconsin fishes. Madison, Wis. State Conserv. Comm. 235 p. 1935.

(27) Cahn, A. R.
The effect of carp on a small lake. The carp as a dominant. Ecology 10: 271-274. 1929.

(28) Van Oosten, J.
Life history of the lake herring *Leucichthys artedi* (Le Seur) of Lake Huron as revealed by its scales, with a critque of the scale method. U. S. Bur. Fisheries, Bul. 44:380-412. 1923.

(29) ______________
The whitefishes *Corregonus clupeaformis*. A study of the scales of the whitefishes of known ages. Zoologica. 2 (17): 380-412. 1923.

(30) Schneberger, Edward
The growth of the yellow perch. Unpublished thesis. Univ. of Wis. 64 p. 1933.

(31) Jobes, Frank W.
Preliminary report on the age and growth of the yellow perch *Perca flavescens* (Mitchill) from Lake Erie, as determined from a study of its scales. Mich. Acad. Sci., Arts, and Letters, Papers. 17:643-652. 1932.

(32) Hubbs, Carl L. and Cooper, Gerald P.
The minnows of Michigan. Cranbrook Institute of Sci., Bul. 8. 84 p. 1936.

(33) Davis, H. S.
Instructions for conducting stream and lake surveys. U. S. Bur. Fishery Cir. 26. 55 p. 1938.

(34) Wright, Anna Allen and Wright, Albert Hazen.
Handbook of frogs and toads. Ithaca. Comstock. 231 p. 1933.

(35) Ditmars, Raymond Lee.
The reptile book. New York. Doubleday-Page. 471 p. 1915.

(36) Pope, Clifford H.
Turtles of the United States and Canada. New York. Knopf. 325 p. 1939.

(37) Clements, Frederic E. and Shelford, Victor E.
Bio-ecology. New York. Wiley. 425 p. 1939.

(38) Van Deventer, W. C.
A winter bird community in western New York. Ecology 17:491-499. 1936.

(39) Chapman, Frank M.
Handbook of birds of eastern North America. New York. Appleton. 530 p. 1921.

(40) Elton, Charles
Animal ecology. New York. MacMillan. 207 p. 1927.

(41) Hamilton, W. J.
American mammals. New York. McGraw-Hill. 434 p. 1939.

(42) Fassett, Norman C.
A manual of aquatic plants. New York. McGraw-Hill. 382 p. 1940.

(43) Standard methods of water analysis. New York. Amer. Pub. Health Assoc. 7th Ed. 180 p. 1933.

(44) Forbes, S. A.
Food of Illinois fishes. Ill. State Lab. Nat. Hist. Bul. 2:71-86. 1878.

(45) Lays plans for planting aquatic food in marsh. Sheboygan, Wis. Sheboygan Press. 33:1, 3. April 15, 1940.

(46) Canfield, H. L. and Wiebe, A. H.
A cursory survey of the Blue River system of Nebraska. U. S. Bur. Fishery Econ. Cir. 73. 10 p. 1931.