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An Ecological Study of the Dead Stream Flooding
Project, Roscommon County, Michigan,
With Special Reference to
Waterfowl.

presented by

John J. Norcross

has been accepted towards fulfillment
of the requirements for

M. S. degree in Zoology

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Major professor

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AN ECOLOGICAL STUDY OF THE DEAD STREAM FLOODING PROJECT
ROSCOMMON COUNTY, MICHIGAN
WITH SPECIAL REFERENCE TO WATERFOWL

By
John Judson Norcross

A THESIS

Submitted to the School of Graduate Studies of Michigan
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Introduction

In recent years, state and federal agencies have developed water impoundments primarily for the purpose of flood control, water storage, and hydro-electric power. Public recreation areas and varied wildlife habitats have come about as adjuncts to these projects. Wildlife has often benefited but in some instances these developments have been detrimental rather than beneficial. The many dams built on the Pacific coast rivers have seriously affected the salmon population. All too often the planning phases of these projects have not given due consideration to wildlife.

Here in Michigan, water impoundment projects have become integrated into the program of wildlife management. These completed or planned projects are not large in size but they have been designed to improve, create, or restore areas for wildlife utilization. This practice of water impoundment is in keeping with the concept of best land use providing the act of flooding will yield the greatest possible returns.

Many of these projects are located in the northern part of the state where much of the land's value lies in the wildlife which it produces. The number of projects which have been completed to date is not known but between

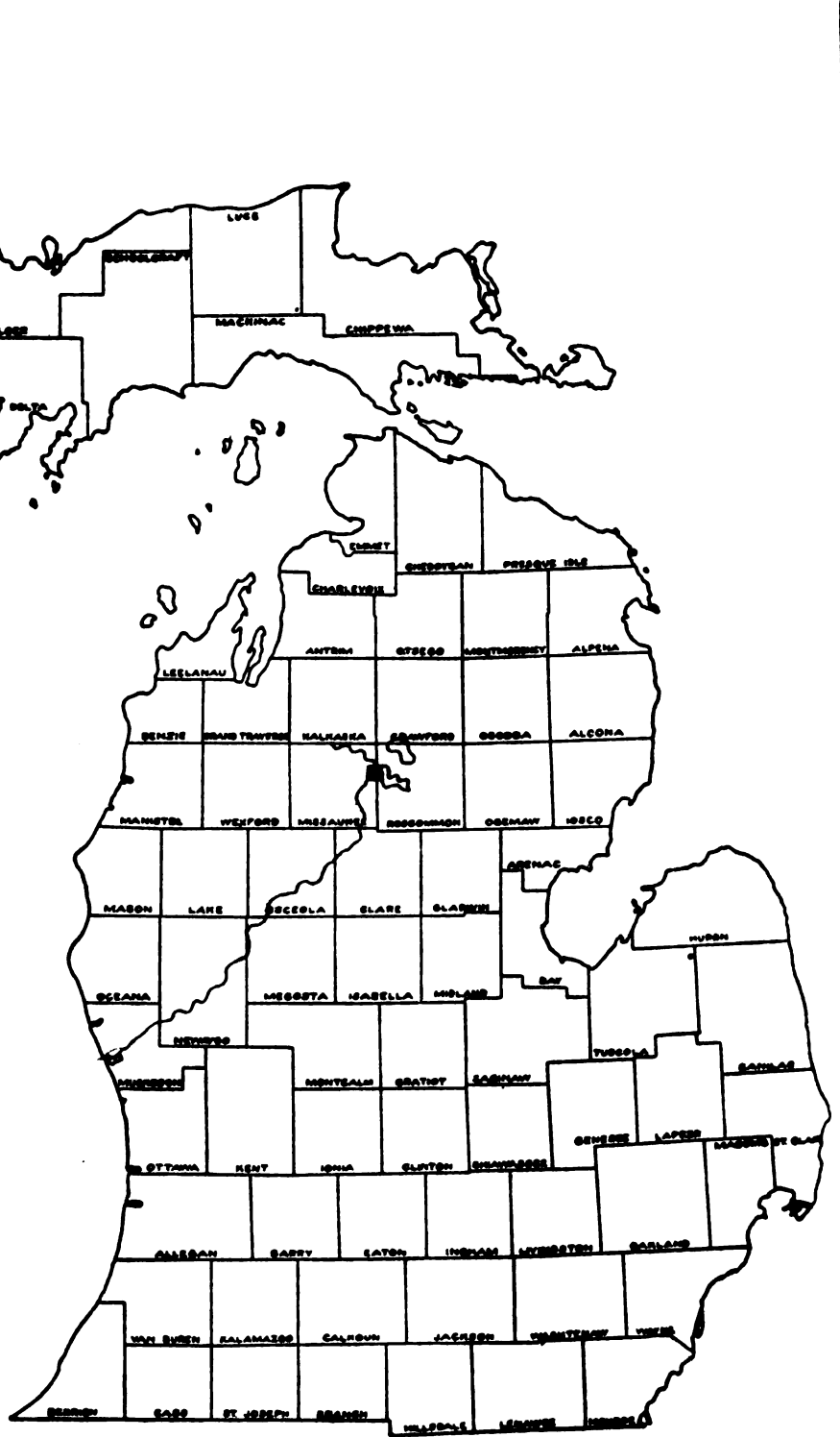
1949 and 1950, 10 low-head dams were built and engineering surveys were completed on 14 others (15th Biennial Report, Michigan Department of Conservation).

The planning of these projects, the preliminary surveys, and the actual construction of the dams are but the initial phase of management. These floodings should be actively managed in order to insure a high level of production but only by studying the natural processes, which follow flooding, can techniques be evolved for sound marsh management. In other words, more needs to be learned of the dynamics of a newly created aquatic habitat in order that future projects may be intelligently and successfully managed.

The Dead Stream Flooding Project is located just west of Houghton Lake, Roscommon County (see map I, page 3). The flooding proper includes all or portions of Sections 4, 5, 6, 7, 8, 9, 17, 18, 19, 20, and 30 of T23N, R4W. The extreme southern portion of the flooding extends into Section 25, T23N, R5W, Missaukee County.

This paper is the culmination of a study of the Dead Stream Flooding which began in July of 1950 and ended in March, 1952. This study was financed by Pittman-Robertson funds during July, August, and September of 1950, but further independent research was conducted by the writer in October, 1950, and for limited periods in the spring

MICHIGAN



Map I

■ Location Map of the Dead Stream Flooding

and summer of 1951 and in March, 1952. The Game Division of the Michigan Department of Conservation furnished a motor boat and duck boat for use in the survey and also made available the department's airplane for inspection of the area from the air.

The primary objectives of this study were: (1) to determine waterfowl production, (2) to determine utilization of the area by waterfowl other than the breeding population, (3) to determine vegetational changes, using data gathered from past studies and the analyses of the study plots obtained in 1950, and (4) to make a survey of existing communities.

History of the Development of the Dead Stream Flooding

The planning stage for this project began in 1931, when engineering surveys were made by the Game Division. Dr. E. C. O'Roke, Dr. M. D. Pirnie, and Mr. H. D. Ruhl visited the area on June 16 and 17, 1932, and made a preliminary investigation designed to evaluate the potentiality of the area provided it were flooded. Pirnie (1932) reported that the Muskegon River and Dead Stream marshes did not provide suitable habitats for breeding waterfowl, but he felt that the proposed flooding would create very favorable nesting habitat for a variety of waterfowl. He also foresaw the possibilities of good hunting and fishing grounds.

DEAD STREAM

HAY
MARSH

MUSKEGON RIVER
POND

DAM



Figure 1. The Dead Stream Flooding as it appears from the air with the camera pointed north. Photo by M. D. Pirnie.

The Dead Stream Game Area, of 53,231 gross acres, was established in 1937 to set aside the region about the Dead Stream as a wilderness area. Later acreage was added to the area to make a total of 70,244 gross acres, 74% of which was state owned. Flooding of the Muskegon River was still under consideration and in 1937 a recheck of the 1931 survey was made by C.C.C. personnel.

Construction of the dam was started in 1938 and completed in time for the area to be flooded in the spring of 1940. The dam was built through C.C.C. aid at an undisclosed cost. The dam was built across the Muskegon River, 11 stream miles from its source at North Bay on Houghton Lake. Most of the dam was formed by adding clay to an abandoned railroad grade (Grand Rapids and Indiana Railroad Company). The rest of the dam was constructed of steel and concrete in such a manner that water levels might be controlled by adding or removing stop gates. The head of water at the dam is approximately 15-18 feet in depth depending upon the volume in the reservoir.

After the desired water levels were attained, approximately 2,000 acres of marsh and timber were flooded (Figure 1). The Dead Stream which lies north of the junction of the Dead Stream and Muskegon River has not been affected to any great degree by the flooding.



Figure 2. The Reedsburg dam on the Muskegon River.

The original policy of the Game Division in keeping the Dead Game Stream Area as a wilderness by allowing restricted development has been closely adhered to. There are only three boat liveries serving the entire flooding and camping grounds have been limited to the area near the dam.

The History of Logging

The following account of the logging history at the headwaters of the Muskegon River has been drawn from the personal history of Delos A. Blodgett, who was a pioneer lumberman of that region. There is much available history concerning logging and lumbering operations of counties adjacent to this area but apparently little has been written about the early days of Roscommon County.

In 1870 Delos A. Blodgett and Thomas Byrne bought from John R. Robinson a tract of pine land in the township of Houghton (such a township no longer exists in Roscommon County, but may have been what is now known as Lake Township). This pine tract contained 3500 acres. During the same year Blodgett and Byrne plotted the village of Houghton.

A sawmill was built in Houghton and pine lumber was manufactured and marketed by rail. This mill burned down in 1876, but was rebuilt and remained in operation until 1881.

Some time between 1870 and 1880, the partners moved their headquarters to the village of Roscommon, which was served by the Jackson, Lansing, and Saginaw Railroad (later the Michigan Central). Later they moved to Grayling, after Byrne had bought all the land owned by the Jackson, Lansing, and Saginaw Railroad Company in Roscommon, Missaukee, and Crawford counties.

Blodgett and Byrne first sold their logs to mill operators at Grayling but later bought the lumber mill of Watson and Hull (or Hall and Watson?) which at that time was one of the best mills on Lake Michigan. It had an average capacity of 200,000 feet of lumber per 10-hour run.

After acquiring the lumber mill, the partners floated their logs down the Muskegon River to the city of Muskegon. The lands in Roscommon, Missaukee, and Crawford counties were located too far from the Muskegon River for teams to haul the lumber, so a narrow gauge railroad was built from the headwaters of the Muskegon River. This railroad was extended each year until it reached the length of 30 miles.

Thomas Byrne died in 1881. Blodgett continued operations under his own name, after settling with Byrne's heirs. During the brief existence of the partnership, the firm manufactured 400 million feet of pine lumber.

Blodgett's logging operations were finished in 1894 but during the 24-year period the combined output of Blodgett and Byrne and later Blodgett amounted to between 60 million and 75 million feet of lumber annually.

A Mr. Blaisdell, a former lumberjack who now tends the Reedsburg boat livery, told me that when operations were at a peak, a million feet of pine lumber were put into the Muskegon River every 24 hours. The roll-away where the logs were dumped into the river may still be seen. This is known as The Dump (see map III inside of back cover).

The first lumbermen who logged the pinery were primarily interested in the more valuable white pine. Many of the operators were financially successful, while others did not realize monetary gains. After the pioneer lumbermen had left, the forests were reworked by operators who were logging the area for a second or even third time. Often substantial profits were made by these men.

The town of Michelson was settled in 1908. Records (Michigan State Gazeteer and Business Directory) did not disclose the founder of the town but presumably it was founded by Nels Michelson, who owned and operated a sawmill there.

Michelson, in 1911, had a population of 225 people, many of whom, no doubt, worked in the lumbermill, which at that time produced lumber, shingles, ties, posts, and

poles. By 1915, the town had a livery, garage, hotel, general store, and a confectionary. The Michelson Lumber Company produced ties, posts, and poles. The town had telegraph and telephone service and was served by the Missaukee branch of the Grand Rapids and Indiana Railroad Company.

A Union Church and a graded school were added to Michelson by 1919. The population had risen to 350 people. Ties, posts, and poles were produced by the Michelson Lumber Company.

The last available data for Michelson come from the year 1931. The population had shrunk to 150 people by that time. The Michelson Lumber Company and Buck Amos Lumber Company were the two main business enterprises. The Grand Rapids and Indiana Railroad continued to serve Michelson but by then had become a branch of the Pennsylvania Railroad Company.

Information obtained from Mr. Fred Crooks and Mr. Blaisdell indicated that Nels Michelson logged the Dead Stream Swamp and portions of the remaining timber in the vicinity of the headwaters of the Muskegon River. Mr. Crooks was an employee of Mr. Michelson.

The year that Michelson was deserted is not known but all that remains of the town are a few house or store foundations and the foundation of the sawmill.

The Climate of Roscommon County

The mean annual precipitation for Roscommon County is 27.4 inches (determined over a 24-year period). Precipitation is usually distributed quite evenly throughout the year. December, January, and February receive less precipitation than any of the other months. February has averaged 1.21 inches which is the lowest average recorded for any monthly period. October has averaged 2.97 inches which is the highest average monthly precipitation rate. Generally from March through to October monthly averages are from 2.53 to 2.92 inches. Rainfall, in the summer, usually occurs as gentle showers and extensive flooding is practically unknown. Snow usually forms a permanent ground cover from November to early April.

Prevailing winds are westerly. Violent windstorms are a rarity.

The average annual temperature is 43.5° F. The January average has been 19.7° F. and the July average 67.6° F. The maximum temperature over the 24-year period was 107° F.; the minimum -48° F. The last average killing frost in the spring has been June 11 and the first in the fall has been September 3. The growing season averages 84 days per year, although frosts of sufficient severity to kill tender vegetation have occurred every month of the year.

There is a high percentage of sunshine in the summer and the number of cloudy days in the year just about balances the number of clear days. Relative humidity is rather high during the winter but is only moderate in the summer. Mean temperatures and total precipitation for the months of April, May, June, and July 1950 did not vary greatly from the expected averages. April was slightly cooler and total precipitation was near normal. May and June had average temperatures but precipitation for each of the months was 1.69 inches below normal. July temperatures were slightly below normal. Precipitation was one inch above normal.

The above information indicates weather conditions were near average for those months. Precipitation averages for May and June, being below normal, indicated favorable conditions for young ducklings which were hatching in greatest numbers during that time.

Topography and Soils

The Dead Stream Swamp lying in an east west direction, extends north from the Dead Stream and the Muskegon River a distance of about a mile and one-half, where it is terminated by the southermost ridge of the Higgins Lake morainic system. A ridge of the Houghton Lake moraine system is found just south of Houghton Lake. It has a relief of 60-100 feet above the lake and lies in a

northwest-southeast direction. West of Houghton Lake this ridge becomes weak and disappears in the Muskegon River valley. It does not again become prominent until five or six miles past the Muskegon River. With the exception of the Higgins and Houghton Lake moraines, which bound the area on the north and partially on the south, the country surrounding the flooding is uniformly flat (Leverett and Taylor, 1915).

Soils

According to the Land Economic Survey of 1924, there are three soil groups found in and about the flooding. These are the swamp soils, marsh border soils, and light sandy soils. Newton loamy sand and Bergland loam make up the marsh border soils. Rifle peat and Houghton muck are the swamp soils and Saugatuck sand is the light sandy soil.

The soil map of the Land Economic Survey shows Rifle peat to be present in the Dead Stream Swamp and in the flood plain of the Dead Stream and Muskegon River except for a small portion near the junction of the two streams. This other soil type is Houghton muck.

Rifle peat is characterized by poor drainage and is a moderate to strongly acid soil. The top layer is composed of dark brown, moderately decayed, woody peat or muck

which extends to a depth of about one foot. Below the top layer, light brown slightly decayed woody peat may be found to depths of two feet. A layer of yellowish-brown, slightly decayed fibrous peat is present from the two to three foot level and below that to a depth of five feet sand or clay is present. Tamarack, spruce, and cedar constituted the original cover.

Houghton muck is a mildly acid soil similar in profile to Rifle peat except for the top layers. Dark brown, moderately decayed fibrous peat or muck to a depth of one foot constitutes the first foot of soil. Below that, a layer of black, well decayed, compact muck may be found extending to the two-foot level. Yellowish-brown slightly decayed fibrous peat extends to a depth of three feet and below that sand or clay may be found. The natural growth on this soil type is bluejoint and sedges with clumps of willow. Cover type in the Muskegon River flood plain suggests Houghton muck rather than Rifle peat as indicated on the soil map.

Newton loamy sand is found in the area east of the Muskegon River and extends in a broad belt to Houghton Lake. Natural drainage of this soil type is slow to poor, since it is but slightly elevated above the marsh border soils. This soil type is acid from the surface layers to the five-foot level. Newton loamy sand has a top layer

of black mucky soil to depths of from six inches to one foot. A brownish gray or mottled gray and yellow wet sand extends from the six-inch or one-foot level to a depth of four and one-half feet and below that wet gray sand may be found.

Original forest growth was a mixture of swamp conifers, ash, elm, red maple, and white pine.

Bergland loam is found in the middle third of the area which forms the western boundary of the flooding. North and south of this belt Newton loamy sand is the predominant soil type. Bergland loam may be either acid or alkaline depending upon the amount of lime present. The top layer, eight inches to one foot in depth, is a black mucky soil. Gray or mottled gray and yellow sandy loam or loam extends from the top layer to three feet. Pale reddish lake clay or heavy sandy clay till constitutes the remainder of the profile. Original forest cover was the same as that of Newton loamy sand.

Saugatuck sand occurs as scattered pockets surrounded by Newton loamy sand. The abandoned townsite of Michelson is situated on Saugatuck sand. Forest litter and mold make up the first three inches of soil. The horizons below the initial layer are variable in thickness. Pale gray sand underlies the litter and mold to depths of from

8 to 15 inches. Below the pale gray sand, a dark "coffee brown" sandy hardpan, two feet in thickness, may be found and below that spotted brown and yellow sands are present. Original forest cover was mainly white pine.

Forest Cover of the Region, Past and Present

The forest cover of northern Michigan represents a transition between the boreal forest formation of the north and the deciduous forest formation of the south (Oosting, 1948). This transition was once characterized by pure stands of white pine (Pinus strobus) with red pine (P. resinosa) and jack pine (P. Banksiana) occupying the less favorable sites. Although white pine was dominant at the time lumbering began, it is considered subclimax to the deciduous forest formation.

White pine and its associates did not occupy all areas in the Great Lakes region. In places where hydrarch succession was initiated and proceeded to a floating-mat stage (mats composed of grasses and/or sedges), ericaceous shrubs such as leatherleaf (Chamaedaphne calyculata), Labrador tea (Ledum groenlandicum), and blueberry (Vaccinium spp.) invaded the mat. Deposition of plant remains proceeded at a comparatively rapid rate due to incomplete decomposition which was favored by a cool moist climate.

As formation of soil progressed, pioneer forest species came to occupy areas which had favored the development of shrubs. Black spruce (Picea mariana) and larch or tamarack (Larix laricina) were pioneer arborescents. Larch, being exceedingly intolerant, often formed closed stands or was reduced to a position next to the shrub border, usually by the invasion of black spruce which is very tolerant (Harlow and Harrar, 1937). When conditions became favorable, white cedar (Thuja occidentalis) and balsam fir (Abies balsamea) became established in these areas. The Dead Stream Swamp is an excellent example of bog succession. Although the swamp stage may persist for many years, it is considered a subclimax.

Secondary succession, in this region, began as soon as the timber was removed. Clear cutting, as practiced in those times, often prevented the original timber from replacing itself. Frequent fires served further to retard succession and in instances where severe fire destroyed the humus, leaving bare rock or sand secondary succession, closely resembling primary succession, was started.

Trembling aspen (Populus tremuloides) and white birch (Betula papyrifera) became dominants over much of the area formerly occupied by white, red and jack pines.

All the area included in this study has been subjected to lumbering and fire. Cover of the Dead Stream Swamp has been replaced, mostly by the original species. Areas which once supported white pine are still in the stage of secondary succession. In a few instances, white pine reproduction is good under seed trees but aspen continues to dominate.

Succession is shown in Figure 3 where traces of the original cover are indicated by the presence of fire-blackened white pine stumps. At this particular spot, birch and aspen predominate and speckled alder (Alnus incana) has come to occupy the saturated soils which border the flooding.

Description of the Dead Stream and Muskegon River Watersheds

A detailed account of the area included in this study is beyond the scope of this investigation, but a generalized account of the area provides a foundation for further discussion. Two river systems are involved, namely, the Muskegon River from its source to the Reedsburg Dam, and the Dead Stream, its headwaters, its course, and its terminus. The cover type through which each stream passes is different, as is the aquatic vegetation of each.



Figure 3. An example of secondary succession. Fire-blackened white pine stumps, in the background, are remnants of the original cover. White birch and aspen have succeeded the white pine. Speckled alder, on the left, is growing in the wet soil of the flooding border.

The Muskegon River after leaving North Bay of Houghton Lake runs northward for a short distance then turns and flows westward. Reference to map III (just inside of back cover) will indicate the course of the river. Due to the fact that the surrounding terrain is level the current of the river is slow (average 2-3 mph.); however, the discharge from Houghton Lake governs the rate of flow. The water color varies from light to dark green and at no time, even during prolonged periods of rainfall, is siltation evident to any great extent.

At first the river plain or bottom is quite narrow. Forest species are usually found near the river and such shrubs as speckled or tag alder (Alnus incana), willow (Salix spp.), and dogwood (Cornus spp.) commonly border the river's edge. Black ash (Fraxinus nigra), elm (Ulmus spp.), and red maple (Acer rubrum) are common but trembling aspen and large-toothed aspen (Populus grandidentata) in many places have assumed a position of dominance. Where the gradient from river bank to shrub zone is shallow, grasses and sedges form a border. Bluejoint (Calamagrostis canadensis) is probably the most important species of grass to be found. Some distance north of the river the Dead Stream swamp of black spruce, white cedar, balsam fir, and tamarack exists. South of the river jack pine is dominant.



Figure 4. Aerial photograph of the Muskegon River just west of Houghton Lake. The Dead Stream Swamp may be seen in the background. Forest cover of jack pine appears in the foreground.

Ground cover in the jack pine forest consists mainly of blueberry and sweet fern (Comptonia asplenifolia). Figure 4 shows the cover as found along the first few miles of the river.

Two and one-half stream miles from the source, the river enters a wide grass-sedge meadow which is known as the Hay Marsh. The Hay Marsh roughly forms a triangle with the base on the north and the apex to the south. The Hay Marsh is divided into nearly equal east and west portions by a narrow ridge of land which originates near the bank of the river and terminates three-fourths of a mile south. The Muskegon River winds along the northern border of the Hay Marsh until it meets with the Dead Stream. Figure 5 shows the river where it enters the Hay Marsh. Forest cover in the background is Dead Stream swamp, though, at this point a zone of aspen is found between the river and swamp. The eastern boundary of the Hay Marsh is bordered by a shrub zone of willow, tag alder, and dogwood which in turn is followed by such species as trembling aspen, elm, swamp white oak (Quercus bicolor), black ash, white ash (Fraxinus americana), and on the higher ground some red pine and white pine. Islands of timber in the Hay Marsh shown in the background of Figure 5 are covered by aspen.



Figure 5. Flooded grass and sedge marsh. Approximately 150 acres of marsh may be seen. Lines appearing in the Hay Marsh were formerly drainage ditches. Note the lack of large openings in the marsh. Photo by M. D. Pirnie.

Four stream miles from Houghton Lake the Muskegon River is joined by the Dead Stream. At this point the Muskegon River turns and flows in a southwesterly direction. The western boundary of the Muskegon River bottom is determined by a ridge of higher ground which lies in a northeast-southwest direction. The northern point of this ridge gradually slopes until it disappears. Cover on this ridge is much the same as that bounding the eastern border of the Hay Marsh except that aspen is more prevalent and large clearings are present.

The headwaters of the Dead Stream lie in Missaukee County and, although its course is very irregular, the stream proceeds in a southeasterly direction until it encounters the northeast-southwest ridge which forms the western boundary of the Muskegon River bottom. The Dead Stream turns northeast and continues to a point where the ridge disappears. It then flows south to join the Muskegon River.

The headwaters of the Dead Stream were not thoroughly explored, but for the most part the watershed consists of ridges covered by upland timber while in the lower areas swamp hardwoods and conifers are prevalent. Coal Creek, for instance, is a slow-moving stream which passes through a cedar swamp for most of its length. Its water is suitable for brook trout (Salvelinus fontinalis). Other



Figure 6. An aerial view of the Muskegon River, Hay Marsh, and northern end of the reservoir. The flood plain is three-fourths of a mile wide at this point. Photo by M. D. Pirnie.

small feeder streams have similar waters. In Missaukee County, the Dead Stream has clear cool water. The stream is closely bordered by overhanging trees and shrubs but shortly after entering Roscommon County it enters a sedge-grass meadow which in turn is bordered on either side by the Dead Stream Swamp. Here the water becomes much warmer and turns to a deep brown color. The current of the Dead Stream headwaters is slow; near the mouth it is barely perceptible.

Only in the vicinity where the two streams meet is there an appreciable area of sedge and grass west of the Muskegon River. Approximately a half mile (by straight line) south of the junction, this area of grass and sedge gives way to dead timber. After flooding the water table was raised, resulting in death of the timber and establishment of sedge.

Figure 6 was taken at a point three-fourths of a mile south of the Dead Stream-Muskegon River junction with the camera pointed just north of east (bearing 075°). In the foreground, dead timber with sedge ground cover may be seen. The channel of the river appears as a dark band. Beds of aquatic plants, shown as white and grey spots bordering the channel, are very dense and in this particular section of the river wild rice (Zizania aquatica) is dominant.

In the right foreground giant bur reed (Sparganium eurycarpum) appears as small rounded islands of vegetation which merge in a curving line to form a closed stand terminating where the river channel completes an abrupt bend of 180°. Cattail (Typha latifolia) is also present as scattered stands but does not approach the density or frequency of bur reed. Light areas among the islands of bur reed are due to reflected light from the leaves of floating-leaf pondweed (Potamogeton natans).

An east-west drainage ditch appearing as an oblique line may be seen passing through the Hay Marsh to join the Muskegon River near the center of the picture. Dark vegetation bordering the river at this point is cattail and this bed joins with the curving band of bur reed in the foreground. Open water between the cattail and bur reed stands and the Hay Marsh border contains beds of aquatics.

The strip of wooded ridge seen in the background, dividing the Hay Marsh into east and west halves, has a definite pattern of plant distribution. The pattern is determined by the height of the land above the surrounding low ground. Speckled alder and aspen occupy the most northern point. As the ridge increases in elevation, these species give way to white pine, swamp white oak, and cherry (Prunus spp.). Further south, these species



Figure 7. Changes resulting from flooding.

Upper: The Muskegon River, looking north from Michelson, as it appeared before flooding. Photo by M. D. Pirnie taken in 1936.

Lower: The same area as it appeared in 1951. A bed of pickerel weed and bulrush appears behind the boats.

are replaced by aspen and alder and as the ground becomes more saturated and covered with water, willow becomes the sole species of woody cover. Flooding, which materially increased the water depth on either side of the ridge, has not affected, to all out-ward appearances, the timber growing on this strip of land.

South from the point shown in Figure 6 the river continues its winding course, but the channel is no longer marked by the border of cattail and bur reed.

Along the western boundary, dead timber is still evident, but back waters have spread to points further west. The Hay Marsh gradually decreases in width and a ridge of land extends into the marsh from the east. Near Michelson, the river became closely bordered by timber. To show the change which has occurred since flooding, two photographs were taken from the same spot with the camera pointed (as nearly as possible) in the same direction. These two photographs, shown in Figure 7, were taken in 1936 and 1951.

Figure 8 shows a section of the river below Michelson as it appeared in 1936 and 1951. The exact area covered in the older photograph is not known and for that reason the later photograph may not include the same portion of the river. Evidence from stumps still to be seen indicates that before flooding the grass-sedge border was entirely



Figure 8. The Muskegon River before and after flooding. The upper photo shows the Muskegon River, south of Michelson, as it appeared in 1936. Photo by M. D. Pirnie. The lower picture was taken of the same general area in 1951.

eliminated and that swamp hardwoods grew on the banks of the river. Figure 9 shows the cover type found below the dam. Maple, elm, and ash are the main species. Slope of the bank permits these species to grow almost to the water's edge.

Aquatic Vegetation of the Flooding

The biological production of any lotic or lentic environment may be determined in part by the aquatic vegetation of the lake or stream. Growth of aquatic vegetation is one measure of production; animal life is another. Animals are dependent upon plants either directly or indirectly and so vegetation, ranging from phytoplankton to the higher flowering plants, constitutes the building block upon which an animal population is built.

Growth and production of aquatic vegetation, in itself, will not insure maximum production. Some plants are more desirable for wildlife than others and of equal importance is the manner in which they are distributed. Biologists, for some time, have recognized the value of interspersion or edge in creating a diversified habitat. Leopold (1947) has defined game as a phenomenon of edges.

The aquatic vegetation of the Dead Stream Flooding has some desirable features and others that are not. It



Figure 9. The Muskegon River below the Reedsburg dam. Red maple constitutes most of the stream border cover seen in this photograph. A white pine may be seen on the right bank.

provides nesting cover for waterfowl, brood rearing cover, and food in more than ample quantities. Also the requirements are met, to a degree, for fish and fur production, but some changes would undoubtedly increase the overall biological production.

Physical features determining plant composition and distribution in a river system are many. The more important factors are climate, soils, rate of flow, siltation, and the cross-profile of the stream valley. As a stream valley matures, the action of the shifting channel gradually widens the stream valley until the width of the valley, or strath as it is called, is greater than the diameter of the meanders. Maturity of the valley usually results in a broadly flaring profile in which drainage becomes progressively poorer and erosion is lessened. (Longwell, Knopf, and Flint, 1948).

When a stream meanders, the current is deflected first from one side and then to the other. Deposition of silt occurs on the inner and upstream sides, while the current gradually undercuts the opposite bank. The steepest bank lies on the outer side of a meander. Overflow of the banks results in deposition of materials on the side nearest the current causing a natural levee to be gradually built up. Further, as the river swings back and forth across the

stream plain, the channel may cut through the neck of a meander creating an oxbow.

The Muskegon River and the Dead Stream are meandering streams, both very old, yet it appears that evolution of the two valleys has proceeded slowly since waters of the last glacial sheet ceased to flow in them. This is understandable, since neither stream is subjected to great fluctuations in water levels and the rate of flow is quite slow.

Conditions described for a meandering stream hold fairly well for the Muskegon River although the river channel does not appear to have shifted recently. Only one complete oxbow is present but numerous indentations (upstream) into the flood plain are remnants of oxbows which have been filled in except for the extreme downstream end. The Dead Stream has no indentations of this sort.

From the preceding discussion one can, by reference to map III, determine where the slope of the river basin is shallow. The maximum number of plant zones are found on the inner and upstream sides of the meanders. Where the river course is straight, the slope is usually gentle and the depth of the river is quite shallow.

The composition and distribution of aquatic plants in the Muskegon River before flooding is not known. Changes undoubtedly occurred when millions of board feet of lumber

were floated down the river, but it is safe to say that the greatest change has taken place since the area was flooded. Flooding created a hydroseric disclimax. Such a disclimax may be maintained for an indefinite period by manipulation of the water level.

Submerged Aquatics

The river border, not affected by the flooding, has a definite pattern or zonation of plants from the deep waters of the channel, to the mud flats, and to the banks and plains. Deeper water contains several species of submerged aquatics. Pondweeds are represented by such species as the clasping-leaf pondweed (Potamogeton Richardsonii), Robbin's pondweed (P. Robbinsii), sago pondweed (P. pectinatus), and the variable pondweed (P. gramineus). The bushy pondweed (Najas flexilis) and the waterweed (Anacharis canadensis) are also very common. Wild celery (Vallisneria americana) is present but is limited in its distribution to a few spots of deep water. This species was not found until the middle of August at which time the fruiting stems emerged.

Mixed stands of various submerged aquatics are not uncommon but it was found that generally each species forms a community of its own but rather restricted in size. This condition differs from that of the broader lake-like waters

of the reservoir where one species may form a dense bed of considerable extent. It is difficult to appraise the submerged aquatics of the upper stretches of the Muskegon River to determine the degree of abundance of each species. Waterweed is probably the most abundant plant.

Floating-leaved Aquatics

The next zone of vegetation is normally characterized by the floating-leaved variety of plants which develop in water shallower than that occupied by the submerged aquatics. Shading of the bottom eliminates, to a large degree, the submerged aquatics. The floating-leaved species such as white water lily (Nymphaea odorata), yellow water lily or spatter-dock (Nuphar advena), and water shield (Brasenia Schreberi) have a poor representation in the Muskegon River. White and yellow water lily are present but their role in the scheme of succession is almost negligible.

Emergent Aquatics

Wild rice almost completely occupies areas suitable for the floating-leaved species as well as emergent aquatics. Occurring in large solid stands, its zone of growth extends from waters that usually support submerged aquatics to a point where other emergents become interspersed with the

rice. Wild rice not only grows on the mud bars of the river but has actually invaded swifter waters of the channel where the bending action of the current never permitted the fruiting heads to emerge, thus eliminating reproduction by those plants. Figure 10 shows the extent to which wild rice has become established in parts of the river. In some instances, the open channel has been narrowed to less than five feet with rice completely covering the stream bottom from the steeper sloping bank on the one side to the shallow slope on the other. These stands of wild rice serve to catch suspended debris thereby increasing both deposition of silt in the beds and the rate of flow in the channel.

Softstem bulrush (Scirpus validus), giant bur reed, wild rice, and to a lesser extent rice cut-grass (Leersia oryzoides), occur in various combinations and make up a rather indeterminate border between the pure stands of wild rice and plants on the banks. Nearer the bank, arrowhead (Sagittaria latifolia) and smartweed (Polygonum natans) form a narrow girdle between the wild rice stands and the next zone of vegetation. Pickerelweed (Pontederia chordata) is not common; it occurred as scattered clumps between the wild rice and plants of the bank. Swamp loosestrife (Decodon verticillatus) holds a similar position but was found only below the Muskegon River-Dead Stream junction.



Figure 10. Wild rice in the Muskegon River. Beds, such as the one seen in the center of the picture, occupy mud bars of the river.

Cattail, when present, usually is found between the arrowhead-smartweed zone and the next zone of vegetation which is composed of bluejoint and sedge (Carex spp.) Cattail was found in appreciable amounts only south of the confluence of the two streams.

Beyond the arrowhead-smartweed border, or in the case where cattail may be found, bluejoint and sedge constitute the widest zone of vegetation found along the stream plain. Figure 11, taken in May before new growth of this association had gained its maximum height, shows the nature of this cover. Both grass and sedge form clumps which are in close proximity to each other. There are few openings in the meadow, consequently the total amount of edge is slight.

The sedge-grass marsh is bordered by a strip of shrubs, the most common of which is willow, red-osier dogwood, (Cornus stolonifera), and speckled or tag alder. Small amounts of leatherleaf may also be found. Forest species, with trembling aspen the dominant tree, follow the shrub zone.

The foregoing discussion has been limited to the section of the Muskegon River which has not been influenced, to any great degree, by the increased water level. The description of the plant zonation is general, yet there is a consistency in plant distribution and species involved.



Figure 11. The Hay Marsh taken from the Dead Stream-Muskegon River junction with the camera pointed southeast. Vegetation consists of bluejoint and sedge. New growth had not started at the time the picture was taken.

The zone most likely to be absent is composed of the floating-leaved species and most of the emergents. Particularly where the bends are sharp and the current flows near the bank most of these plants will be eliminated. Bluejoint and sedge may grow almost to the water's edge in these instances, yet arrowhead and smartweed usually may be found, if only in a very narrow strip.

A photograph (Figure 12) taken from the high bank of the Muskegon River at Mead's Landing (near Houghton Lake) shows the nature of the zones found on the opposite side of the river where the gradient is more gently sloping. Submerged aquatics cannot be seen but wild rice is shown growing from the open water to a dark band of vegetation which in turn is bordered by a lighter band of plants. The dark strip is composed of bulrush and bur reed and the lighter band is bluejoint.

A closer view of the river border vegetation is shown in Figure 13. This photograph was taken in 1951 of a new study plot which was established a short distance below the Dead Stream and Muskegon River junction. Wild rice, bur reed, and bulrush may be seen in the foreground. Cattail is present in the background with some stems of bluejoint intermingled. At the left are floating leaves of the white waterlily. Duckweed (Lemna minor) grew on the surface and waterweed in the deeper part of the quadrat.



Figure 12. Plant Zonation. This picture, taken from the high bank at Mead's Landing, shows plant zonation on the opposite bank. Zone A is composed of wild rice, Zone B of bur reed and bulrush, Zone C of bluejoint. Photo by M. D. Pirnie.



Figure 13. A close-up of the river border vegetation. Taken at a point just below the mouth of the Dead Stream, this is a photo of study plot 21. Wild rice and burreed may be seen in the foreground. Cattail appears in the background.

Although damming the Muskegon River resulted in overflow of the stream banks to the point where the river enters the Hay Marsh, little change is noted until at a point about one stream mile below the Dead Stream-Muskegon River junction. Here openings begin to appear in the grass-sedge zone on either side of the river. These openings usually run parallel to the river, but are separated from it by a belt of cattail and bur reed growing on the natural levees. Possibly these clearings, resulting from the disappearance of grass and sedge, were once a part of the river bed but since then have been partially filled in to form shallow basins. Also there are openings, angling upstream from the river into the stream plain, which probably are remnants of oxbows.

As previously stated, the river, before flooding, flowed near the timber growing along the western boundary of the stream plain and that grass and sedge occupied most of the triangular shaped area east of the river. At the present time grass and sedge has receded eastward an average distance of 300 yards, forming a border which runs in a northeast-southwest direction. In the extreme left center of Figure 6 the Hay Marsh appears to merge with vegetation along the river course, but slightly to the right open water begins to appear and the western border of the Hay Marsh becomes clearly marked. The border of

the Hay Marsh continues southwestward for two-thirds of a mile where it is replaced by dead timber. In the section on waterfowl brood census areas, I have referred to the intervening space between the vegetation along the river and the border of the Hay Marsh as the river flats.

The open waters at the north end of the reservoir contain dense beds of aquatics. Flat-stemmed pondweed (Potamogeton zosteriformis), floating-leaf pondweed, smartweed, water milfoil (Myriophyllum spp.), bladderwort (Utricularia vulgaris and U. intermedia), and water marigold (Megalodonta Beckii) are the more important species which occur in large stands.

It is indeed difficult to ascertain the order of abundance for each species. Some of these plants occur in limited areas, others form closed stands of considerable extent but are also found as scattered stems among the other species. To show the difficulties which arise when making a visual appraisal, figure 14 was taken in mid-July when the two species of bladderwort were in bloom. Looking across the surface of the pond a yellow mass of color met the eye but inspection of this area revealed the fact that these plants occurred as scattered individuals rarely forming a closed stand. This is an example of aspect dominance (Oosting, 1948). Bladderwort appeared to be the



Figure 14. Growth of aquatic vegetation in the northern end of the pond. Floating-leaf pondweed and smartweed occupy most of the area shown. Bur reed clumps appear in the right background. The western border of the Hay Marsh may be seen as a light line extending across the field of view in the background.

most abundant but actually floating-leaf pondweed, flat-stemmed pondweed, and smartweed were much more prevalent.

Bur reed and small amounts of cattail are the two important emergents in the pond. Bur reed tends to form small rounded closed stands but grows in a belt (see Figure 15) on the inundated natural levees. Wild rice becomes noticeably absent in the sluggish water.

The distribution of flat-stemmed pondweed, floating-leaf pondweed, bladderwort, and water marigold exhibited no definite pattern. One species may form almost pure stands in some places and occur as scattered individuals in others. Water milfoil, for instance, was found adjacent to the Hay Marsh, but mixed with it, in small amounts, were coontail (Ceratophyllum demersum), waterweed, and flat-stemmed pondweed.

Generally, the floating-leaf pondweed and smartweed were the most common aquatics in the upper end of the reservoir but in deeper water flat-stemmed pondweed becomes most abundant. The deep waters of the pond at Michelson contain flat-stemmed pondweed beds, water milfoil beds, and scattered specimens of smartweed. This condition prevails from a point approximately one-half mile above Michelson south to the dam. In the deepest waters of the flooding water milfoil is the most abundant plants occupying the natural levees. In shallower water, cattail-bur reed



Figure 15. Bur reed beds. They occupy the natural levee which here is covered by 2 to 3 feet of water. Smartweed may also be seen.

or bur reed alone grows on the natural levees. Figure 16 shows water milfoil with its fruiting heads protruding from the water.

Plant zonation is apparent in the lower portion of the reservoir. Species which were common in the upper portion of the pond occupy the shallow water of the periphery. Composition of species involved does not change but the weed beds are not as extensive. The banks of the artificial lake may be bare in some places but in other locations small groups of bur reed, cattail, sedge, bulrush, pickerelweed, and spike rush (Eleocharis spp.) may be found.

Description of the aquatic vegetation found in the backwaters of the flooding are not given here since they are included in a description of the duck brood census areas.

The Dead Stream presents an entirely different picture than that of the Muskegon River and pond. There, changes are so pronounced that even those who have little knowledge of biology can detect, almost immediately, the dissimilarities between the two streams. On entering the Dead Stream, water color changes from the dark green of the Muskegon River to a dark coffee-brown and the current is very slow (less than one mile per hour).

More important are the differences in aquatic vegetation, especially of the submerged and emergent plants. Wild rice, cattail, arrowhead, and smartweed are not found in the



Figure 16. Water milfoil growing in deep water. The fruiting heads may be seen. These plants are growing on the old river bank at a depth of about 10 feet. Photo taken 200-300 yards above Reedsburg dam.

Dead Stream. Giant bur reed is missing but a species of bur reed believed to be floating-leaf bur reed (Sparganium angustifolium) grows in the shallow headwaters of the stream. The Dead Stream is closely bordered by bluejoint and sedge or in some cases by sweet gale (Myrica Gale). Increased water levels have had no apparent effect on the grass and sedge.

In bends of the stream where the current impinges on the opposite bank, coontail occupies the deepest water, followed by spatter-dock, and finally grass and sedge or sweet gale. This is shown in Figure 17. Occasionally beds of flat-stemmed pondweed could be seen at depths of around three feet and in one spot star duckweed (Lemna trisulca) covered the bottom. Production of submerged aquatics is curtailed by the absence of light which fails to penetrate the heavily stained water. This zonation of coontail, spatterdock, and grass-sedge border is repetitious into the upper stretches of the Dead Stream.

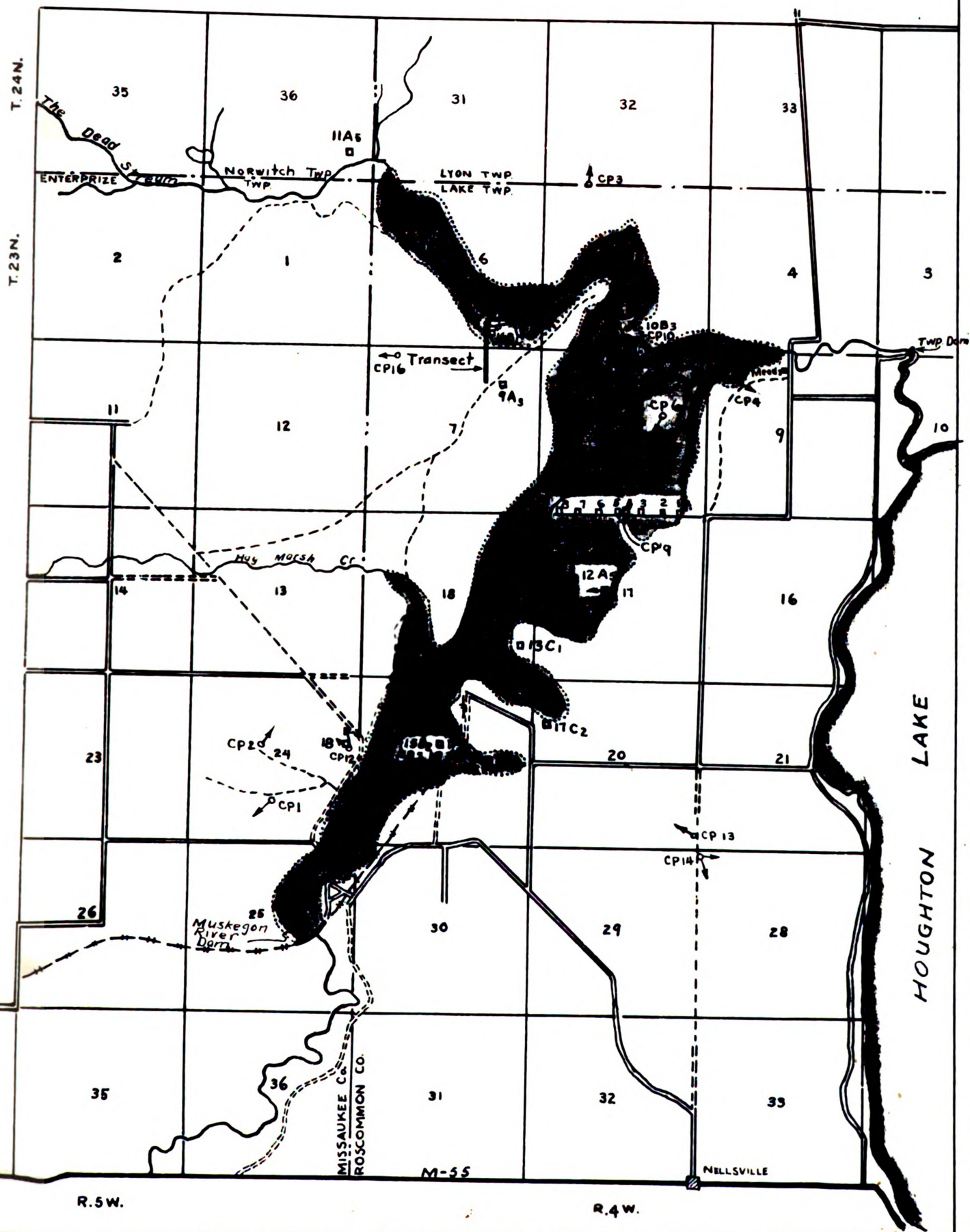
The productivity of aquatic plants in the Dead Stream has a direct relationship with the productivity of muskrats and waterfowl. Very few muskrats and duck broods were seen along the Dead Stream.



Figure 17. Vegetation of the Dead Stream. Coontail may be seen in the foreground, spatter-dock in the background, followed by a border of sweet gale. Spire of black spruce and dead white cedar appear along the skyline.

DEAD STREAM PROJECT

Showing Location of Sample Plots
And Camera Points



Study Plots

A study of the Dead Stream Project started on October 17, 1939, when B. C. Jenkins and Cash Wonser of the Game Division, Michigan Department of Conservation, established a series of sample plots, marked them with cedar posts, and recorded the vegetation found in them. This was done before the area was flooded. Periodic recordings of the vegetation were made until 1950 at which time I made an analysis of all the plots with the exception of plot 16B. Data, prior to 1950, came from the Game Division files.

The purpose of establishing these plots was to determine what species were most resistant to flooding, to determine pioneer aquatics and finally to gain an all-over picture of plant succession and the situation as it exists at the present time.

The first plots established were located on the east-west section line originating at the corner of Sections 8, 9, 16, and 17, T23N, R4W, Roscommon County. Plot 1A₂ was located ten chains west of the section corner and thereafter for every ten chains four plots were established. All these plots, with the exception of plot 4B₄, had an area of one milacre. Plots 5A₂, 6A₂, 7A₂, and 8A₂ vary somewhat in their distances from each other. The locations are given for each. Reference to the map on preceding page will show the location of these plots in relation to the river.

Plot 1A₂

1939--A heavy growth of bluejoint and sedge was present. The ground was covered, in spots, by moss. East of the plot there was a strip of willow one chain wide followed by alder, dogwood, and highland poplar.

1943--A heavy growth of grass was present.

1946--Sedge had become the dominant plant. Bluejoint had been reduced to just a trace. Several species of aquatics had become established. Poplar located just outside the plot and willow had died.

1950--Sedge was the most abundant plant although bluejoint was plentiful. Smartweed and milfoil were found growing in the plot. A limited amount of bur reed was present outside the plot. Willow east of the plot was present and some of it was still alive. Northeast of the plot, tag alder had established itself.

Summary--Water depths (1"-3") were apparently not sufficient to kill the vegetation that was present before flooding, in fact, sedge and bluejoint was thriving, having grown to heights of 70" and 66" respectively. Smartweed and milfoil apparently were the pioneer aquatics. Willow is resistant to increased water levels.

Plot 2A₂

1939--This plot had a heavy growth of sedge and some bluejoint. Seven clumps of spice bush (Benzoin spp.) occupied about 40 percent of the plot. A few stems of aster and tag alder were present.

1940--Bluejoint was found growing at a height of six feet.

1946--Sedge had been opened by the action of muskrats. Bluejoint was present as scattered stems.

1950--Five clumps of sedge, with intermingled stems of bluejoint, were growing in this plot. Four specimens of willow (reproduction size class) as well as four stems of meadow-sweet (Spiraea alba) were found here. Duckweed, smartweed, and water milfoil were present in small quantities. Muskrat activity had ceased.

Summary--Water depths had increased to two feet. Spice bush had become eliminated soon after flooding. Sedge, though dense before flooding, had been opened. Willow reproduction is taking place and a few aquatics have become established.

Plot 3A₂

1939--This plot was dominated by a clump of willow 80" in height, bluejoint and sedge occupied the remaining area in the plot.

1946--Muskrats had opened the grass and sedge and aquatics had become established.

1950--Water milfoil was the only aquatic found. The willow clump, which dominated this plot in 1939, continued to occupy most of the area at this time.

Summary--After this plot was flooded, muskrats moved in and created some openings in the grass and sedge. Their activities had ceased by 1950. Willow in this plot grew 16" in the eleven year period.

Plot 4B₄

1939--This plot was located on a low ridge of Newton sand. It was one chain square with a smaller milacre plot located in the southeast corner. Vegetation in the chain square consisted of poplar, white ash, traces of alder, trembling aspen, willow, dogwood, red raspberry (Rubus idaens) and blackberry (Rubus spp.). Ground cover consisted primarily of grass and goldenrod (Solidago spp.).

1946--Sedge had become the most abundant ground cover. Bracken (Pteridium aquilinum) also appeared at this time.

1950--Analysis of the chain square plot showed water to be two inches in depth in the northeast and northwest corners and cattail had become established there. Spirea was present outside the northeast corner and tag alder was found outside the northwest corner. The northern half of

the plot was occupied by sedge. The southern half consisted principally of bluejoint and bracken with scattered goldenrod. Vegetation on the milacre plot was composed mainly of bluejoint. Two plants of meadow-sweet were present as were small amounts of sedge and goldenrod.

Summary--The greatest change in this plot has been the appearance of cattail, sedge, and bracken. Trembling aspen was noticeably affected by the elevated water table. Most of it was dead, that which was still alive had a sickly appearance. White ash, on the other hand, appeared to be thriving under the changed condition.

Plot 5A₂

1939--This plot is located two chains west of plot 4B₄. A heavy growth of reedy grass and bluejoint was present. Clumps of willow were present about the area.

1946--The vegetation had begun to open and only one-fourth of the plot was occupied by sedge.

1948--Aquatic vegetation had become established.

1950--Water milfoil had become the dominant aquatic with a few specimens of marsh cinquefoil scattered through the plot. Clumps of sedge were found in and about the plot. These clumps of sedge were not rooted to the substratum. Flat-stemmed pondweed formed dense beds just west of the plot.

Summary--This plot had undergone a greater change than any of the previous plots studied. Water depth here was about two feet and much of the former emergent vegetation had been eliminated. Water milfoil became the most abundant aquatic.

Plot 6A₂

1939--Plot 6A₂ was set up ten chains west of plot 5A₂. The vegetation consisted primarily of short reed grass (Glyceria?) and bluejoint. Four willow shoots, small bunches of moss, and a few stems of Aster spp. were found.

1946--Bluejoint and willow had disappeared and the vegetation consisted of reed grass and submerged aquatics.

1948--Scattered stems of sedge and aquatic plants characterized the vegetation at this time.

1950--Sedge occupied most of the area in the plot. Flat-stemmed pondweed had formed a bed in the southeast corner of the plot. Water milfoil was scattered throughout the plot. Two plants of floating-leaf-pondweed had become established in the center of the plot. Cattail had become established sixty feet west of the plot. Spatterdock was present east of the plot, and sweet gale was growing in close proximity.

Summary--Sedge has been very persistent. Aquatics found growing in this plot were flat-stemmed pondweed, floating-leaf pondweed, and water milfoil. They were present throughout this general area and probably were among the first aquatics to become established after formation of the reservoir.

Plot 7A₂

1939--This plot was located 760 feet from the east bank of the Muskegon River. Vegetation was composed mainly of bluejoint with one willow and a little sedge comprising the remainder. Willow surrounded the plot.

1946--Coontail and smartweed were established and dominated the plot at this time. Willow was dead.

1948--Coontail and smartweed continued to dominate the area in 1948.

1950--Water milfoil and flat-stemmed pondweed had formed dense closed stands. A filamentous alga was seen attached to flat-stemmed pondweed. A small stand of wild rice was located near the northeast corner.

Outside the plot, white and yellow water lily, coontail, floating-leaf pondweed, and waterweed were found growing. Although willow was reported dead in earlier observations, a few leaf-bearing twigs were noted at this time.

Summary--Bluejoint and sedge became completely eliminated with several species of aquatics succeeding. Willow, again, demonstrates its ability to withstand prolonged submergence and is probably the most resistant to flooding of any woody species. Wild rice, in the immediate vicinity, may indicate spread of this species from the mud flats of the river further north.

Plot 8A₂

1939--This is the last of the plots located along the section line. It was located 100 feet from the Muskegon River. Bluejoint and sedge growing to a height of five feet dominated this plot.

1946--Sedge and bluejoint had disappeared with smartweed becoming dominant. Cattail had become established just north of the plot.

1950--Floating-leaf pondweed dominated this plot. Associates of the floating-leaf pondweed were water marigold, flat-stemmed pondweed, water milfoil, and bur reed. Wild rice was also present near the plot.

Summary--Sedge and bluejoint apparently was eliminated a very short time after the flooding. It seems that smartweed became the first aquatic to invade but since had been replaced. Bur reed now occupies the area which was reported to be growing cattail in 1946.

Plot 9A₂

This plot is situated in the southwest corner of the NE 1/4, NE 1/4, Sect. 7, T23N, R4W. It is 50 links x 50 links in area.

1939--This plot is situated in what appears to be an old lake bed or possibly an ancient channel of the Muskegon River. Greenwood peat, at depths of 6" to 18", is the soil type found here. Leatherleaf and blueberry were dominant in that order. Pigeon wheat moss (Polytrichum) covered the ground and traces of grass were present.

1950--A cover map was prepared of this plot and on comparison no change was noted. This plot probably has not been influenced by the flooding.

Summary--There was no change.

Plot 10B₃

This plot is located in the SW 1/4, SE 1/4, Sect. 5, T23N, R4W near the junction of the Dead Stream and the Muskegon River.

1939--Black ash, approximately 40 feet in height and averaging 132 years in age dominated the plot. Black ash exhibited buttressing to a degree. Some red maple was present. These trees averaged 35 years in age.

1941--The ground was completely covered with water and most of the ash appeared half dead with only a few leaf bearing branches on each tree.

1943--Ash appeared to be fairly healthy. Diameter measurements taken in 1939 and again in 1943 indicated an increase of 1.34" for the ash and 1.1" for the maple.

1946--There was no apparent change in the plot except establishment of aquatic vegetation which was not identified.

1950--At this time thirteen black ash were still alive, five were dead. Only one red maple remained living. Branches, bearing leaves, were found only on the middle third of the trees. This was true of both the ash and maple. Clumps of bluejoint were found growing near the ash. Duckweed covered most of the surface and a tangled mass of vegetation, presumably Riccia, was found beneath the surface. Water-arum (Calla palustris) bur reed, and blue flag (Iris versicolor) were present just outside the southwest corner.

Summary--This plot has been continuously covered with water since early 1940. Black ash and red maple lost more than two-thirds of their foliage soon after this plot was flooded but many of the ash survived. Red maple does not seem to be as resistant to flooding as does black ash. Bluejoint and other aquatics have become established, in response to ample moisture and the reduction of the canopy which permits more light to enter.

Plot 11A₅

This plot, one rod square, is found in the SE 1/4, SE 1/4, Sect. 36, T24N, R5W.

1939--Red-osier dogwood, speckled alder, traces of willow, with ground cover of sedge and bluejoint constituted the cover at this time.

1943--Red-osier dogwood, speckled alder, and sedge was growing thriftily.

1946--No apparent change, except growth of the above named species, was noted.

1950--Sedge was the most abundant ground cover. Red-osier dogwood, speckled alder, and willow was growing at heights of twelve feet.

Summary--This plot is located outside the flooding zone, therefore, any changes which have occurred are not attributable to flooding.

Plot 12A₅

This plot is located in the SE 1/4, NW 1/4, Sect. 17, T23N, R4W near the eastern border of the Hay Marsh.

1939--Vegetation consisted of reed grass, alder shrubs, leatherleaf, and sphagnum moss (Sphagnum spp.). A red pine seedling was also present.

1943--Alder and grass was dying. Birch and meadow sweet, not recorded in the original survey, was dying. The red pine seedling was not found. Leatherleaf and willow (not mentioned in the first analysis) appeared to be healthy.

1946--Leatherleaf dominated one-third of the plot. The rest was open water.

1950--Leatherleaf, in good condition, occupied the western border of the plot. A clump of willow with a few leaf-bearing twigs occupied the northwest corner. Midway along the south line of the plot, a clump of meadow sweet and leatherleaf with intermingled stems of bluejoint was found. Bluejoint and leatherleaf grew in the center of the plot. Bladderwort was the most abundant aquatic in the plot. In lesser quantities, were found water milfoil, duckweed, marsh cinquefoil, and smartweed.

Summary--Leatherleaf has shown its resistance to flooding. Bladderwort has invaded the plot and has become the most abundant aquatic. About the plot, willow and meadow sweet were very plentiful. West of the plot, speckled alder was growing. A clump of cattail was seen approximately 200 yards southwest of the plot. Vegetation has formed floating mats both in the plot and between the plot and the edge of the flooding. It is not known how long this condition has been present.

Plot 13C₁

This quadrat is found on an island in the flooding north of the Michelson boat landing. Its location is E 1/2, SE 1/4, Sect. 18, T23N, R4W.

1939--Cover consisted of white birch, aspen, red maple, red oak (Quercus rubra), and one white oak (Q. alba). Shrubs were red-osier dogwood and blackberry. Goldenrod, bracken fern, wintergreen (Gaultheria procumbens), partridge-berry (Mitchella repens), pigeon wheat moss, and Aster spp. made up the ground cover.

1943--Little change was noted except for sedge which had become established in low spots.

1946--Sedge and grass was becoming more prominent. Bracken was less plentiful. Beaver had cut all the aspen.

1950--White birch was the most abundant tree followed by red maple. Red oak, white oak, and one cherry comprised the rest of the timber species. Reproduction of white ash and red maple was good. Bluejoint and bracken were in abundance on the floor. Meadow sweet and sedge was found in the southeast corner of the plot.

Summary--Aspen was eliminated by beaver and apparently white birch will be replaced by white ash and red maple. Although the water table has been significantly elevated,

there has been no apparent damage to timber species growing there. Dogwood and blackberry disappeared and bluejoint became the most abundant plant on the forest floor.

Plot 14B₃

This plot is located in the SE 1/4, NW 1/4, Sect. 19, T23N, R4W.

1939--A dense coppice of second growth soft maple and black ash saplings two and one-half feet in height dominated this plot. Occasional red-osier dogwood, willow, and blue beech (Carpinus caroliniana) were seen. Elm, which was left when the ash and maple was cut, dominated in size but not in number. Ground cover consisted of sedge, ryegrass (Lolium spp.), moss, strawberry (Fragaria spp.), and ferns.

1943--Soft maple was still alive after continuous flooding. Most of the ash and elm was dead.

1946--A few ash were still alive. Floating and submerged aquatics had become established.

1950--One black ash had five twigs which bore leaves. All other trees were dead. Flat-stemmed pondweed occupied most of the plot. Waterweed and coontail occurred as single plants scattered through the bed of flat-stemmed

pondweed. Floating-leaf pondweed, bur reed, spike rush, and spatter-dock were found outside the plot.

Summary--All timber, with the exception of one black ash, succumbed to flooding. Flat-stemmed pondweed, which is perhaps the most common submerged aquatic in the entire flooding, probably was one of the first aquatics to be established after the impoundment.

Plot 15B₂

This plot is located 100 feet northwest of plot 14B₃.

1939--This plot contained a stand of aspen 40'-60' in height and white cedar 18'-25' in height. From the data, it appeared that white cedar was succeeding the aspen. Ground cover was lacking.

1943--All trees were dead. Aspen, quick to rot, was beginning to fall.

1950--White cedar trunks were still standing. Aquatic plants were plentiful with a mixture of bladderwort, hornwort, waterweed, water milfoil, and flat-stemmed pondweed being present.

Summary--Aquatic plants became dominant as no timber species survived. White cedar and aspen died soon after flooding.

Plot 17C₂

This quadrat is located in the N 1/4, NW 1/2, Sect. 20, T23N, R4W.

1939--Jack pine dominated the plot. Shrubs consisted of one Viburnum, and one shad bush (Amelanchier canadensis). Ground cover consisted of bracken fern, blueberry, trailing arbutus (Epigaea repens), and goldenrod. Pigeon wheat moss was found over most of the surface.

1950--After flooding, the water table was raised until it was but a few inches below the surface of the ground. Despite this fact, little change was noted from 1939 to 1950. Jack pine, by 1950, was still alive, although only about one-third of the upper branches bore needles. This may have been due entirely to natural pruning but outside the plot it was noted that several jack pine were dead. Bracken fern and blueberry constituted most of the ground cover.

Summary--Jack pine appears to be very adaptable to changing moisture conditions, probably due to the fact that the root system is moderately shallow.

Plot 19

Plot 19 is a new plot. It was established in the summer of 1950. It is located in the NW 1/4 NW 1/4,

Sect. 17, T23N, R4W. It is a square rod in size and may easily be seen from the river. This plot is typical of the vegetation in the immediate area and was utilized to a great extent by fall waterfowl concentrations.

The most abundant aquatic was floating-leaf pondweed. Its leaves covered most of the surface of the plot. Water smartweed was present as an occasional scattered throughout the plot. A stem of wild rice was present in the northeast corner of the plot and surrounding the plot could be seen scattered patches of bur reed. The floating-leaf pondweed produces an abundance of seed considered prime waterfowl food. The stem of wild rice suggests invasion of this area by this species. Wild rice was not seen growing south of this plot. The high density, at the present, of floating-leaf pondweed should make evaluation of successional changes in the future of this plot an easy matter.

Plot 20

Plot 20 is located in the SW 1/4, SW 1/4, Sect. 8, T23N, R4W. It was established in 1950. Its area is one rod square. A mixed plant community exists in the immediate surroundings and for this reason the plot was located here.

A stand of bur reed 3' x 10' in extent was located in the northeast corner. Another stand of bur reed was also located in the center of the plot, its size being 2' x 2'. In the southwest corner of the plot, there was found a small stand of bur reed. Floating-leaf pondweed covers most of the open water with stems of flat-stemmed pondweed and waterweed scattered through the plot.

Cattail is growing 75-100 feet north of the plot. Wild rice, bur reed, and cattail was also seen as scattered clumps about the plot. A pure stand of bur reed was found 100 yards north of the plot.

Future study of this plot should indicate the progression or recession of wild rice, bur reed, and cattail in this vicinity.

Plot 21

Plot 21 was established in 1950 on the east bank of the Muskegon River fifty yards below the junction of the Dead Stream and Muskegon River. The vegetation zones of the stream border are found in this plot.

The northern one-half is dominated by bur reed with scattered wild rice and bulrush stems. The eastern boundary of the plot is composed of cattail, scattered on the north of the line, becoming dense on the south end. Bluejoint grows sparingly in association with the cattail. The south

one-half, excepting the eastern border, is composed chiefly of wild rice with a mixture of white water lily, bulrush, water smartweed, and bur reed. Just south of the plot, a bed of swamp loosestrife, 8' x 8' in area, was established.

Summary of Plot Analyses

An accurate account of the vegetational changes which have occurred since the area was flooded cannot be made for several reasons. Actual boundaries to be created by the flooding were not known at the time the study plots were established and some of the areas subjects to greatest change were not included in the initial study. Identification of aquatics establishing themselves as succession progressed was not made and finally no phytosociological methods were used which insured accurate qualitative and quantitative data. This is no reflection whatever on those who realized a need for a long term study of such a project. Rather it shows the short-comings of such work and the need for a standardized procedure to be used in this type of study. It is felt that much information gained was useful, and to be consistent analysis of the plots in 1950 was conducted in the same manner.

The most definite information gained was that of the survival of different forest species when subjected to flooding. White cedar, usually found on moist sites, was

one of the first species to die. White cedar in healthy condition is growing at present in the Dead Stream Swamp on soil that is saturated, pools of water being evident throughout the locality. Apparently this species dies quickly after the shallow root system has been covered by water for an appreciable length of time. Jack pine, usually found on dry sandy sites, is at present growing near the edge of the backwater. The water table is but a few inches below the surface but apparently the elevated water table has had no effect on the jack pine which at maturity usually has a rather shallow root system.

Black ash appears to be the most resistant of all timber species to flooding. A study plot, located near the junction of the Dead Stream and Muskegon River, has at present 13 black ash trees which are still living. Although this plot is located far from the dam, it has been continuously flooded since 1940. Apparently the depth of water to which the tree is subjected has a bearing on its survival. In other areas of the flooding, black ash which are standing in three or four feet of water are dead; those in water six inches to two feet continue to survive. Studies in Illinois (Yeager 1948) on the effect of flooding timber species shows white ash to be a very resistant species. Black ash and white cedar, though dead, have remained

standing. Aspen appears to be very susceptible to rot after dying and soon topples into the water.

Red maple is another species which is resistant to flooding though apparently not to the degree exhibited by black ash. Both species lose their crown and only a few leaf-bearing twigs remain.

Willow shrubs are very resistant to the effects of water covering the root system. An acre or so of willow persists in the flooding where the depth of water is four feet and although most of it is dead an occasional leaf-bearing twig may be seen. Further back from the river but in territory that is flooded to depths of one to one and one-half feet, willow appears healthy and thriving.

Plots 5A₂, 6A₂, 7A₂, and 8A₂, located in a section of the river bottom where water was of sufficient depth to effect drastic changes in the vegetation, yielded information on the survival of grass and sedge which were dominants at the time these plots were established. Unfortunately, no data are available between the years 1940 and 1946, but evidence strongly suggests that bluejoint is not as tolerant of substantial increases in the water level as is sedge. It may be that before flooding, bluejoint occupied most of the Hay Marsh area, while sedge existed in the lower spots or depressions in the stream plain. The fact that scattered

sedge clumps make up the present western border of the Hay Marsh indicates that bluejoint is not able to survive water depths of three feet or more. East of the border, water depths gradually decrease, sedge clumps grow in closer proximity to each other, bluejoint begins to appear, and the stand eventually becomes closed.

The establishment of submerged aquatics followed closely the recession of grass and sedge. Probably many of these aquatics were present in the Muskegon River before it was flooded and spread quickly when conditions became favorable for growth. Pirnie (1932) reported beds of sago pondweed, but for the most part, submerged vegetation was lacking. Coontail and smartweed were mentioned in early findings of the study plot analyses. Floating-leaf pondweed, bladderwort, water milfoil, water marigold, and flat-stemmed pondweed are now the most important of all the submerged aquatics. Of these, flat-stemmed pondweed is found in greatest quantity.

Wild rice, according to local residents, was not present before flooding, but after impoundment, was obtained from the beds in Houghton Lake, and planted in the Muskegon River. Whether that be the case or not, wild rice has spread rapidly. At present, it is restricted mainly to mud bars covered by running water, but the presence of

scattered stems in the standing waters at the north end of the pond suggests spreading by this species.

Bur reed is one of the pioneer aquatics. Pirnie (verbal communication) has found that often it appears after flooding and apparently is able to seed more quickly than other emergent vegetation. Probably it was present before flooding and then came in as soon as the sedge and grass sod was destroyed. It seems to be a competitor of cattail, in that it occupies sites which undoubtedly would support good stands of the latter. Observations indicate that bur reed is able to grow in deeper water than cattail possibly because of its ability to seed in at greater depths.

The status of cattail in the flooding is not clearly understood. Pirnie (1932) reported small stands of cattail. Its spread has not been as great as that of bur reed. Whether cattail will eventually replace bur reed remains to be seen. Unquestionably, cattail is to be preferred over bur reed, especially from the standpoint of muskrat production.

Waterfowl Investigation

This unit of the study received more time and attention than did any other phase of the project. Inasmuch as the waterfowl investigation was one of the primary objectives, it was felt that the study should include more than the

duck brood census. Therefore, in addition to brood counts, the summer populations and fall build-up, a check of the hunting season, and a breeding bird census were included. The stages of the waterfowl investigation are here described in chronological order, from the return of ducks in the spring to the hunting season in the fall. During the winter months of 1950-1951 the area was not under observation. Although stretches of open water may be found for some distance after the Muskegon River leaves Houghton Lake, in the flooding itself, and below the dam, so few waterfowl are found after the freeze-up it is evident that little use is made of this area in winter.

Breeding Bird Census

The easiest and most economical method of determining a nesting population is to conduct a census of breeding birds. The Fish and Wildlife Service, in determining the spring breeding population, uses established aerial transects (Special Scientific Report 1949). This type of censusing is applicable to the expansive areas of the Canadian shield and prairie, but smaller units, such as found in Michigan, are more effectively and accurately covered by boat or on foot.

A breeding duck census is based on the fact that during the period of egg laying and early incubation the birds

remain paired and may be seen on the male's territory. Although the female may not often be seen during incubation, the drake is usually present on the loafing spot or on a special out-of-territory waiting spot. Such pairs may be distinguished from transients by their reluctance to leave the territory; when flushed they usually circle the intruder and seldom fly far (Hochbaum, 1944).

There are drawbacks to this method of estimating a breeding population. One of the most serious lies in the fact that the census may not be conducted at the proper time. Adverse weather conditions may delay the return of ducks in the spring, or favorable weather may accelerate their migration. Arrival dates for the various species which nest in the area vary considerably. At best, a breeding bird census can only indicate trends in production.

A breeding bird census was conducted by M. D. Pirnie on June 3 and 4, 1950. His coverage by boat extended from Mead's Landing on the Muskegon River up the Dead Stream to Coal Creek, back down the Dead Stream to the Muskegon and then south on the latter for approximately two miles. Thirteen pairs of ducks were observed: blue-winged teal (6), mallard (1), wood duck (2), and ring-necked duck (4). Also seen, but not paired, were black ducks, lesser scaup, and hooded mergansers. The data thus obtained were consistent with my later findings on duck broods, but

only to the extent that it indicated what species were nesting in the area. There was no correlation between the number and species of breeding pairs and the number and species of duck broods observed at a later date.

A census conducted May 13, 1951, did not disclose as many breeding pairs as did the later period a year previous, nor was the coverage the same. The area censused in 1951 included the flooding from the Reedsburg boat landing to the mouth of the Dead Stream. Groups of golden-eye, lesser scaup, mallard, black duck, wood duck, blue-winged teal, ring-necked duck, and hooded merganser were seen. Presumably the golden-eye and lesser scaup were transients while the others may have remained in the area to nest. During the census two pairs of blue-winged teal, two pairs of ring-necked ducks, and one pair of black ducks were seen.

Area Method of Brood Study

The flooding area has been broken down into seven different units based on cover type and location. Such a division has made it possible to locate areas of duck brood utilization. Not until the entire area had been covered and duck broods had been found was it apparent that these natural units existed. If duck brood censusing is conducted at a future date, it is felt that time will be saved if

only these areas are checked. The total hours given for censusing each area are reasonably accurate but do not include travel time to and from the areas.

Area I

Area I includes all of the Hay Marsh north of an east-west drainage ditch shown on map III. This area is characterized by a heavy growth of bluejoint and sedge except for the southwest corner where the cover has been opened. Drainage ditches cut in this marsh years ago to improve conditions for harvest of the hay, made a greater coverage possible. A duck boat was pushed through these ditches and out into openings. Wading in this area proved to be impracticable because of water depths (two-four feet) and the height of bluejoint and sedge. Broods were often seen crossing the ditches. An estimated total time of 25 hours was spent in this area.

Area II

This area includes the open water of the river flats, between the open channel of the river and the western border of the Hay Marsh. This area extends from the east-west drainage ditch on the north southward to the island shown on the map. The width of this strip is fully 400 yards in some places. Vegetation includes dead willow (excellent



Figure 18. Brood Census Area I.

Upper: The Hay Marsh as it appears near the river. There is good interspersed cover.

Lower: The east-west drainage ditch which forms the southern boundary of Area I. This photo was taken 1/4 mile from the river with the camera pointed west. Note the lack of openings in the grass-sedge cover.

escape cover), beds of water milfoil, flat-stemmed pondweed, water marigold, bladderwort, and scattered stands of bur reed and smartweed. This area was censused by boat. Approximate time spent censusing was twenty hours.

Area III

The location of this area may best be seen by consulting map III. It is a small isolated pocket found in the southwest corner of a north-south ridge and an east-west ridge. These ridges support heavy growths of speckled alder, bluejoint, sedge, and bracken. This flooded pocket contained water too deep for wading. Dead trees, willow shrubs, and clumps of bluejoint and sedge constituted the vegetation. Aquatic vegetation was not checked. The area was censused on foot and the total time spent there was four hours.

Area IV

This area was known locally as the "Hell Hole" and travel conditions well justified the name. It was located on the west side of the river in flooded timber. The aerial photograph taken of this region in 1938 shows a series of low depressions, which in times of ample rainfall undoubtedly were ponds, even before the dam was constructed.



Figure 19. Upper: Brood Census Area II.
Lower: Brood Census Area III.

Throughout this area all timber was dead. Some of it had remained standing while other trees had fallen and become waterlogged. Many old white pine stumps bordered the eastern edge of the flooding. Scattered clumps of pickerelweed were present and smartweed appeared occasionally. Star duckweed was found in mats on the bottom and watermeal (Wolffia columbiana) covered much of the surface. Vegetation of the flooding border consisted mainly of sedge. Water arum was present at the very edge of the flooding, indicating standing water at previous intervals.

The area was censused on foot after access was gained by the duck boat. White pine stumps, which were four to five feet in height, gave command of large areas for observation. A period of 12 hours was spent censusing this area.

Area V

A large circular area was formed by the flooding just north and east of the Michelson boat landing. Vegetation was similar to that described for Area IV except the area was more open and flat-stemmed pondweed was the most abundant aquatic. It was censused by wading and by use of the duck boat. Approximately eight hours were spent censusing this area, but no duck broods were seen here.

Area VI

Hay Marsh Creek, before flooding, joined the Muskegon River west of Michelson. The banks of the stream have been flooded back to the point where the creek turns and flows in a southerly direction, which is about one-half a mile from the general flooding. Dead black ash, elm, aspen, and white birch were present along the course of the backwater. Cattail, bluejoint, and sedge were associates growing in the shallows. Near the Muskegon River pond, the area widened, and along the periphery arrowhead was prominent. Water milfoil and flat-stemmed pondweed were the most abundant aquatics in the deeper water.

Census of this area was conducted on foot and although no broods were seen, the habitat appeared to be excellent for breeding wood ducks and hooded mergansers. Five hours were spent censusing this area.

Area VII

From Peterson's Landing on the west shore of North Bay of Houghton Lake, a drainage ditch runs due west until it joins with the flooding. It cuts through an old abandoned railroad grade and shortly thereafter merges with the general flooding area. At the point where the grade is



Figure 20. Upper: Brood Census Area IV.
Lower: Brood Census Area V appearing as circular area in the left center of the picture. Michelson boat landing appears in upper right hand corner. Photo by M. D. Pirnie.

cut by the ditch, the flooding spreads more or less evenly in all directions, describing a rather circular area, with the old grade bisecting it. The bank of the drainage ditch is still apparent and covered with a dense growth of aquatic and semi-aquatic vegetation. Bur reed and wool grass (Scirpus spp.) are abundant with such species as spike rush and sedge present.

The aquatic vegetation growing in the drainage ditch was also very dense. Waterweed and flat-stemmed pondweed were the most abundant aquatics. A bed of large-leaf pondweed (Potamogeton amplifolius) was found in the ditch near the point where it joined the flooding. Water milfoil was also present as well as a potamogeton of the foliose type. In the shallower areas adjacent to the ditch flat-stemmed pondweed, floating-leaf pondweed, water weed, bladderwort, coontail, and spatter-dock had become established. A bed of stonewort (Nitella spp.) was found in the northwest sector of the drainage ditch-railroad grade bisection.

Bur reed and cattail with a mixture of sedge constituted the important emergent aquatics. There was also dead timber present but much of it had fallen.

Total time spent here was ten hours, and the census was conducted on foot and by boat.



Figure 21. Upper: Brood Census Area VI.
Lower: Brood Census Area VII.
Photo by M. D. Pirnie.

Age Determination of Ducklings

It is essential to determine as accurately as possible the age of a duck brood. Species identification, age determination, and the number of ducklings in the brood are criteria which enable the investigator to follow the pre-flight stages of development of a duck brood. Using these data, periods of egg laying, incubation and hatching, as well as brood movements, mortality, behavior patterns, and growth rates may be computed. An accurate estimate of age helps to put a "tag" on that brood and in this way minimize the possibilities for repeat counting.

Study of recent literature (Special Scientific Report, 1949) reveals inconsistency among various workers in establishing criteria for placing ducklings in different size classes. For instance, investigators in eastern Washington have classified ducklings into three groups, namely; $1/3$ grown, $1/2$ - $1/3$ grown, and $2/3$ grown. New Brunswick biologists placed broods into three different size groups. These were: Class I-up to $1/4$ grown, Class II- $1/4$ - $3/4$ grown, and Class III- $3/4$ grown to full grown. Workers in British Columbia employed the following classification: 0-1 week, 1-4 weeks, 4-8 weeks, and 8 weeks to full grown. The criteria used by these investigators to group their duck broods are not known.

Hochbaum (1944) studied pen-reared birds and noted their feather development and growth in size during their pre-flight stages. Blankenship (1952) was able, under ideal field conditions, to trace the development of wild ducklings from hatching to the flight stage. Frequent observations permitted him to follow their growth closely and he was able to classify their ages by weekly periods.

There can be no entirely reliable standards for determining the age of a brood by its appearance. Available food and length of day are factors in the development of ducklings. There are differences in growth rates of different species and Blankenship (1952) found variations among broods of the same species as well as variations within a brood itself.

Accuracy of age determination is dependent upon the length of time a brood is under observation. Cover was so abundant in the Dead Stream flooding that all too often only a glimpse of a brood was afforded. Rarely did observations on a brood exceed a minute. Pursuit of a brood for further observation was never successful. All that could be hoped for were species identification, size of the brood, and approximate age by class rating.

In this study the following criteria were used to record age or development of the broods.

Class I--Very small, bright natal down, under 1/3 grown, no juvenal plumage feathers.

Class II--Down becoming faded, appearance of juvenal plumage on shoulders and flanks, size 1/3 to 2/3 that of the adult.

Class III--Nearly size of adult, 2/3 grown or more, natal down if evident, chiefly on nape and rump.

In all but a few instances, species and size determination were made by using the adult hen as the standard of comparison.

Recounting of Duck Broods

The possibility of duplication in counts of broods is a factor that must be considered when an intensive survey is made of an area. Recounting becomes a problem when a unit is under observation for an extended period and when duck broods are able to move about freely, favored by continuous habitat.

Little is known about the duck brood movements in this area. Frequent sightings of certain duck broods having the same number of ducklings, of the same species, of the same size, and in the same general area lead me to believe that some broods were being seen repeatedly. I usually

made sightings of this nature while traveling in the boat and not specifically looking for duck broods. Three ring-necked duck broods are tabulated in this report, but more than three observations were made of ring-necked ducks. All ring-necked duck broods were seen in Area II.

On another occasion, a duck brood was reported to me by a fisherman who saw it several different times while fishing Coal Creek. Some time later the area was visited and a brood of mallards found. Possibly there was more than one duck brood using Coal Creek but the description given by the fisherman checked well with my observation.

The two examples cited indicate that some broods tend to remain in a rather localized area. Whenever broods were found, they were checked against previously collected data. If the last brood seen compared closely in size, number, and location with a previously tabulated brood, that observation was assumed to be a repeat observation. The tables present, as far as possible, the actual number of broods of each species seen and not a total of brood observations.

Brood Data

Bennett (1938), in his weekly counts of young ducks and females, discarded the term "Brood Count" and simply totaled ducklings and adults seen. The willingness of

ducklings to abandon their mother for some other female led to this decision. On this basis, he determined brood average by dividing the number of ducklings by the number of adult females.

In this study any group of ducklings of the same species and size accompanied by an adult was considered a brood. No unusually large broods (15 plus) which would be suggestive of additions to the original family group were encountered.

Black duck, mallard, blue-winged teal, and ring-necked duck females were seen with broods.

Table I

Brood Data on All Species

Species	Number of Broods	Average No. of Ducklings Per Brood	<u>All Species</u> Percent of Total Broods	Total Ducklings	Span of Hatching
Black Duck	13	5.92	40.6	77	June 6-July 27
Mallard	5	5.8	15.6	29	June 1-June 16
Blue-winged teal	11	5.37	34.4	59	June 23-July 21
Ring-necked duck	3	6.3	9.4	19	June 14-July 4
Wood duck				3	
Unidentified	10				
Totals	42	5.85	99.1	187	

The table is self-explanatory except for the computed probable hatching dates. The problem of estimating hatching periods arises when inadequate data are obtained. Also the ages of ducklings are difficult to determine, if broods have not been under continuous surveillance during their pre-flight stage. It has been brought out that there are variations in growth rates of ducklings under different conditions. Knowing that differences are more pronounced between species, this has been taken into account in determining the average age for the different size classes. Hochbaum (1944), Blankenship (1952), and others have pointed out the different growth rates between species. For example, the blue-winged teal is capable of flight six weeks after hatching (Bennett, 1938). The mallard, on the other hand, requires a period of from 52-60 days (Blankenship, 1952).

The following estimates were used to compute probable hatching dates.

Table II

Average Age for Size Classes

Species	Average Age		
	Class I	Class II	Class III
Black Duck	1 week	4 weeks	6 weeks
Mallard	1 week	4 weeks	6 weeks
Blue-winged Teal	1 week	3 weeks	5 weeks
Ring-necked Duck		4 weeks	

Table III

Data on Black Duck Broods

Date	Number of Ducklings	Class	Area	Estimated Hatching Date
July 4	7	II	I	June 6
July 4	6	I	I	June 27
July 17	10	III	I	June 5
July 26	8	III	II	June 14
July 26	5	II	II	June 28
July 27	8	III	I	June 15
July 27	2	III	I	June 15
July 28	6	II	III	July 1
July 28	4	II	III	July 1
July 28	7	III	III	June 16
July 28	2	III	III	June 16
Aug. 5	4	II	V	July 8
Aug. 24	8	II	II	July 27

The black duck did not show a decided habitat preference. Of the 13 broods seen, 8 broods were found in the Hay Marsh openings and surface weed beds and 5 broods were observed in flooded timber.

Computed probable hatching dates show two peaks of hatching. Between June 14 and 16, five broods were hatched and between June 27 and July 1, four broods were hatched.

Table IV

Data on Mallard Broods

Date	Number in Brood	Class	Area	Probable Hatching Date
July 12	5	II	Dead Stream	June 14
July 12	9	III	Coal Creek	June 1
July 14	10	III	IV	June 3
July 14	4	I	IV	July 7
July 28	1	III	III	June 16

Definite conclusions as to the habitat preference of the mallard are hardly justified. Only five broods were seen and two of these were found some distance from the general flooding area.

Hatching dates were distributed over a period of 37 days and data are insufficient to determine any hatching period peaks.

The first observation of juvenals flying was made August 3, 1950. The length of the pre-flight period has been computed to be 63 days.

Table V

Data on Blue-winged Teal Broods

Date	Number in Brood	Class	Area	Probable Hatching Date
July 1	5	I	I	June 23
July 4	4	I	I	June 26
July 4*	?	?	I	
July 25	2	II	I	July 4
July 26	3	II	I	July 5
July 27	10	II	IV	July 6
July 28	6	III	III	June 23
July 28	8	III	III	June 23
July 28	6	I	III	July 21
July 28	7	III	III	June 23
July 28	8	III	III	June 23

*Brood identified as to species but numbers in brood and size class not known.

Blue-winged teal broods were almost evenly divided in their habitat preference; five broods were seen in the Hay Marsh and six in flooded timber.

There were two hatching peaks, the first during the last week of June and the second peak during the first week of July.

The first juvenals in flight were seen August 3, 1950, a period of 41 days after the first brood was estimated to have hatched.

Table VI

Data on Ring-necked Duck Broods

Date	Number in Brood	Class	Area	Probable Hatching Date
July 12	6	II	II	June 14
July 27	10	II	II	June 29
August 2	3	II	II	July 4

All of the ring-necked duck broods were found in Area II. Probable hatching dates have little significance in determination of peak hatching periods because of the paucity of records.

There is the possibility that the brood seen on July 27 was the same as the one found on August 2, but because of the large difference in numbers between the two broods they are listed separately.

The first juvenals in flight were seen on August 16. A total number of 63 days elapsed between the earliest estimated probable hatching date and the earliest flight date.

So far as can be determined, this is perhaps the first recorded record of ring-necked ducks this far south in Michigan. Pirnie (1935) said that ring-necked broods had been reported from the Houghton Lake area and the Huron Marshes.

Wood Duck Broods

Three juvenal wood ducks were seen August 5, 1950 in Area VII. They were of size class III and appeared to be nearing the flight stage. Since they were not accompanied by an adult, they were not considered as a brood.

After the brood census had been in progress for a month with no wood duck broods seen, I thought that perhaps my coverage of the area had been inadequate. Places which appeared to be good wood duck habitat (flooded timber) were revisited, but with no success. An unidentified brood was seen in Area IV, with a wood duck female in close proximity, but the brief observation prevented positive identification. No doubt wood ducks were reared in this flooding, but my brood census failed to substantiate it.

Mortality

The main objective of the brood census was to cover the area thoroughly and to record, as accurately as possible,

the number of duck broods reared there. Repetition of brood counts was avoided as much as possible in order to gain reliable quantitative data.

Mortality may be estimated by comparing the number of individuals in a brood to the average number of eggs in the clutch for that species. This method of figuring mortality would have greater significance providing all the broods seen were of the largest size class III. Such was not the case. Many of the broods were of the smaller size classes. Mortality can be estimated, but success of the brood from the time of the observations to the flight stage is not known. For this reason, it is felt that any data which could be presented on mortality would have no real significance.

During the course of the study no acts of predation were observed either by avian or mammalian predators. The area has most of the predatory forms known to prey on ducklings. Snapping turtles (Chelydra serpentina), northern pike (Esox lucius), mink (Mustela vison) and many other predators are present and may have been responsible for taking young ducks. O'Neil (1949) states that the bowfin (Amia calva) preys on young muskrats. Many bowfin were seen in the drainage ditches of the Hay Marsh which was also utilized by ducklings. Some predation by bowfin may be possible.

Disturbance of Waterfowl Reproduction by Fishermen

There has been some speculation as to what extent fishing activities effect the reproduction cycle of waterfowl in this flooding. Fishing begins early in the spring and continues into the fall. Most of the fishing is confined to the Dead Stream, the channel of the Muskegon River, and the deep waters of the pond. Acres of suitable rearing habitat exist which are remote from fishing waters and which probably are not visited by man from one hunting season to the next. I believe that man's activities in this area do little to disturb the normal activities of breeding waterfowl.

Summer Population and Fall Build-up

The summer concentration of drakes passing into or already in eclipse plumage was, as far as could be determined, rather low. River ducks (Anatinae), when in complete eclipse and unable to fly, do not, as a rule, concentrate on large bodies of water as do the divers (Aythyinae). They resort instead to skulking and hiding in dense cover and for that reason any estimate of summering drakes is difficult to obtain. Flappers, as flightless ducks are called, often hide until almost stepped upon. Undoubtedly, many flappers will let an observer pass without their being detected. I have stood in one spot for several minutes looking for broods, only to have a duck go skittering out from under foot.

In the course of the brood census, five wood duck drakes and one black duck (sex unknown) were seen in the flightless stage. Two ring-necked duck drakes were seen June 30, still able to fly, but their eclipse plumage was beginning to appear, as indicated by their dark flanks. Mallard drakes were observed as late as July 4, still able to fly but in partial eclipse plumage. Blue-winged teal drakes also were seen at this date, but from all appearances had not started the eclipse molt.

All observations that were made indicated that wood duck drakes as well as those of the black duck and mallard summered in the area, but there were no definite records of other species.

Little flight activity was noted during July. Small groups of black ducks, mallards, wood duck, and an occasional blue-winged teal could be seen in late evening flights over the area. By the second week of August, an increasing number of ducks were seen in the evening flights. The use of the area by ducks began to shift from backwaters, where they were observed during the brood study, to areas along the river course. Frequent trips down the river revealed greater numbers of ducks using the rice beds and mud flats adjacent to the river.

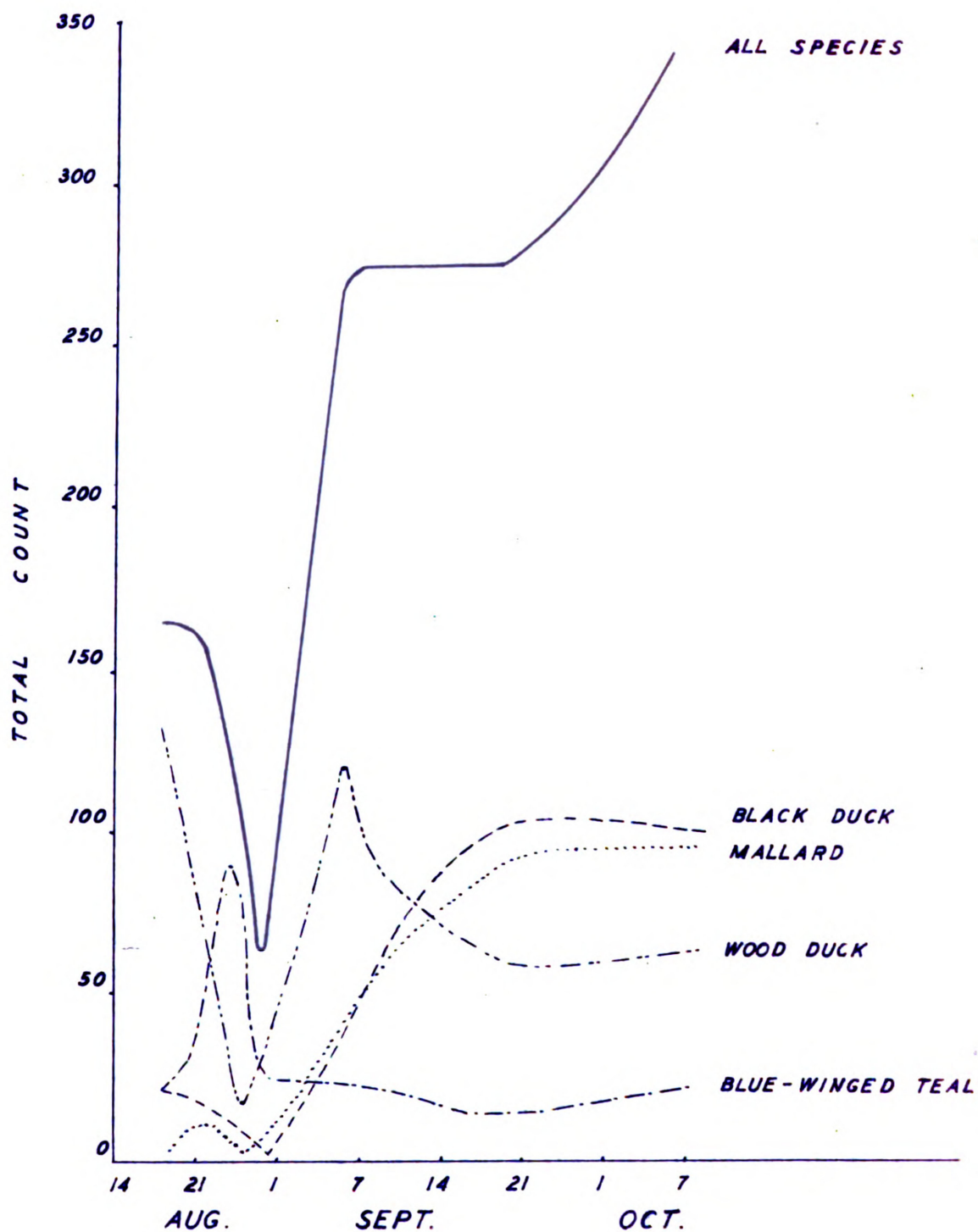
It was interesting to note that certain species preferred specific locations along the river. Some of the wild rice beds came to be recognized as loafing or feeding spots for either wood ducks or mallards and black ducks. Blue-winged teal selected the more open beds of smartweed and floating-leaf pondweed. The ring-necked ducks were found in a stretch of open water in Area II which contained beds of water milfoil. Map III shows the areas where fall concentrations of waterfowl were found.

A method of obtaining some knowledge of the species using the area as well as their relative abundance was needed. No attempt was made to determine total numbers but rather to observe trends and population shifts. An actual species count was made on each census trip. A count on any trip could not possibly have represented the total population but it was hoped each count would provide a good sample.

The observations to determine population trends began August 18, 1950. The procedure consisted of operating the motor boat at half speed (approximately 5 m.p.h.) down the river, counting ducks flushed and those flying overhead or within range permitting identification. These trips began about two hours before darkness and were four and one-half miles in length, over the same route. Experience had shown that this distance was most likely to give an adequate sample. This method was followed on all occasions, and was continued at intervals until one week before the opening of the hunting season on October 7.

A graph has been prepared showing the population trend of four of the most common species: black duck, mallard, wood duck, and blue-winged teal. The graph, drawn from data obtained from the evening censuses, shows a steady increase in numbers from August 26, 1950, until the last observation was made on October 7. Increases in black

WATERFOWL POPULATION TRENDS



duck and mallard, plus arrival of such species as baldpate, green-winged teal, and more ring-necked ducks, in part offset the decline in numbers of blue-winged teal and wood duck.

The wood duck was present in greatest numbers at the time the census to determine fall build-up began. The third week of August showed a drop in numbers followed by a steady increase until a second peak was reached on September 5, 1950. From September 5, a gradual decrease was noted until the population leveled off at approximately one-half of the numbers found at the second peak. Fluctuations of the wood duck are hard to explain, but possibly the first peak represented summering adults and juvenals reared in the area. The subsequent drop may have been caused by an exodus of this group which was then followed by an ingress of wood ducks not reared in the area. However, it is presumed that all summering adults and juvenals did not leave the area, nor was the build-up caused entirely by a different population. The graph does show population shifts and a gradual departure following the peak of September 5, 1950.

The population trend of the blue-winged teal reveals a very definite pattern. From August 18 to 24, the population rose quite sharply. This may have been due to two causes: (1) juvenals reared in the area being able to

fly, plus (2) an influx of a migrant population. It is felt, however, that the rise in population was due largely to the increased flight activity of young blue-winged teal reared in the area. In a period of two days, August 24 to 26, the population dropped sharply and leveled off at less than one-third of the peak. This is indicative of a large movement out at a time when blue-winged teal are known to be on fall migration.

The population trends of both mallard and black duck are quite similar, although the black duck was present in slightly greater numbers. From August 18 to September 1 relatively few of either species were seen, but from that point until September 17 a gradual increase was noted. A leveling off and sustained population was noted until October 7, 1950.

The Hunting Season

The entire Dead Stream area was open to the public for shooting. The season opened Sunday, October 15, 1950, which permitted many to hunt who otherwise would not have been able to do so. Although the season on all small game opened at this time, it is felt that many ruffed grouse hunters passed up opening day on their favorite game for duck hunting.

Two checking points were established to examine game passing out of the area, one at Mead's Landing, the other

at the Michelson boat landing. The author assisted a member of the Game Division, Thomas Martin, in checking the bag tally. In addition to the two checking stations, hunters were contacted in the area between the two checking stations.

The first day of shooting proved to be the most productive both from the standpoint of hunters checked and birds examined. The following week-end showed a marked drop in the number of hunters and of birds bagged. Observations following the opening day revealed a sharp decline in the waterfowl population. This may be explained in part by the fact that the marsh was quickly "burned out." Shooting on opening day was intense for a period of about two hours; thereafter, it dropped off to occasional shots.

Table VII

Bag Tally for October 15, 1950

Species Bagged	Male		Female		Total
	Adult	Juvenal	Adult	Juvenal	
Black	18 - (2)	5	16	6	47
Mallard	11 - (2)	3	15 - (4)	1	36
Wood Duck	12	2	1 - (4)	x	19
Blue-winged Teal	1	6	1	2	10
Green-winged Teal	1	x	3	x	4
Ring-necked Duck	x	x	x	3	3
Baldpate	x	x	1	x	1
Pintail	x	1	x	x	1
Totals	43 (4)	17	37 - (8)	12	121

() Denotes birds sexed but not aged, not included in age ratios.

In addition to identification, sexing, and aging, of ducks killed the following additional information was obtained from hunters:

Other birds: Hooded mergansers-4, Coots-13, Gallinule-1

Unretrieved ducks: 76--This figure indicates that for every two birds killed and found there was slightly more than one bird wounded or killed and left in the field.

Sex ratio--64 males, 57 females Adult-Juvenal ratio--80:29

Age determined by tail-feather method, therefore figure given for adults includes both adult and juvenals.

Total hunters checked: 135

Total hunter hours: 639

Average hours per hunter: 4.7

Average ducks per hunter: 0.90

Table VIII

Bag Tally for October 21 and 22, 1950

Species Bagged	Male		Female		Total
	Adult	Juvenal	Adult	Juvenal	
Black	2	2	2	x	6
Mallard	2	x	1	2	5
Green-winged Teal	1	x	x	x	1
Ring-necked Duck	x	1	x	x	1
Totals	5	3	3	2	13

Other birds: Coot-5

Unretrieved birds: 15

Sex ratio: 8 males, 5 females

Adult-Juvenal ratio: 8:5

Total hunters checked: 18

Total hours hunted: 87

Average hours per hunter: 4.8

Average ducks per
hunter: 0.72

Comparison of the Bag Tally to the Estimated Population Composition

One method for testing the reliability of the census method technique would be to compare results of the last census, taken before the start of hunting season, with the bag tally of the opening day. The bag tally should be a representative sample of the population providing duck hunters do not shoot selectively, providing all species

behave in the same manner to gunfire, and providing the population remains more or less stable during the period between the last census and the day the sample is taken.

It is felt in this case that selective shooting, i.e. passing up a green-winged teal to wait for a larger duck, was the exception rather than the rule. Of the 135 hunters contacted, not one had obtained the bag limit of four ducks. In other words, shooting was not good enough to permit selectivity.

Another factor operating against a representative sample being taken is the behavior of waterfowl after the opening day bombardment begins. The greatest kill undoubtedly occurs during the first half-hour of shooting; thereafter it drops off quite rapidly. Some species are noted for their wariness, others consistently suffer heavy losses. Generally all species new to an area are subject to heavier mortality than is ordinarily the case.

There were two elements which made up the population on opening day. One element consisted of mallards, black ducks, blue-winged teal, and wood ducks. Very possibly some of these birds were reared in or near the flooding and had gathered there some time before the season opened. Duck hunters assume that a large part of the first day's kill are locals.

The other element was composed of baldpates, pintails, ring-necked ducks, and green-winged teal. All those ducks, with the possible exception of the few local ring-necked ducks which may have remained in the area, were transients. During the census of October 7, 70 baldpates, 2 pintail, 4 green-winged teal, and an estimated 1500 ring-necked ducks were seen besides the "local" group. The raft of ring-necked ducks was concentrated in Area II. These ducks were gathered some distance from the census route, did not fly, and hence were not tabulated in the count. The estimate of the population composition would have been distorted had the ring-necked ducks been counted. The method used to obtain the population composition was based on the supposition that only fractions of the total numbers of the various species present were being seen, yet practically all the ring-necked ducks were grouped in one spot and their total numbers could be estimated.

The opportunity to observe the behavior of "local" ducks and transient ducks under gunfire came on opening day. Shooting time began at 10 A.M. but by 9:30 A.M. ducks, which had been flushed by hunters entering the marsh, were gathered in flights everywhere over the flooding. The ducks were beginning to settle down again, after hunters had taken their stands, when the shooting began. Ducks then rose in large numbers from their loafing and feeding grounds (see

map III for areas used by fall concentrations) and began to mill about. Shooting was so intense at times, during the first half-hour, that individual shots blended into a rear.

M. D. Pirnie, hunting Area II, reported that black ducks, circling repeatedly the shallow backwater areas, were shot at time after time until killed or else were discouraged enough to leave. Several hundred mallards were flushed from the northern end of the Hay Marsh before shooting time and later the same species were observed to return time and again attempting to alight. Hunters, stationed there, prevented their doing so.

Baldpates were in flight high over the area before shooting. Returns on baldpate obtained from the bag tally suggests that these birds quickly deserted the area after shooting commenced. The large raft of ring-necked ducks sustained a very light kill. Observations prior to opening day showed the tendency for these birds to leave the area for a considerable length of time if disturbed. It is thought that hunters moving about in the marsh caused the ring-necked ducks to leave the area and when shooting began those seeking to return were scared away. The baldpates and ring-necked ducks did not subject themselves to gunfire as did the mallards, black ducks, blue-winged teal, and wood ducks.

The behavior of the mallards and black ducks strongly suggested that some of them were juvenals which were reared in the area and reluctant to leave favored loafing and feeding grounds. Unfortunately, age ratios obtained the first day of the season are unreliable due to the fact that most of the birds were sexed and aged under the pressure of impatient hunters. Most of the hunters remained in the field as long as was permitted and consequently most of the ducks were checked in a very short period of time.

Few blue-winged teal and wood ducks were seen after shooting started, therefore, it is not possible to comment on their behavior. These ducks did sustain a kill which seemed proportionate to their estimated abundance.

The waterfowl population did not remain constant between October 7 (last census date) and the opening day. A census was not made October 14 because the waterfowl population was disturbed more than usual by pre-opening day activities of hunters. Observations made on October 14 gave indications, however, that the population had declined from the previous week.

Table IX has been presented to show the comparison between kill and estimated population composition.

Table IX

Comparison of Bag Tally
to Estimated Population Composition

Species	Census, October 7, 1950		Bag Tally, October 15, 1950	
	Estimated Population Composition		Total Kill	Percent of Total Kill
	Number Observed	Percent of Total Population		
Black	98	28.0	47	38.84
Mallard	89	25.5	36	29.70
Wood duck	65	18.5	19	15.70
Blue-winged teal	22	6.3	10	8.25
Green-winged teal	4	1.1	4	3.31
Baldpate	70	20.0	1	.83
Ring-necked	--	--	3	2.48
Pintail	--	--	1	.83

In a comparison of relative numbers of ducks seen and ducks shot, including only the first four species, a chi square test shows that the differences could have originated from chance sampling.

Table X presents data for the chi square test.

Table X

Chi Square Test

The numbers under the term "expected" are computed on the basis of marginal totals. $\text{Chi square} = 2.56$ for 3 degrees of freedom

Species	Kill		Census		Total
	Observed	Expected	Observed	Expected	
Black	47	42.1	98	102.9	145
Mallard	36	36.3	89	88.7	125
Wood duck	19	24.4	65	59.6	84
Blue-winged teal	10	9.3	22	22.7	32
Totals	112		274		386

The Status and Importance of the Muskrat in the Flooding

Undoubtedly the muskrat is present in greater numbers than any other large or medium-sized mammal. Data as to past populations are meager, but information obtained from those who had trapped the marsh at an earlier period indicated a peak was reached during the year of 1942, followed by a gradual decrease in the population until the area was closed to trapping the fall of 1950. Trapping may have been intense but it is doubtful if this factor alone was responsible for the population decline.

In early May, 1951, I made a house count from the mouth of the Dead Stream down the Muskegon River to a point $3/4$ miles above the Michelson boat landing. Counting procedure was made quite simple by the fact that bluejoint, sedge, bur reed, and cattail had only limited growth at that time, so a wide field of view was open on both sides of the river. All houses on the river bank and in the marsh on either side could be counted from the motor boat. Binoculars were used to check distant areas of the marsh. Muskrat houses were easily seen protruding above the dead and prostrate stems of plants. An even easier and more informative method would be to conduct the census in winter when ice permits travel over the marsh.

All houses built by muskrat are not used as dwelling sites. The non-dwelling units are smaller, have no nest chambers, and usually have only one plunge hole. Some people believe these afford feeding sites closer to preferred food, others believe they furnish breathing holes during freeze-ups. Their location is not always close to preferred food nor is there any correlation between their number and the number of dwelling houses. Bellrose (1950) found variations from 9-57 non-dwelling houses (or feeding houses as he prefers to call them) to 100 dwelling houses. Variations occurred in lakes having high or low populations or poor or excellent food conditions. In my count, a number of



Figure 22. Muskrat House. This house is typical for those found in cattail beds along the river.

the smaller structures were noted but due to the lack of information concerning them, all houses were considered as dwelling houses. If only occupied houses were recorded, the population density here computed would be appreciably lower.

In order to obtain accurate density figures, only that part of the marsh which contained muskrat houses was included. Fifty-five houses were counted on an area estimated to be 350 acres, an average of slightly more than 6 acres per house or .156 houses per acre. On 13 Illinois lakes Bellrose (1950) found that the highest density of muskrat dwelling houses per acre was 9.5 and the lowest was .2 houses per acre. Comparison of these figures with mine shows the muskrat population of the Muskegon River marsh to be very low.

Not all muskrats were confined to the river banks and marsh, for a few were observed using bank dens on the periphery of the flooding and along the Houghton Lake drainage ditch spoil bank. It is felt, however, that the bulk of the population was found in the area where the census was conducted.

All but five of the houses were located in or near stands of cattail. After the low density of muskrats was noted for the marsh, reference was made to findings of

other workers with particular regard for the muskrat-food relationship. Foods, in order of preference, were found by Bellrose to be: (1) cattail, (2) pickerelweed, (3) hard and softstem bulrush, (4) river bulrush, (5) smartweed, (6) waterlily, (7) sedges, (8) American lotus, (9) black willow, (10) duck potato, (11) reed cane, (12) wild rice, (13) water milfoil, and (14) coontail. Plants utilized as building material varied somewhat from those used as food, Cattail ranks high for both and though wild rice is considered poor food it is used extensively as building material. Muskrat habitat in Illinois and Michigan may differ but the aquatic plants in Illinois are similar to those in the Dead Stream flooding. Availability is an important factor determining which plant foods will be used most. Takos (1947) studying muskrat food habits found that muskrats tended to feed chiefly on the most readily available plants. Factors determining utilization of plants were; density of the stand, water levels, and phenological stages in the plant life histories, i.e. preference for tender shoots in the spring. Giant bur reed, which is common in the flooding, was found by Bellrose in some of the lakes studied but no mention was made of its use, either as food or building material.

The relatively small amount of cattail, its distribution, and the lack of other suitable foods strongly suggests that

this is a factor limiting the increase of muskrats. Building material does not appear to be a limitation because wild rice is very plentiful. Many times during the summer months muskrats were seen cutting and transporting wild rice stems. The winter feeding radius of muskrats is limited to about 30 yards and thus it becomes necessary to locate houses near available food. This was shown by the distributional pattern of 'rat houses which followed closely the distribution of cattail.

There may be other factors such as disease operating to suppress the population, but it is felt that until more favorable food supplies become available muskrat numbers will remain low. Perhaps a better explanation could be offered, if the condition of the marsh were known at the time the population was at its peak. It is not certain whether cattail is spreading or being crowded out by other species. As pointed out previously, cattail is limited chiefly to the river banks, but as water depths increase nearer the dam, cattail is entirely replaced by bur reed. Also bur reed is growing in solid stands where cattail would probably thrive. In time bur reed may run its course and be replaced by cattail.

The role of the muskrat in the ecology of the flooding is difficult to evaluate. It was hoped that after flooding muskrats would invade the Hay Marsh and by their activities

create openings in the grass and sedge stands. Thus far they have failed to do this.

The duck-muskrat relationship is an important one. Hochbaum (1944), discussing territories of waterfowl, enumerates four territorial requirements, namely, water, loafing spots, nesting cover, and food. Further, a loafing spot is a most important factor, especially for puddle ducks. Hochbaum lists boulders, spits of mud, muskrat houses, stretches of beach, or mats of reed as loafing spots. The Muskegon River marsh is long on water, nesting cover, and food but short on loafing spots. There are logs, remnants of logging operations, which provide loafing spots, but these are few in number. Muskrat houses offer the best loafing spots for waterfowl but at present they are scarce and poorly distributed.

The muskrat population may be stabilized and remain so until conditions are altered in the marsh. It appears that a management program should be built around the propagation of more muskrats. If the muskrat production can be increased, waterfowl production may do likewise

Discussion

There has been a tendency across this country to consider the job done when dikes or dams have been built

and a new habitat created by putting water on the land. This is incomplete management. If a project is worthy of planning and initiating, then certainly appropriate management techniques should be tested and applied in order to maintain or attempt to maintain the very functions for which the project was designed.

Marsh management is an infant science. Progress has and is being made toward a better understanding of the dynamic processes which occur in a marsh habitat but there is a need for continued fact finding. Development of a sound management program can only be evolved through intensive studies of successional changes and by controlled experiments.

The Dead Stream Flooding at the present time is producing a good crop of waterfowl. The area is also utilized by other birds and mammals. The question of primary interest is whether this level of production can be maintained or possibly be increased. Yearly surveys of the wildlife produced in the flooding should be made in order to determine production trends. Likewise, successional changes of the vegetation must be recorded. Intensive life history studies of the game population and their ecology should be included in the overall plan of investigation.

The Dead Stream Flooding offers an excellent opportunity for experimental studies. There has been some groundwork laid for a long-term study of this project. At the present time there are approximately 350 acres in the Hay Marsh which have remained essentially unchanged since the surface of the ground was flooded. This area is almost a solid block of grass and sedge which might be developed and which could well be a testing ground for developing marsh management techniques.

Water level control is a very useful tool for manipulation of the habitat. Drastic changes in the water level are not always needed to produce the desired results. When water levels are to be raised or lowered, other interests must be taken into consideration. If feasible and possible, the Hay Marsh should be diked off from the rest of the flooding so that water levels could then be controlled without changing the level of the reservoir.

Additions and refinements of present management techniques could also be developed in the Hay Marsh. Besides water level control, use of herbicides, level ditching (by blasting or drag lines), burning, planting, and the use of bulldozers to turn over sod or soil offer means of changing the habitat. Certainly there are as yet undiscovered methods for habitat improvement and control.

Plant succession proceeds at varying rates but I believe that eventually control of aquatic vegetation in the reservoir will have to be considered.

This investigation was of the type which may be used more in the future. The present thinking in waterfowl management has come to recognize the value of intensive rather than extensive investigations. Both types of survey are necessary and should be used where applicable.

Summary

1. This is a report of a study of the Dead Stream Flooding Project of Roscommon County, Michigan.

2. The primary objectives of this study were: (1) to determine water production, (2) to determine utilization of the area by waterfowl other than the breeding population, (3) to determine vegetational changes, using data gathered from past studies and the analyses of the study plots obtained in 1950, and (4) to make a survey of existing plant communities.

3. The Dead Stream Flooding was created in 1940 by the Game Division, Michigan Department of Conservation when a dam was completed across the Muskegon River 11 stream miles from the source, which is Houghton Lake. As a result approximately 2,000 acres of marsh and timber were flooded.

4. The planning stage of this project began in 1931.

5. A history of lumbering operations and the history of the town of Michelson is discussed.

6. The average annual precipitation for Roscommon County is 27.4 inches. The average temperature is 43.5° F. The growing season averages 84 days per year.

7. The Dead Stream Flooding Area is uniformly level except for the Higgins Lake moraine on the north and slightly elevated ridge of the Houghton Lake moraine on the south.

8. Three soil groups are found in and about the flooding. These are swamp soils, marsh border soils, and light sandy soils.

9. With respect to the climax formations of North America, this region is known as a transition zone between the boreal forest formation of the north and the deciduous formation of the south.

10. A description of the Muskegon River and Dead Stream watersheds is discussed.

11. The aquatic vegetation of the Muskegon River and Dead Stream is described (check list of plants is included in the appendix).

12. Vegetational changes, which resulted from flooding, have been summarized from periodic analyses of study plots established in 1939 by B. C. Jenkins and Cash Wonser of the Game Division.

13. The most definite information gained from these study plots was the survival of different forest species when subjected to flooding.

14. White cedar was among the first species to die after flooding. Black ash, red maple, and willow appear to be very resistant to flooding.

15. It appeared that bluejoint was not able to survive deeper waters as well as sedge.

16. Wild rice became established soon after flooding.

17. Bur reed appears to be a pioneer aquatic. Cattail has made little progress in spreading.

18. A breeding bird census was conducted in 1950 and 1951.

19. The flooding area has been broken down into seven different units based on plant associations and waterfowl utilization.

20. A discussion is made of the importance of age determination of ducklings and a method used to classify ducklings is given.

21. The possibility of recounting duck broods is discussed.

22. Black duck, mallard, blue-winged teal, and ring-necked duck females were seen with broods. Black duck broods, of which 13 were seen, averaged 5.92 ducklings per

per brood. Five broods of mallards, averaging 5.8 ducklings per brood, eleven broods of blue-winged teal, averaging 5.37 ducklings per brood, and three broods of ring-necked ducks averaging 6.3 ducklings were seen. There was a total number of 187 ducklings counted. There was a total of 10 unidentified broods.

23. Wood ducks were present in the area throughout the study, but only 3 juvenals, unaccompanied by an adult, were seen.

24. Possible mortality factors are discussed.

25. Disturbance of waterfowl reproduction by fishermen is discussed.

26. A check was made of the summer population of drakes during the duck brood census.

27. The fall build-up and population shifts of waterfowl using the area was determined by a census procedure which consisted of counting ducks along an established route. This procedure was conducted from August 18 to October 7.

28. A check of hunting results was made during the first two week ends of the season.

29. Results showed that most of the waterfowl abandoned the area after shooting began.

30. A comparison is made of the bag tally with the estimated population composition as determined by the census route method.

31. A discussion is made of the status and importance of the muskrat in the flooding.

32. A census of muskrat houses revealed a very low population density.

33. The discussion points out the need for further research and experimentation in order to gain a better understanding of marsh management.

34. Mammals and birds, exclusive of waterfowl, found in the area are listed.

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APPENDIX

- I. Check List of Plants
- II. An Annotated List of Birds
- III. An Annotated List of Mammals

I. Check List of Plants

(Nomenclature follows Gray's Manual
and Fasset's Manual of Aquatic Plants)

Thallophyta

Characeae

Nitella spp.

Bryophyta

Spagnaceae

Sphagnum spp. - Sphagnum moss

Polytrichaceae

Polytrichum spp. - Pigeon-wheat moss

Hepaticae

Riccia spp. - Slender riccia

Pteridophyta

Polypodiaceae

Pteridium aquilinum - Bracken

Spermatophyta

Pinaceae

Abies balsamea - Balsam Fir

Picea mariana - Black Spruce

Larix laricina - Larch, Tamarack

Pinus strobus - White pine

Pinus resinosa - Red or Norway Pine

Pinus Banksiana - Jack Pine

Thuja occidentalis - White Cedar, Arbor Vitae

Typhaceae

Typha latifolia - Common cattail

Sparganiaceae

Sparganium eurycarpum - Giant Bur reed

Sparganium angustifolium - Floating-leaf Bur reed

Najadaceae

Potamogeton pectinatus - Sago Pondweed

Potamogeton Robbinsii - Robbins' pondweed

Potamogeton zosteriformis - Flat-stemmed pondweed

Potamogeton amplifolius - Large-leaved pondweed

Potamogeton natans - Floating-leaf pondweed

Potamogeton Richardsonii - Red-head or clasping-leaf pondweed

Potamogeton gramineus - Variable pondweed

Najas flexilis - Bushy pondweed

Alismaceae

Sagittaria latifolia - Duck-potato, Swamp-potato, Wapato

Hydrocharitaceae

Anacharis canadensis - Waterweed, Water-thyme, or Ditch-moss

Vallisneria americana - Wild or water celery

Gramineae

Glyceria spp. - Reed-meadow grass

Lolium spp. - Rye-grass

Calamagrostis canadensis - Bluejoint

Leersia oryzoides - Rice Cut-grass

Zizania aquatica - Wild rice, Water oats

Cyperaceae

Carex spp. - Sedge

Eleocharis spp. - Spike Rush

Scirpus validus - Great or Soft-stem Bulrush

Scirpus spp. - Wool grass

Araceae

Calla palustris - Water arum

Lemnaceae

Lemna minor - Duckweed

Lemna trisulca - Star Duckweed

Wolffia columbiana - Watermeal

Pontederiaceae

Pontederia chordata - Pickerelweed

Iridaceae

Iris versicolor - Blue flag

Salicaceae

Salix spp. - Willow

Populus tremuloides - Quaking aspen, Trembling aspen

Populus grandidentata - Large-toothed aspen

Myricaceae

Myrica Gale - Sweet Gale "Meadow Fern"

Comptonia spp. - Sweet fern

Corylaceae

Carpinus caroliniana - Blue or Water Beech

Betula papyrifera - White Birch

Alnus incana - Speckled Alder

Fagaceae

Quercus alba - White oak

Quercus bicolor - Swamp white oak

Quercus rubra - Red oak

Ulmaceae

Ulmus spp. - Elm

Polygonaceae

Polygonum amphibium - Water Smartweed

Ceratophyllaceae

Ceratophyllum demersum - Coontail

Nymphaeaceae

Nuphar advena - Spatterdock, yellow pond lily

Nymphaea odorata - White Water Lily

Brasenia Schreberi - Watershield

Lauraceae

Lindera Benzoin - Spicebush

Rosaceae

Amelanchier canadensis - Juneberry, Shadbush

Fragaria spp. - Strawberry

Potentilla palustris - Marsh cinquefoil

Rubus idaeus - Red Raspberry

Rubus spp. - Black Raspberry

Prunus spp. - Plum, Cherry

Spiraea alba - Meadow-sweet

Aceraceae

Acer rubrum - Red Maple

Lythraceae

Decodon verticillatus - Swamp Loosestrife Water Willow

Haloragidaceae

Myriophyllum spp. - Water Milfoil

Cornaceae

Cornus spp. - Dogwood

Cornus stolonifera - Red Osier Dogwood

Ericaceae

Ledum groenlandicum - Laborador-tea

Chamaedaphne calyculata - Leatherleaf

Epigaea repens - Trailing Arbutus

Gaultheria procumbens - Wintergreen

Vaccinium spp. - Blueberry

Oleaceae

Fraxinus americana - White ash

Fraxinus nigra - Black ash

Lentibulariaceae

Utricularia vulgaris - Common Bladderwort

Utricularia intermedia - Bladderwort

Rubiaceae

Mitchella repens - Partridge berry

Compositae

Megalodonta Beckii - Water marigold

Solidago spp. - Goldenrod

Aster spp. - Aster

II. An Annotated List of Birds (Exclusive of Waterfowl)

Flooding of the area has created several different types of habitat which many species of birds now utilize as homesites. Since waterfowl were my chief interest, observations on other birds were incidental to the rest of the study. The following list includes most of those species found in the flooding but not all the species inhabiting the uplands. Also, the list is not complete in that some of the species using the area as a stopover between nesting grounds and wintering grounds are not included.

Pied-Billed Grebe (Podilymbus podiceps). Summer resident. Two broods were seen. It preferred open water of the river and openings in stands of cattail and bur reed. Nesting sites were not found, but a photo by M. D. Pirnie shows the nest of the pied-billed grebe.

Double-crested Cormorant (Phalacrocorax auritus). Reported to be nesting in the area, but observations did not substantiate this. One cormorant was seen flying, at great height, over the area July, 1950. Two birds observed in the Houghton Lake drainage ditch by M. D. Pirnie and myself, August 1950, strongly suggested this species.

Great Blue Heron (Ardea herodias). A common summer resident. A heron rookery (Fig. 24) has been established in dead timber across the river from the Michelson boat landing. The rookery had approximately 70 nests, although probably all were not occupied.

Green Heron (Butorides virescens). Not common, though it probably nests in the area. It preferred dead flooded timber of the back waters.

Black-Crowned Night Heron (Nycticorax nycticorax). Not common. Five individuals were seen together at one time. This species probably nests in the area. This bird was observed in dead timber of back waters.

American Bittern (Botaurus lentiginosus). A common summer resident. It was frequently flushed from grass and sedge of the Hay Marsh. Individuals were often seen feeding in vegetation along mud flats of the river.

Least Bittern (Ixobrychus exilis). Common summer resident. It was frequently flushed from cattail stands bordering the river.

Turkey Vulture (Cathartes aura). Frequently seen in flight over the area. These turkey vultures were perhaps non-breeding birds attracted to the area by the availability of winter-killed deer.

Cooper's Hawk (Accipiter cooperii). Seen infrequently in hunting flights over the area. Nesting sites unknown.



Figure 23. Upper: Floating nest of the pied-billed grebe.
Lower: Nest of the black tern. Both photos
by M. D. Pirnie.

Bald Eagle (Haliaeetus leucocephalus). A pair was seen almost daily in the early morning hours. Observations indicated that they used the area for loafing. Eagles were never seen feeding or harassing ospreys in the area. They preferred certain dead trees near the river for perching sites.

Marsh Hawk (Circus cyaneus). The marsh hawk was seen, infrequently, in hunting flights over the marsh.

Osprey (Pandion halioetus). Common in the area. Four nests were built in dead trees located in the pond. All were occupied. Ospreys were never observed fishing in the flooding, however, they were often seen carrying fish from Houghton Lake.

Ruffed Grouse (Bonasa umbellus). Common permanent resident of upland timber surrounding the flooding. Three broods of ruffed grouse were observed during the study period.

King Rail (Rallus elegans). Status unknown. It is possible that the king rail nested in the Hay Marsh. One was seen along the river border in the vicinity of the Hay Marsh. This is the second observation made this far north, in Michigan. The first was reported by Gower December 1938 near Prudenville (Wood, 1951).

Sora (Porzana carolina). Fairly common summer resident of the Hay Marsh. Its voice was often heard but few sight



Figure 24. Upper: Heron Rookery.
Lower: Typical construction and location of
the osprey nests in the flooding.

observations made. An adult and juvenal was seen on one occasion.

Florida Gallinule (Gallinula chloropus). Summer resident. Frequently seen in the river or openings in the cattail stands. The nesting population was believed not to be high. Broods were observed and one Florida gallinule was shot the opening day of duck season.

Coot (Fulica americana). Encountered often during the summer months. No broods were seen. They preferred openings in the bur reed and the cattail stands. Hunters killed 18 coot.

Woodcock (Philohela minor). Not observed as a summer resident. Numbers of woodcock were found in early fall. They preferred tag alder thickets bordering the flooding.

Wilson's Snipe (Capella gallinago). Rare. Two pairs were seen lighting in the Hay Marsh in late summer.

Black Tern (Chlidonias niger). A colony established in the Hay Marsh numbered close to 1000 individuals. Black terns returned to their home site early in May, and incubation was started by late May. Juvenals appeared the third week of June and by the latter part of July were flying. My intrusion into the nesting area provoked repeated diving attacks by the adults. Adults have been observed feeding the young even after they are able to fly.

Migration occurs early in August with the entire group leaving in a period of a few days.

Belted Kingfisher (Megaceryle alcyon). Common.

Observed frequently perched on trees located near the deeper water. Fishing activities were observed. No nesting sites were seen.

Flicker (Colaptes auratus). Common. They usually were seen flying across the flooding.

Kingbird (Tyrannus tyrannus). Common. Kingbirds were frequently encountered near the junction of the Dead Stream and Muskegon River where willow afforded perching and possibly nesting sites. Fledglings recovered from stomachs of largemouth bass (Micropterus salmoides) were possibly kingbirds.

Tree Swallow (Iridoprocne bicolor). Present in large numbers. They could be seen in flight any time of the day throughout the summer season. Nesting sites were not found, though many spots are available in dead standing timber.

Crow (Corvus brachyrhynchos). Common in the region. Most of their activities were confined to timbered areas adjacent to the flooding.

Cedar Waxwing (Bombycilla cedrorum). Common. Often seen perching in dead timber. Nest sites were not found.

Red-Wing (Agelaius phoeniceus). Not common in early summer. Concentrations began to build-up by early August. Large flocks of red-wings systematically worked from one rice bed to another, probably harvesting more wild rice than any other species of bird.

Swamp Sparrow (Melospiza georgiana). Fairly common. Usually seen in the Hay Marsh. Nests were not found.

III. An Annotated List of Mammals

This list of mammals is based on actual observations made during the duck brood census and inspection of study plots, including evidence from tracks and "sign." Except for the muskrat, no attempt was made to determine population densities or to enumerate such small mammals as moles, shrews, mice, lemmings, and voles.

Black Bear (Ursus americanus). Common though not present in large numbers. It was never actually seen but droppings were found and damage to shadbush was noted. Its activities were confined mainly to the Dead Stream Swamp.

Raccoon (Procyon lotor). Common. A family of raccoons nightly raided the garbage can at my camp at Mead's Landing. Tracks and scat indicated their presence at other points in the area.

Long-tailed Weasel (Mustela frenata). Status unknown. Tracks found in the snow suggested the long-tailed weasel. No actual observations were made on this animal.

Mink (Mustela vison). Common. Tracks and other observations indicated this animal to be fairly common in the flooding. The ability of the mink in catching fish was remarkable. In one instance, a mink was seen to catch and carry four fish to a bank den. Dives were of short duration and only in one case did a dive prove unsuccessful.

The fish appeared to be suckers (Catostomus spp.)

River Otter (Lutra canadensis). Common. Observations on the otter occurred with greater frequency than on any other mustelid. There was a total count of fourteen individuals, at widely scattered points, but due to the fact that the otter has a large home range (estimated from 15 to 100 miles of shoreline, Burt, 1946) this count probably includes some repeats. On July 27, 1950 three otter were observed in the flooding a quarter of a mile north of Michelson. One week later three otter were seen in Coal Creek and on September 8, 1950 a group of five was seen swimming in the flats west of the Hay Marsh. The last group observed definitely established the fact that at least five otter utilized the area. The two groups of three individuals may have been two separate groups or a recount of the same group.

Red Fox (Vulpes fulva). Status unknown. Tracks and frequent spots of acrid urine in the snow indicated the presence of fox. Since the grey fox (Urocyon cinereoargenteus) is very rare in the lower peninsula of Michigan (Burt, 1946), it is assumed these tracks were made by the red fox. Tracks were seen on the ice-covered reservoir.

Woodchuck (Marmota monax). Status unknown. No woodchucks were seen but dens suggested their presence.

Red Squirrel (Tamiasciurus hudsonicus). Common. Red squirrels were seen in the timbered areas bordering the flooding.

Fox Squirrel (Sciurus niger). Status unknown. Only one fox squirrel was seen in the area. It is not as common as the red squirrel.

Beaver (Castor canadensis). Rare. Old lodges, dams, and cuttings indicate that beaver were once common in the area. Beaver were last reported in 1946. Data from study plot 17C shows that beaver had cut all the aspen on an island north of Michelson between 1943 and 1946. A new beaver dam, located on Hay Marsh Creek just above the flooding zone, was found in 1951, but there was no trace of a lodge. It is not known if the animals have re-established themselves in the area.

Muskrat (Ondatra zibethica). Common. The muskrat, which was the most abundant and, ecologically, the most important mammal in the flooding, has been discussed in detail in a preceding section.

Porcupine (Erethizon dorsatum). Common. Porcupines were frequently seen crossing roads adjacent to the area. They were reported to have girdled trees in the Dead Stream Swamp.

Snowshoe Hare (Lepus americanus). Common. Though it was never seen, tracks in the snow indicated a fair population of the snowshoe hare.

Cottontail (Sylvilagus floridanus). Scarce. There is an overlap in distribution of the snowshoe hare and cottontail in this region with the cottontail near the limit of its northern range. (Burt, 1946). Cottontail tracks were seen in the snow but those of the snowshoe hare were more numerous.

White-tailed Deer (Odocoileus virginianus). Common. The population density of white-tailed deer in Roscommon County is high. On several occasions they were seen feeding on aquatic plants in the Hay Marsh. Ridges and islands in or near the flooding were threaded with deer runs.

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