DOCTORAL DISSERTATION SERIES

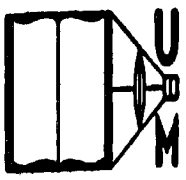
TITLE THE ECOLOGY OF THE POINTE MOUILLÉE MARSH, MICHIGAN, WITH SPECIAL REFERENCE TO THE BIOLOGY OF CAT-TAIL (TYPHA)

AUTHOR MALCOLM E. MC DONALD

UNIVERSITY OF MICH. DATE 1951

DEGREE Ph. D. PUBLICATION NO. 2421





UNIVERSITY MICROFILMS
ANN ARBOR · MICHIGAN

THE ECOLOGY OF THE POINTE MOUILLÉE MARSH, MICHIGAN, WITH SPECIAL REFERENCE TO THE BIOLOGY OF CAT-TAIL (TYPHA)

by

Malcolm E. McDonald

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy in the
University of Michigan
1951

Committee in charge:

Professor Warren W. Chase, Chairman
Professor Samuel T. Dana
Professor Lee R. Dice
Professor Frederick K. Sparrow
Professor Paul S. Welch
Associate Professor Josselyn Van Tyne

ACKNOWLEDGMENTS

The author wishes to thank Dr. Warren W. Chase, who first suggested this problem, and Mr. Harry Ruhl, Chief of the Game Division, Michigan Department of Conservation, who made the study possible by paying the expenses from Game Division funds and by making the facilities of the Pointe Mouillée State Game Area available. Much assistance was received from the successive District Game Managers of District 12, and from the staff of the Pointe Mouillée State Game Area.

The identification of many plants was checked by Professor Charles L. Gilly, Curator of the Herbarium, Michigan State College, and his help is gratefully acknowledged.

Special appreciation is due Mr. Edward Lezotte, proprietor of the Pointe Mouillée Boat Livery and former punter for the Pointe Mouillée Shooting Club, for constant help and information.

The author's wife deserves great credit for field assistance, encouragement, and the wearisome task of typing the manuscript.

TABLE OF CONTENTS

Page

LIST OF FIGURES..... v

LIST OF PLATES..... vi

LIST OF TABLES..... viii

LIST OF FIGURES AND TABLES IN APPENDIX..... ix

INTRODUCTION..... 1

Chapter

I. DESCRIPTION OF AREA..... 5

Geology
Soils
Water Level Fluctuations
Physical and Chemical Conditions of the Water
Climate
Climate During Period of Study
History of Exploitation

II. BIOTA OF MARSH..... 33

Plants
Vertebrates
Number of Mammals and Birds

III. HISTORY OF SUCCESSION OF VEGETATION..... 43

Change in Shore Lines
Vegetation Before 1944
Succession Following the Die-off of Marsh Vegetation
Ecological Consequences of the Die-off

IV. BIOTIC COMMUNITIES OF MOUILLÉE MARSH..... 74

Previous Studies on Marsh Communities
Wild Celery (*Vallisneria americana*) Community
Bushy Pondweed-Coontail (*Najas-Ceratophyllum*) Community
Bladderwort-Coontail (*Utricularia-Ceratophyllum*) Community
Floating-leaf (*Nymphaea-Nuphar*) Community
Stiff Wapato (*Sagittaria rigida*) Community
Wild Rice (*Zizania aquatica*) Community
Narrow-leaved Cat-tail (*Typha angustifolia*) Community
Blue Flag (*Typha glauca*) Community

Chapter Page

Round-stem Bulrush (Scirpus) Community
River Bulrush (Scirpus fluviatilis) Community
Reed (Phragmites communis var. Berlandieri) Community
Bulrush--Cat-tail (Scirpus-Typha) Community
Sedge-meadow (Carex-Calamagrostis) Community
Flotage and Mud Bank Communities

V. BIOLOGY AND ECOLOGY OF CAT-TAIL..... 121

Review of Literature on Typha
Role in Ecological Succession
Habitat Requirements and Preferences
Distribution in Southeastern Michigan
Life History
Growth of Rhizomes
Roots
Germination and Growth of Seedlings
Oxygen Requirements
Adaptive Modifications of Structure
Insects and Typha

VI. DIE-OFF OF EMERGENT VEGETATION..... 149

Review of Literature
Progress of Die-off in Michigan
Rejected Causes
Suggested Cause--Drowning by High Water Level in Winter

VII. SUGGESTIONS FOR MARSH MANAGEMENT PRACTICES..... 159

SUMMARY..... 164

LITERATURE CITED..... 167

APPENDIX..... 177

LIST OF FIGURES

Figure		Page
1.	Location of Pointe Mouillée State Game Area....	6
2.	Soil Map of Mouillée District.....	12
3.	Climatic Fluctuations in Water Level of Lake Erie.....	14
4.	Oscillations in Water Level; Aug. 2, 1947, Mouillée Marsh.....	16
5.	Oscillations in Water Level During Twenty-four Hours, Mouillée Headquarters.....	17
6.	Progression of Abandonment of Cultivated Land, Mouillée District.....	20
7.	Monthly Means of Precipitation and Temperature, Monroe, Michigan.....	26
8.	Land Survey Map, Mouillée District, 1817.....	44
9(A-F).	Lake Erie Shore Line, Mouillée District...	45-47
10.	Sketch Map of Pointe Mouillée Shooting Club, 1910.....	50
11.	Relative Extent of Cover Types, 1944 - 1949; Pointe Mouillée State Game Area.....	57
12.	Changes on Line Transect, Die-off Area, 1947 - 1949.....	60
13.	Ecological Consequences of Die-off of Marsh Vegetation.....	71
14.	Growth Curves of *Typha* Shoots, 1949.....	129
15.	Correlation of Temperature and Rates of Growth of *Typha* Shoots, 1949.....	130
16.	Comparison of Profiles of Soil Surface in *Typha* Stands.....	135
17(A,B).	Spread of *Typha glauca* by Vegetative Reproduction.....	136,137

LIST OF PLATES

Plate		Page
1.	Pointe Mouillée State Game Area, looking down Huron River, 1947. Pointe Mouillée State Game Area from Lake, 1949...	8
2.	Willow tree on one of the permanent islands. Clark Island.....	9
3.	Sheets of ice carrying soil lifted from marsh. Dead trees along barrier beach.....	19
4.	Dead stand of Typha angustifolia. Dead stand of Typha glauca.....	51
5.	Dead stand of Scirpus validus. Dead stand of Scirpus fluviatilis.....	52
6.	Dead stand of Phragmites communis var. Berlandieri. Dead stand of Cephalanthus occidentalis.....	53
7.	Clark Island and vicinity, September, 1947. Clark Island and vicinity, October, 1949.....	61
8.	View of Horse-shoe, September, 1947. View of Horse-shoe, October, 1949.....	62
9.	View north from Post 1 on transect; 1947, 1948, 1949.....	63
10.	View northeast from Post 10 on transect; 1947, 1948, 1949.....	64
11.	View west from Post 60 on transect; 1947, 1948, 1949.....	65
12.	Band of seedlings on exposed mud bank, July. Cat-tail invading stand of wild rice, in cat-tail die-off area.....	68
13.	Coot nest built of cat-tail stems. Pied-billed Grebe nest.....	97
14.	Muskrat feeding platform on cat-tail clump. Cat-tail stem eaten at base by muskrat.....	103
15.	Opening in cat-tail made by muskrat. Muskrat houses.....	104
16.	Floating muck island just emerged. Floating muck island one year old, vegetation starting.....	115

Plate | Page

17. Floating muck island covered with vegetation. Loose clump of Typha angustifolia..... 116

18. Comparison of height of seedlings and mature stand of Scirpus validus..... 117

19. Black Tern nest on flotage of dead cat-tail. Black Tern nest on floating muck island..... 119

20. Cat-tail stem growing in five feet of water. Seedling cat-tail on dead sedge tussock..... 140

21. Comparison of height of seedling and mature cat-tail..... 141

LIST OF TABLES

Table		Page
1.	Number of Seiches over 0.5 Feet at Put-in-Bay, Ohio, 1941	15
2.	Climatic Summary, Monroe, Michigan	25
3.	Number of Muskrats Trapped on Pointe Mouillée State Game Area	37
4.	Number of Birds on Pointe Mouillée State Game Area at Two-week Intervals, 1947 - 1949	39
5.	Cover Types of Pointe Mouillée State Game Area, 1944 - 1949	56
6.	Amount of Die-off and Recovery, Mouillée District	58
7.	Number and Size of Units of Vegetation, Mouillée District, 1944 and 1949	72
8.	Plant Communities of Mouillée District	78
9.	Frequency of Aquatic Plants Found with *Vallisneria*, Die-off Area, 1949	81
10.	Frequency of Aquatic Plants in *Najas-Ceratophyllum* Community, Die-off Area, 1949	84
11.	Frequency of Aquatic Plants Found with *Nymphaea*, Die-off Area, 1949	88

APPENDIX

Page

Distribution of Aquatic Plants, Mouillée District, 1949

Fig. 18 *Vallisneria americana*..... 178

Fig. 19 *Potamogeton americanus*, *P. natans*, *P. amplifolius*..... 179

Fig. 20 Nymphaeaceae..... 180

Fig. 21 *Sagittaria rigida*, *S. latifolia*..... 181

Fig. 22 *Lophotocarpus calycinus*, *Pontederia cordata*, *Decodon verticillata*..... 182

Fig. 23 *Zizania aquatica*..... 183

Fig. 24 *Phragmites communis* var. *Berlandieri*..... 184

Fig. 25 *Scirpus fluviatilis*..... 185

Fig. 26 *Scirpus americanus*..... 186

Fig. 27 *Scirpus* spp. (*S. acutus*, *S. validus*)..... 187

Fig. 28 *Typha angustifolia*..... 188

Fig. 29 *Typha glauca*..... 189

Fig. 30 *Typha latifolia*..... 190

Fig. 31 *Cephalanthus occidentalis*..... 191

Table 12 Species of Plants and Their Ecological Distribution, Pte. Mouillée State Game Area.. 192

Table 13 Vertebrates Observed on Pte. Mouillée State Game Area, 1947 - 1949..... 220

Table 14 Extent of Cover Types in Mouillée District, 1944 - 1949..... 234

Table 15 Shifts in Cover, 1944 to 1947, Mouillée District..... 236

Table 16 Shifts in Cover, 1944 to 1949, Mouillée District..... 237

Table 17 Species of Insects Reported from *Typha* in the United States..... 238

Cover Maps, Mouillée District, 1944, 1947, 1949.....Inserts

INTRODUCTION

In 1946 it became apparent to men interested in waterfowl and marshes that a drastic change was taking place in the marshes of Lake Erie and Lake Huron. Large expanses of cat-tail (Typha) had abruptly died, transforming marsh lands into open water. In the early spring of 1947 these lands stood black and bare, as if blasted by fire. Scattered over the barren flats the muskrat houses were revealed unscreened; all remaining cover had been used in their construction. It was feared that this change might continue and completely destroy the marshes.

The Michigan Department of Conservation had just purchased the Pointe Mouillée State Game Area as a public hunting ground for waterfowl on Lake Erie. A large portion of the marsh had been destroyed by this die-off and made useless for waterfowl hunting. It was decided that information must be obtained concerning the cause of this condition and control measures determined if possible.

The die-off had occurred along the southern shore of Lake Erie from the mouth of the Detroit River at least as far east as Cleveland, and had also appeared in marshes of Lake St. Clair and Saginaw Bay of Lake Huron. It was believed that the information desired could be gained most readily by intensive observation of one area, using surveys of other marshes to verify or check any conclusions that might be reached. The Pointe Mouillée State Game Area was chosen for this intensive investigation, since it was readily accessible, with local facilities for living and working, and some

information was already available about the marsh.

Intensive studies were made by the author during the summers of 1947, 1948, and 1949. Each year from the middle of June to the middle of September, several days each week were spent in observation. Additional visits to the marsh were made during the rest of the year at approximately two-week intervals. All possible information concerning the marsh as an environment was obtained. Detailed notes were kept on all wildlife seen and records were made of the condition of the cat-tail, water levels, and other important points. When it was discovered that the die-off had ended by the time the study was started, the purpose of the investigation was broadened to include the total ecology of the marsh, with special attention to the successional changes in vegetation.

In 1947 emphasis was placed on a careful search for possible biological causes of the die-off, including fungus disease and insect damage. The insects of cat-tail at Pointe Mouillée and around Ann Arbor were studied and their life histories observed. Normal and abnormal appearing cat-tail tissue was studied in microscopic sections. A systematic attempt was made to secure material from plants in the process of dying, but this was fruitless. A large part of the summer was taken up in learning the intricacies of the marsh channels and trying to determine previous conditions of vegetation. The latter study was not completed until 1949, when lowered water levels exposed a large part of the soil surface.

During 1948 and 1949 the ecology of the marsh was studied in more detail, and the successional stages were

closely followed. The changes occurring as a result of the die-off and their relation to the water level were particularly noted. The differences in growth and response to the environment between the species of cat-tail were recorded.

Except for the investigations of cat-tail tissues and insect life histories, all observations were made in the field. Growth rates, rates of spread, tolerances to water levels and soils, and differences between species of cat-tail were observed in the field but not checked by experimentation. Repeated measurements of growth and spread were made at marked locations and transects. Photographs were taken each year from camera stations and from the air, The great difficulty, at times the impossibility, of traversing the marsh prevented the procuring of certain desired data, particularly information from large numbers of quadrats. In a considerable portion of the marsh winter ice floes remove all types of markers so that some stations could not be marked.

A cover map was made in 1947 by triangulation, using aerial photographs of the Soil Conservation Service as a base map. Changes were marked each year and a new cover map drawn in 1949. New aerial photographs of the entire region were made in 1949 by the Detroit-Edison Company, and these were used to check the cover maps. Acreage was determined from these maps by means of a planimeter. The area studied included not only the State Game Area but a wide belt of land behind it, making a total of about 4200 acres. This total study area is referred to as the "Mouillée District" in the following pages.

Gray's Manual of Botany, Eighth Edition (Fernald, 1950), has been used as a guide in botanical nomenclature. Identifications were made by the author. Specimens of ninety-five per cent of the species mentioned have been placed in the herbaria of the University of Michigan and Michigan State College. A list of all species found is given in the appendix.

The form designated by Hotchkiss and Dozier (1949) as Typha glauca and so listed by Fernald (1950) is prominent in this marsh and has distinct characters; so, for convenience, that name has been used throughout this paper, although there may be a question as to the correct taxonomic status of this form. Characteristics are as given in the first-cited paper, with some differences in extremes of certain gross measurements.

A complete list of vertebrates seen in the marsh is given in the appendix. Identification is based on recent manuals, particularly Burt (1946), Peterson (1947), Wright and Wright (1949), and Hubbs and Lagler (1947).

CHAPTER I

DESCRIPTION OF AREA

Pointe Mouillée State Game Area is a marsh of 2609 acres, roughly three miles long by one and a half miles wide, situated just below the mouth of the Detroit River (Figure 1). The Huron River winds across one end for a distance of one and three-fourths miles, and the east and south sides of the marsh are bordered by Lake Erie, with a total shore line of four and one half miles. A narrow ridge of sand runs between the lake and the marsh, while the inner side is bordered by low farmlands and wet meadows. The marsh is traversed by a number of channels, which widen out into a bay on the south, opening into the lake. Several small creeks, Mouillée Creek, Bad Creek, and Bondy Creek or Lautenschlager Drain, flow into the marsh on the west side. The water level in the marsh is the same as that in Lake Erie and varies with changes in the lake level. Several islands occur in the northern part of the marsh, rising from three to six feet above its surface. Pointe Mouillée is a French name meaning "Wet Point," and was applied to the point at least as early as 1749 (Karpinsky, 1931). "Dead Man's Point" is a more recent appellation for nearly the same projection, applied because the currents setting in from the Detroit River occasionally bring in bodies.

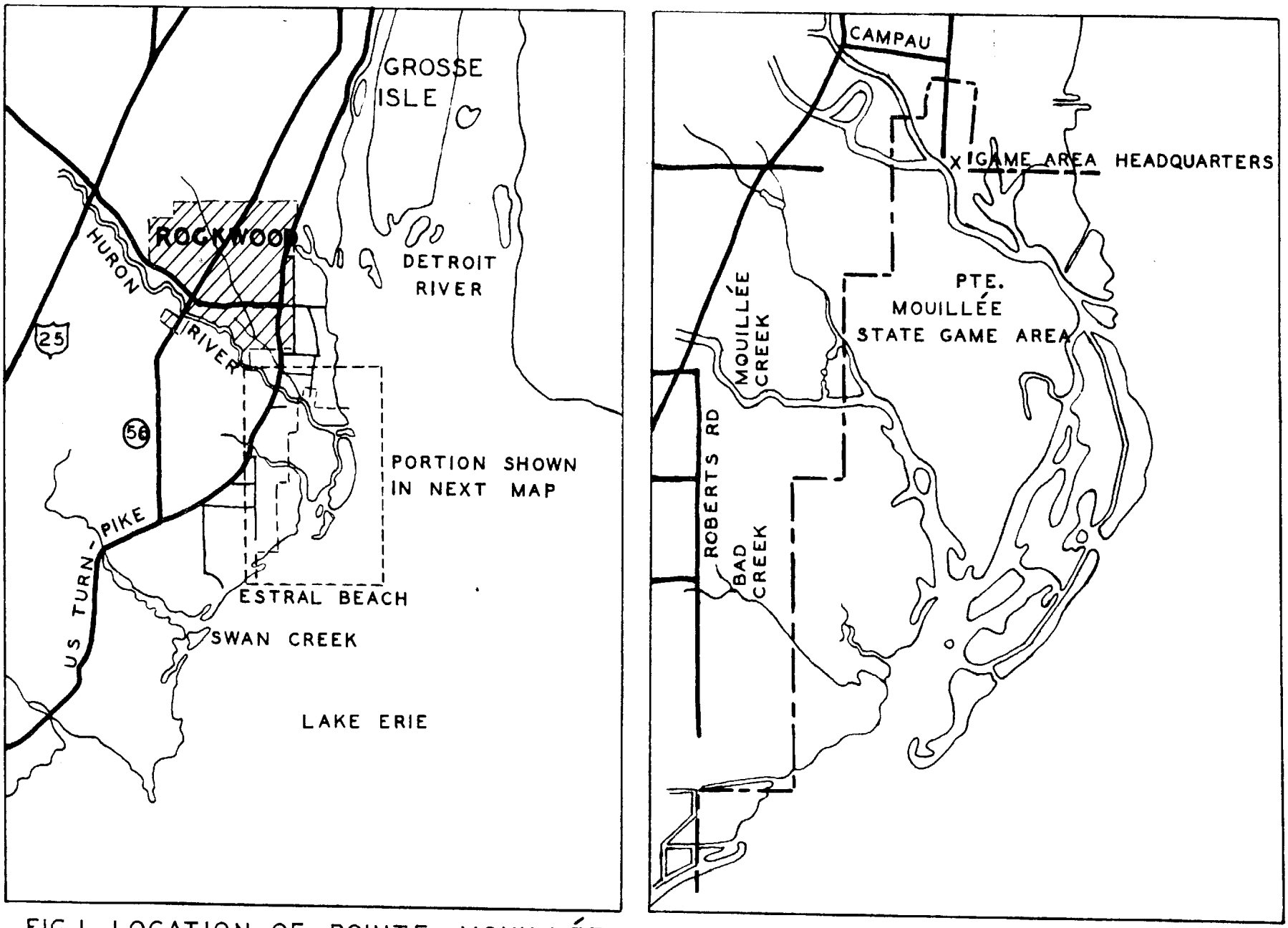


FIG. 1 LOCATION OF POINTE MOUILLÉE STATE GAME AREA

Geology

The geology of the general region has been fully discussed by Sherzer (1900, 1917) and Leverett and Taylor (1915). The development of the drainage pattern of the Huron River was described by Bay (1938). However, no detailed observations have been recorded concerning the portion of the State Game Area south of the Huron River.

The Mouillée District is a part of the Huron-Erie Plain, formed by lacustrine clays laid down during the later stages of the Wisconsin glacial period (Sherzer, 1917). While the glacier was receding, the area was covered by a series of lake stages, and deposits of fine clays resulted. The surface of these clays is not even, but is in undulations or ridges, the higher of which form the islands which now rise above the level of the marsh. These ridges in general run from northwest to southeast and probably represent ridges between early distributaries of the Detroit River, such as those described north of the area (Leverett and Taylor, 1915). As the lake declined in size and level, the Huron River extended its mouth across the newly exposed land, forming the channel it now fills. At two of the later stages the level of Lake Erie was considerably lower than at present. During that time the Huron River eroded its channel nearly to base level and meandered at its mouth. Later Lake Erie rose and the mouth of the river was drowned for four miles upriver (Sherzer, 1900). The sand of the present barrier beach comes from a submerged beach lying offshore, formed at the time of the lower stage of the lake (Leverett and Taylor, 1915).

Plate 1



Pte. Mouillée State Game Area, looking down Huron River, 1947. Headquarters area in foreground.

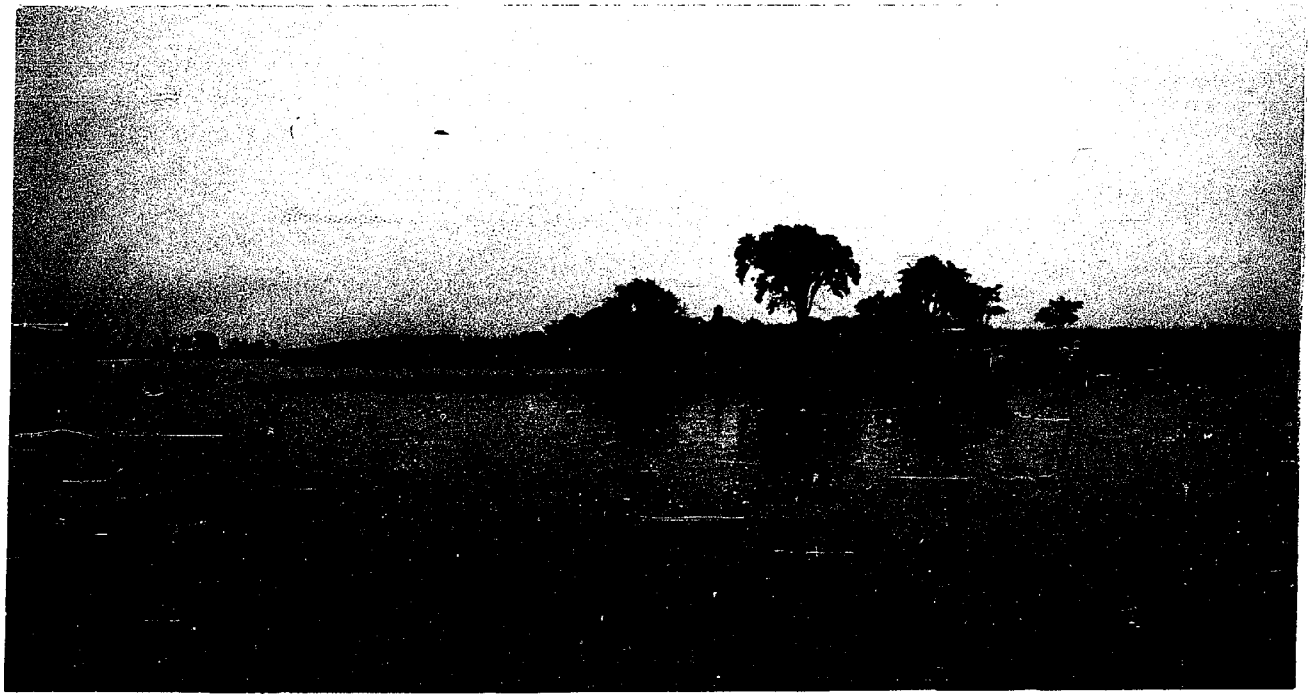


Pte. Mouillée State Game Area from lake, 1949. The canal formerly continued along present position of beach.

Plate 2



Willow tree on one of the permanent islands.



Clark Island. This is the largest of the permanent islands.

The Mouillée marsh was apparently formed by this rise in lake level. The Huron River winds through the area with little or no current most of the time, although its channel is reported to be twenty-five feet deep in places. Mouillée Creek was also drowned, and its old channel can be traced across the now open bay and through a gap in the barrier beach into the lake. The barrier beach built up by the lake reaches two feet above the present water level, and is as much as fifty yards wide in places.

A progressive deepening of the south side of Lake Erie is occurring due to an earth-tilt effect (Moseley, 1904; Taylor, 1927). The northern part of the lake including the Niagara River outlet is slowly rising and consequently damming the waters of Lake Erie and tilting the lake against the south side. For western Lake Erie the resultant rise has been calculated at rates varying from 2.14 feet per century (Moseley, 1904) to 0.75-1.00 feet per century (Freeman, 1926; White, 1944). It has had considerable effect on the south shore of the lake, because of the nonresistant structure of the soil.

Soils

This region is included in the general discussion of the soils of Michigan by Veatch (1933a). The soils of the Mouillée District were mapped in detail by the Game Division of the Michigan Department of Conservation in 1944 (Figure 2). The marsh lies in two of the land types of Michigan, the Lake Bed Clay Plains Type and the Lake Shore Type (Veatch, 1933a).

Seven soil types are shown in the Mouillée District (Figure 2), of which two are very minor. The farmland on the inner side of the marsh consists of Brookston and Conover clay loams, fertile dark-colored soils underlain by clay. The original cover on these soils was hardwood forest, which is now represented by a few woodlots. Several islands in the marsh are also covered by Conover clay loam. Bordering these soils is a band of Clyde clay, with a much higher percentage of organic matter (sometimes even mucky) at the surface, underlain by clay; the original cover was hardwood forest or sedges and grasses. This clay also forms a band along the lake shore. The central area of the marsh is Houghton muck, dark brown fibrous peat and muck, with a cover now largely of cat-tail (Typha). The river is bordered by Griffin silty clay, an alluvial soil. On the river bank near the Game Area Headquarters there is a patch of Berrien loamy fine sand. The sand ridge along the beach consists of Eastport fine sand, loose sand containing large numbers of shells.

Water Level Fluctuations

The levels of the Great Lakes are measured by the U. S. Lake Survey and published in the form of mean monthly levels for each lake (U. S. Lake Survey, 1950). Seiches in Lake Erie have been studied by Hayford (1922) and Chandler (1944), while small oscillations were studied by Krecker (1928).

As stated before, the level of water in the marsh is the same as that in Lake Erie. The lake level has an annual fluctuation averaging 1.55 feet in the past fifty years,

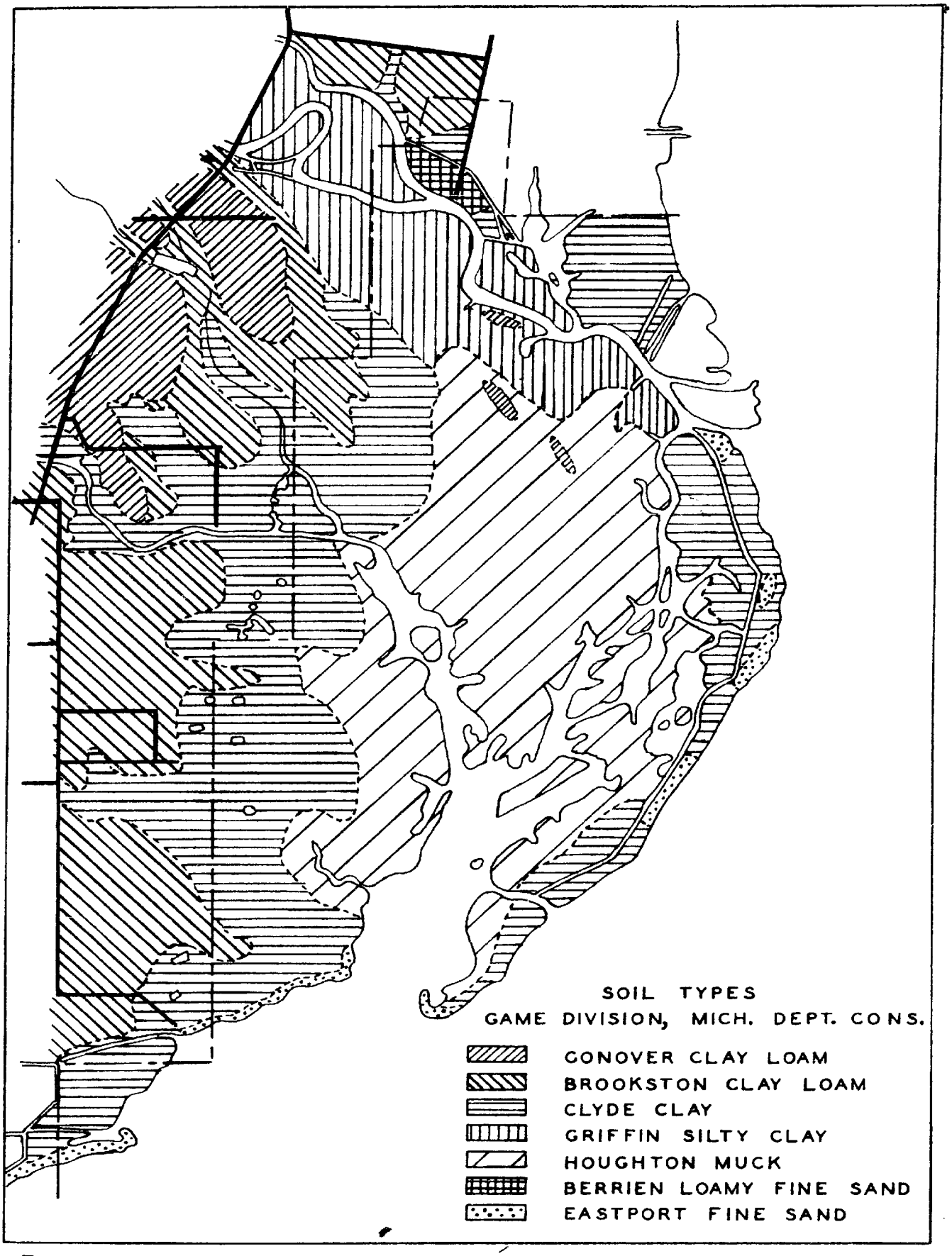
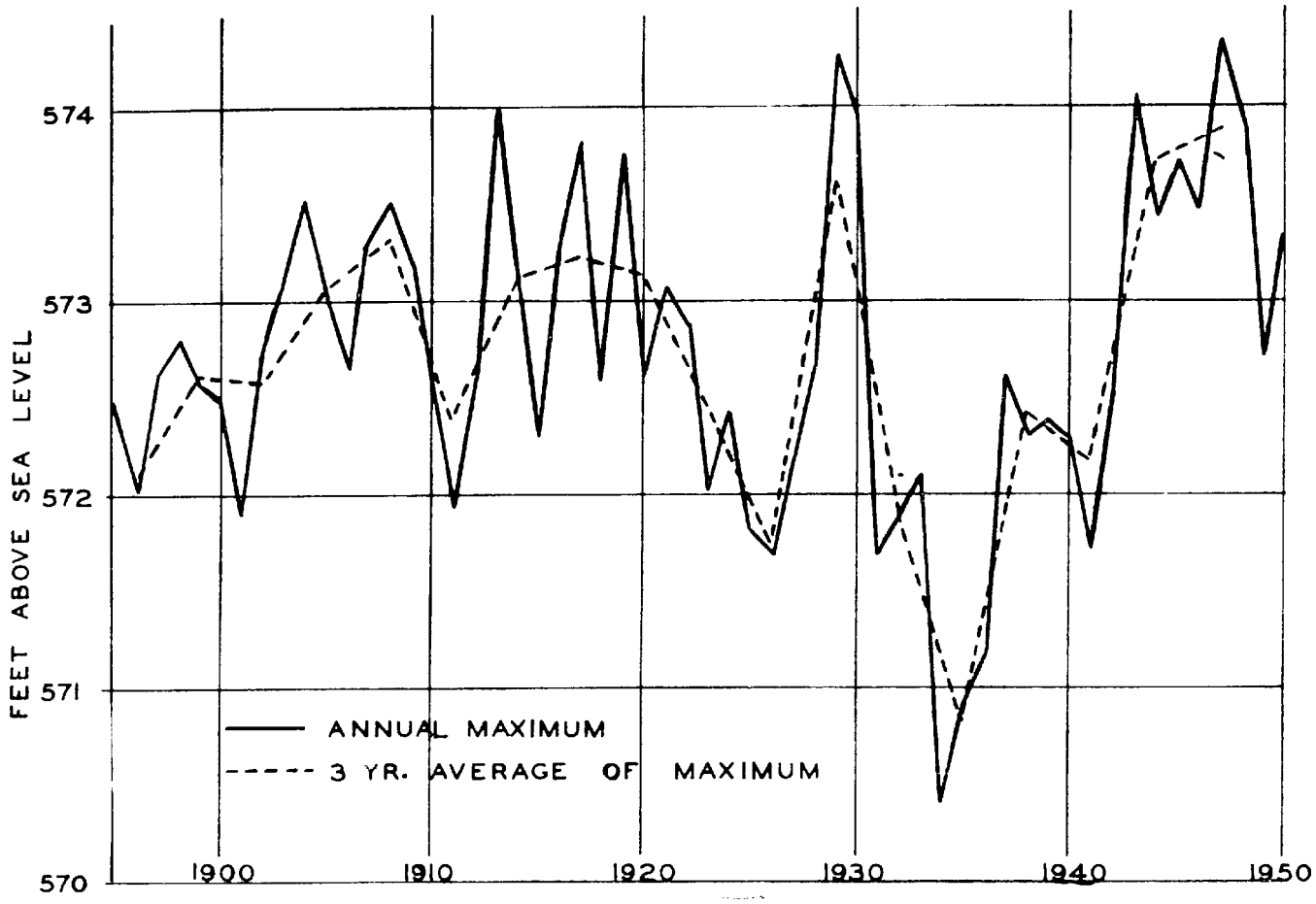


FIG. 2 SOIL MAP OF MOUILLÉE DISTRICT

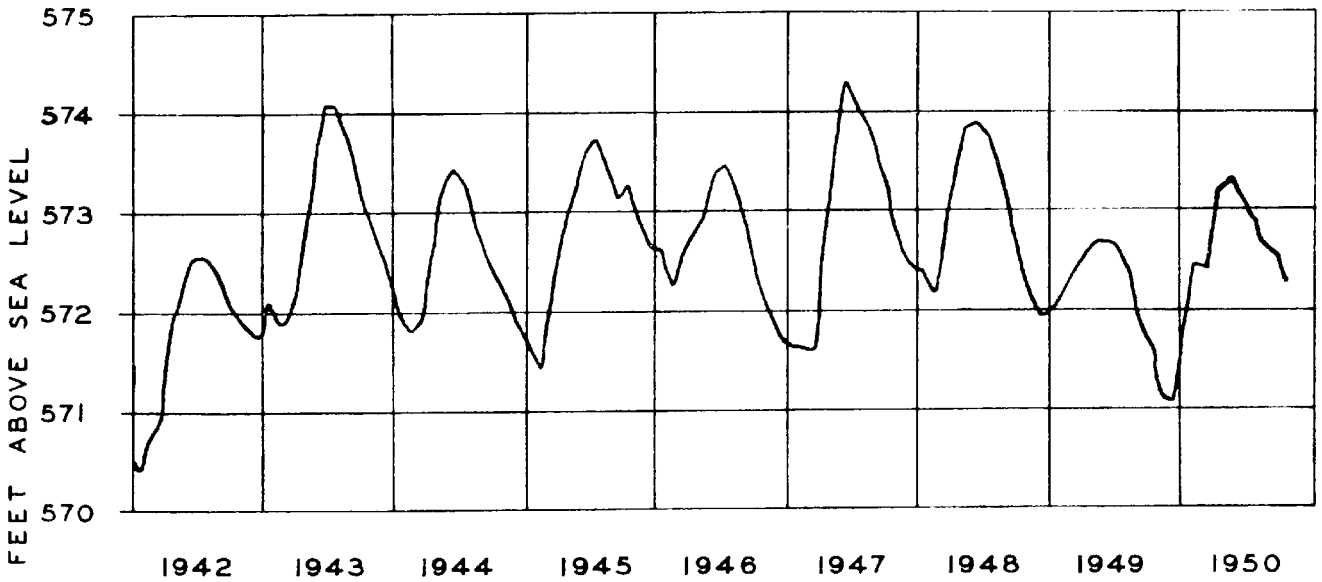
reaching its lowest point in February or March and the highest point in June. The least annual fluctuation was 0.64 feet in 1941 and the greatest was 2.75 feet in 1947 (Figure 3). Since 1860, when the Lake Survey started recording levels adjusted to a known base level, the minimum record of the level of Lake Erie is 569.4 feet above sea level (February, 1936), and the maximum is 574.52 feet (June, 1876). The level in June, 1947, is the second highest recorded, 574.33 feet above sea level (U. S. Lake Survey, 1950). In 1838 the level is supposed to have reached 575.11 feet (Freeman, 1926). These are monthly means; much greater extremes are reached for short periods.

The level of Lake Erie and the other Great Lakes fluctuates considerably over a period of years (Figure 3). After an extreme high in 1929, the annual maximum in Lake Erie fell to an extreme low in the drought year of 1934. Then it rose approximately 1.75 feet for the period 1937-1942, rose again 1.75-2.00 feet for the period 1943-1948, and declined 1.25 feet in 1949. Musham (1943) detected a cycle of maxima of 21-23 years, with two intermediate highs in the tenth and fifteenth years. After the maximum in 1929, according to this theory, highs would have occurred in 1939, 1944, and then in 1952; lows would have occurred in 1936-37, 1940-41, and 1947-48. Instead, highs occurred in 1933, 1937, 1943, and 1947; lows occurred in 1934, 1941, and perhaps in 1949 (U. S. Lake Survey, 1950). Billings (1949) states that the only consistency evident is the absence of regularity.

There are many oscillations of level, occurring



A. ANNUAL MAXIMUM MONTHLY MEAN LEVEL



B. MONTHLY MEAN WATER LEVEL

FIG. 3 CLIMATIC FLUCTUATIONS IN LAKE ERIE WATER LEVELS (U.S. LAKE SURVEY, 1950)

primarily about sixty minutes and eighteen minutes apart, with magnitudes of one-half inch to eight inches (Figure 4). Tidal oscillations of about four inches occur in twelve-hour periods (Krecker, 1928). The seiches at Cleveland have periods of 3.7 hours and 13.1 hours (Hayford, 1922), and those of western Lake Erie, which is independent of the rest of the lake, have periods of 2.6 hours and 14.2 hours (Chandler, 1944). Indications are that those at Pointe Mouillée are of approximately this length (Figure 5). The smaller oscillations are suppressed up the Huron River, so that not as many fluctuations are recorded at the Pointe Mouillée State Game Area Headquarters as in the marsh away from the river (compare Figures 4 and 5).

TABLE 1

NUMBER OF SEICHES OVER 0.5 FEET AT PUT-IN-BAY, OHIO, 1941
(Chandler, 1944)

Amplitude in feet	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
0.50-0.75	7	48	33	45	64	26	29	17	14	283
0.76-1.00	..	8	12	14	11	12	22	11	12	102
1.01-1.25	..	1	1	1	3	5	5	7	11	34
1.26-1.50	..	..	1	..	..	..	9	5	5	20
1.51-2.00	..	1	..	1	..	4	5	3	2	16
2.01-5.00	..	..	..	..	..	4	4	3	7	18
Total	7	58	47	61	78	51	74	46	51	473

The larger seiches are invariably wind-produced, and each is accompanied by a rise in turbidity (Chandler, 1944). At Put-in-Bay, Ohio, in 1941, 473 seiches over 0.5 feet in

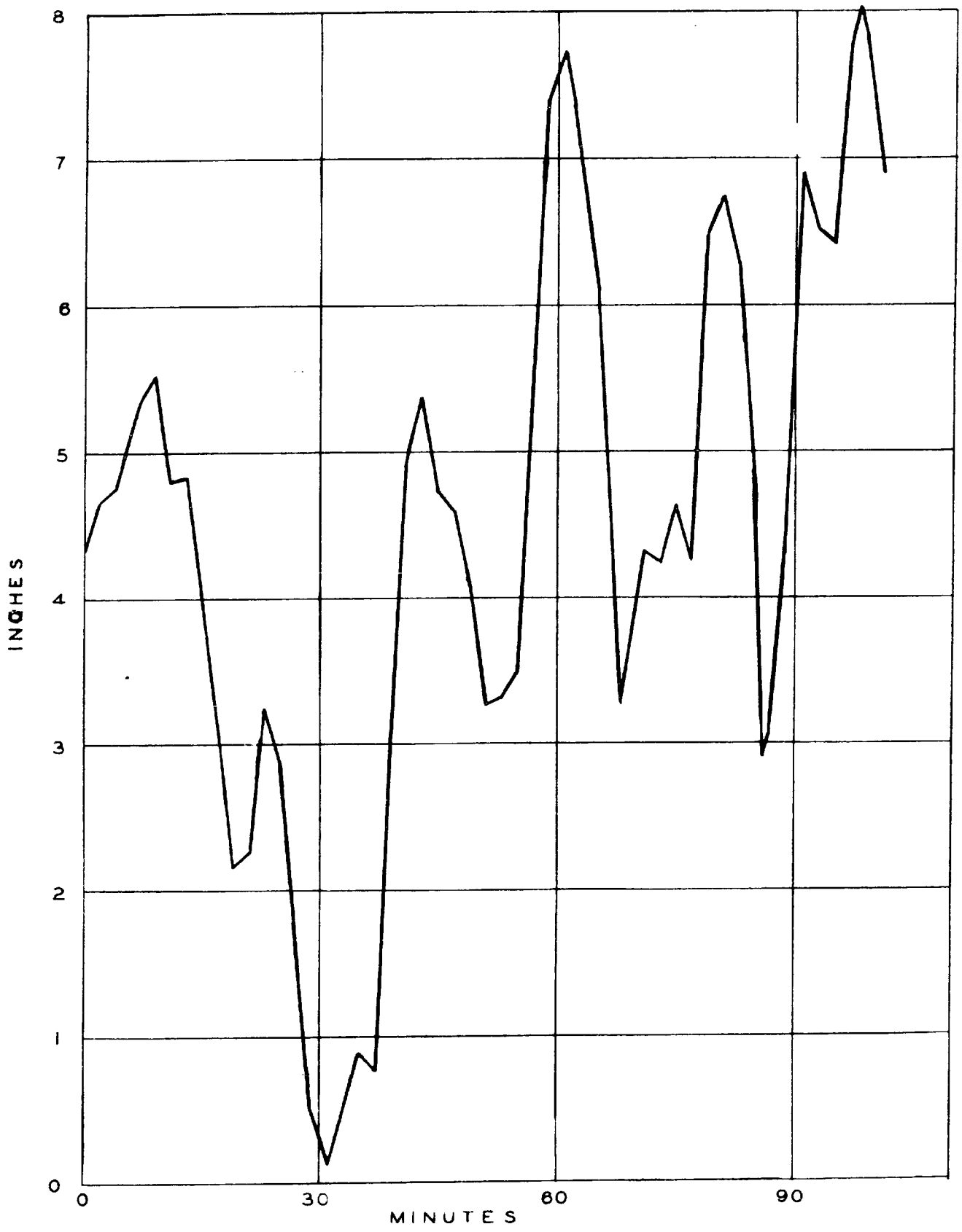


FIG. 4 OSCILLATIONS IN WATER LEVEL, AUG. 2, 1947
MOUILLÉE MARSH

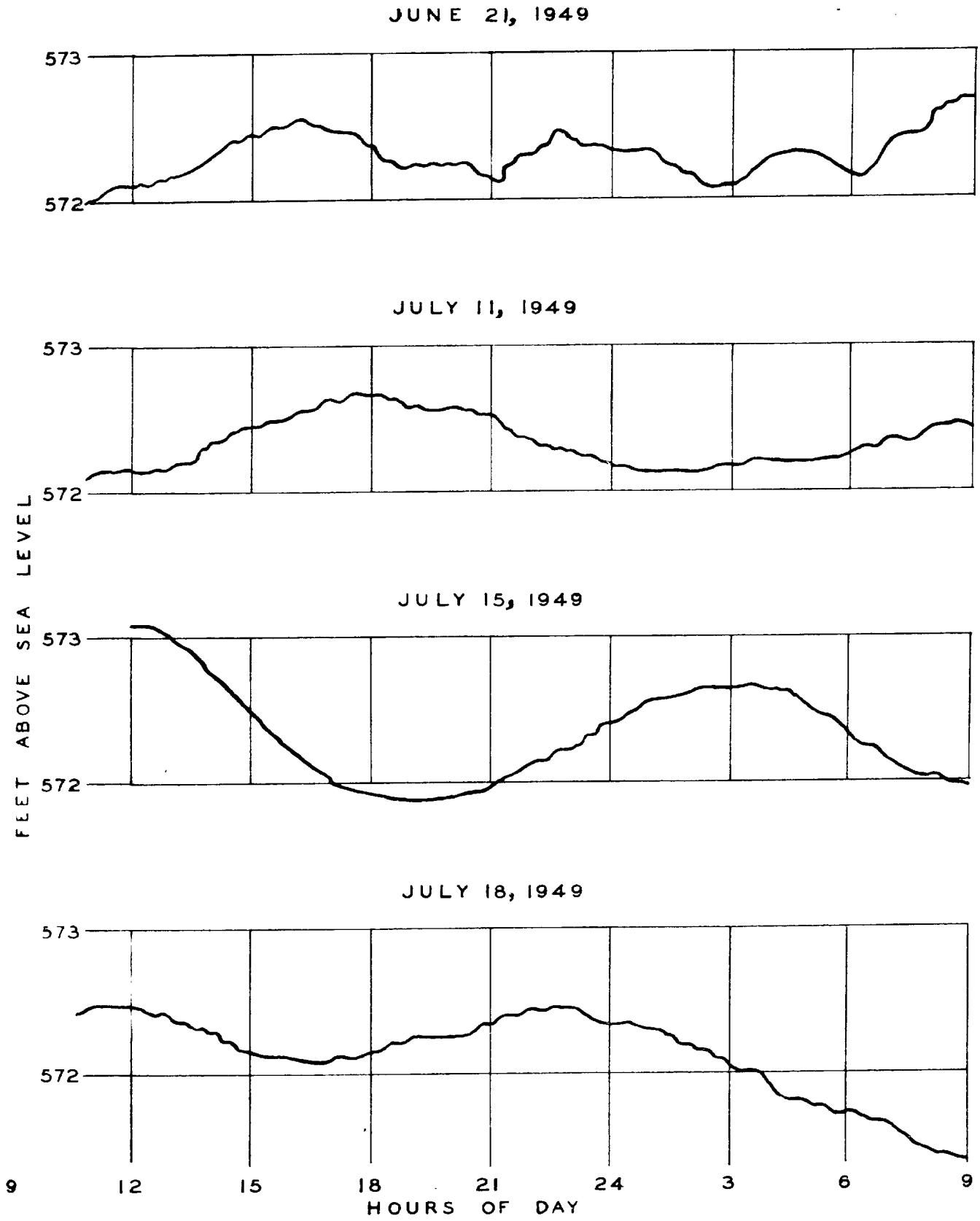


FIG. 5 OSCILLATIONS IN WATER LEVEL DURING 24 HOURS, MOUILLÉE HEADQUARTERS

amplitude were recorded (Chandler, 1944); their distribution is shown in Table 1. The amplitude of all seiches varied from 0.2 to 4.8 feet. In 1942, 614 seiches were recorded at Put-in-Bay over 0.5 feet in amplitude (Chandler and Weeks, (1945). There were 374 of 0.5-0.75 feet, 156 of 0.76-1.0, 27 of 1.01-1.25, 17 Of 1.26-1.50, 23 of 1.51-2.0, and 17 with amplitudes between 2.01 feet and 6.0 feet. The maximum amplitude was 5.9 feet.

The seasonal fluctuation results in a low level of water in the marsh in winter and a high level in summer. The minor oscillations produce reversing currents in the channels, suspension of materials in the water, changes of exposure of shallows, mixture of marsh and lake water, and probably greater deposition of materials. The large seiches combined with strong winds result either in severe wave action or exposure of aquatic vegetation to wind action during a period when water support is lacking. During periods of low water the current in the Huron River becomes much stronger, and the channels leading from the marsh have strong currents which erode the bottom. Birds nesting in the marsh or vicinity experience rises of water amounting to at least two feet every year.

The high water of 1943-1948 killed many trees on the barrier beach, and the lake broke through the beach in eight places in 1946 and 1947. The beach was partly destroyed and pushed inland, with a broad delta of sand washing into the marsh at every break-through, covering the muck. Many of the dead trees are now standing or lying in water one to three feet deep, as much as two hundred feet from shore. The high

Plate 3



Sheets of ice carrying soil lifted from the marsh. Storm waters lifted this ice with eight inches of soil and swept it inland.



Dead trees along barrier beach.

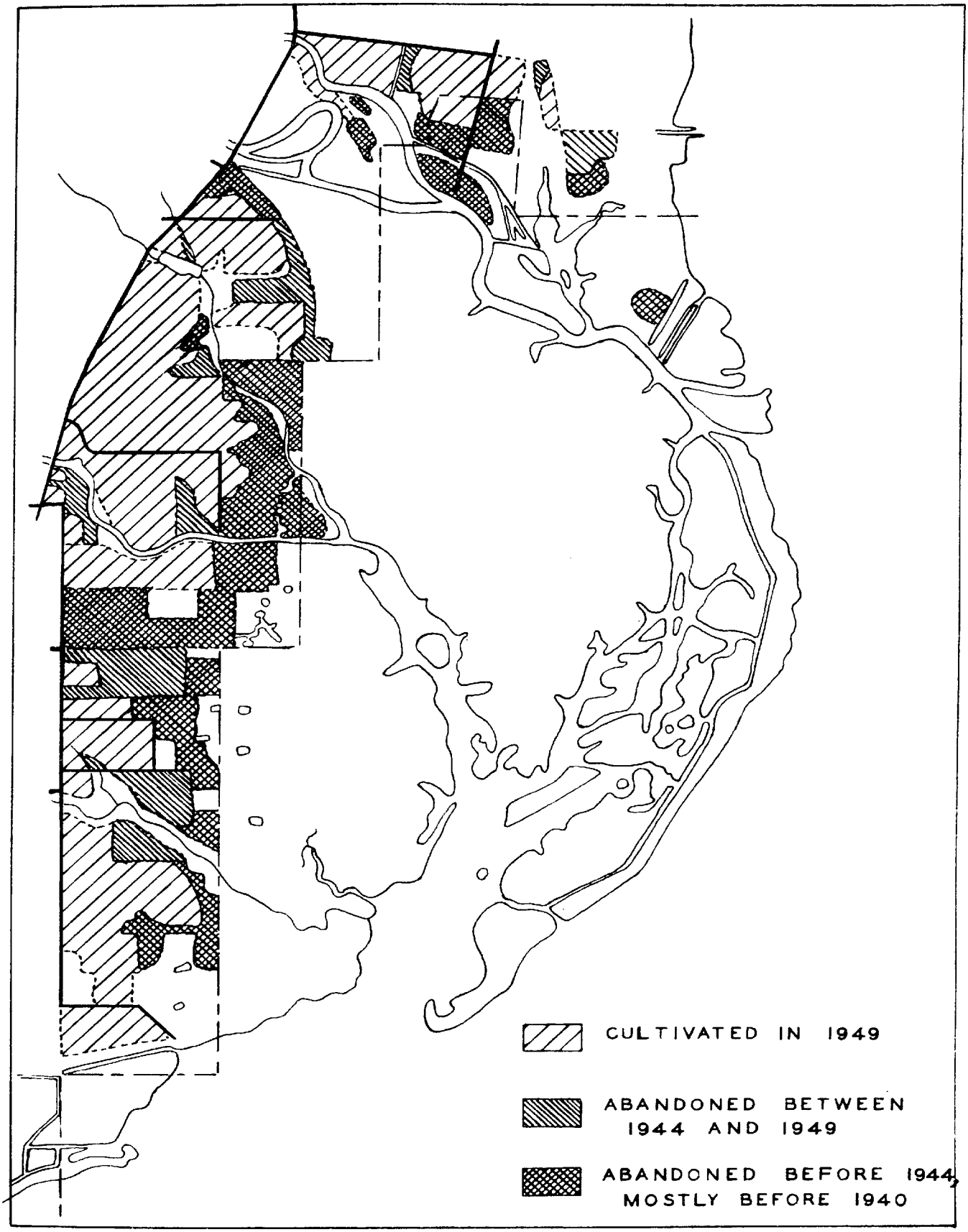


FIG. 6 PROGRESSION OF ABANDONMENT OF CULTIVATED LAND, MOUILLÉE DISTRICT

water also resulted in extension of the marsh inland, and invasion of wet meadow by cat-tail. A belt of farmland adjacent to the Game Area has been abandoned to the marsh (Figure 6). This land has been made unfit for cultivation both by the cyclic rise of the water level and by the rise due to the geological tilting.

During periods of low water the marsh declines in extent. In the summer of 1934 water was present only in a few deep channels and in the bay; the flats were one to three feet above water level. Grasses and sedges extended their range toward the lake and part of the marsh was used for grazing. Fields were cultivated which must be left fallow in wet years. Fences erected at some previous time were standing in one to three feet of water in 1947.

Physical and Chemical Conditions of the Water

The following data for the chemical and physical conditions of the waters of western Lake Erie, from which comes much of the water in the marsh, are given in a series of papers from the Put-in-Bay biological station in Ohio (Chandler, 1940, 1942, 1944; Chandler and Weeks, 1945). Dissolved oxygen varies from five to eight parts per million in late summer to about fourteen p.p.m. in late spring. The pH ranges from 7.5 to 8.5; it is below 8.0 from November to May and 8.0 or above from May to November. Carbon dioxide is present only in winter, when it reaches a concentration of four p.p.m. Carbonates are absent in the winter but in the summer reach a concentration of five p.p.m. Bicarbonates occur in a concentration of about

eighty-five to ninety p.p.m. Temperature at the surface ranges from 32° F. in the winter to about 75° F. in late summer.

No studies were made by the author of the chemical conditions of the water in the Mouillée marsh. Temperatures up to 104° F. were measured in very shallow water in July, 1949. A few observations in midsummer gave pH 8.0 for the water in the open bay and pH 7.8 for water at the head of Mouillee Creek. The portion of the marsh north of Clark Island, which receives water from the Huron River, has water with greater turbidity than that of the southern portion, which receives water mostly from the lake. Exceptions occur when heavy rains cause large amounts of water to come down Mouillée Creek and Bad Creek and make the bay turbid.

Control of aquatic vegetation in the Illinois River lakes by turbidity is described by Bellrose (1941). The factors causing such turbidity included winds, floods, fish, and pollution. According to Chamberlain's observations (Chamberlain, 1948) growth of aquatic plants starts later on a silt bottom than on a sand bottom, and the turbidity over a silt bottom is never reduced sufficiently to permit growth of plants at depths greater than 5.5 feet. In very clear water the amount of photosynthesis was 35 per cent at 19.5 feet and 6 per cent at 32.5 feet, while in maximum turbid water it was reduced to 11 per cent at 3 feet (Meyer and Heritage, 1941).

In the Mouillée marsh the submerged soil is mostly muck. Clay bottom is exposed in the deeper channels and sand occurs on the areas affected by wave action from Lake Erie.

The water is very turbid in the spring but clears up to a depth of four feet in the summer. No difference was observed in the time of development of vegetation over sand or muck. Vallisneria grew in eight feet of water on a clay bottom.

Climate

As this section of the state lies in the pathway of the storms that sweep across the Lake States, the weather is characterized by frequent and rapid changes. Since the area is near the southern edge of Michigan, it has a warmer climate than does the state as a whole. The presence of the lake also modifies the local climate so that temperatures tend to be less extreme than at points thirty miles inland, and the frost-free season tends to be a little longer (U. S. Weather Bureau, 1936). The frequent changes of water level in the lake delay or prevent the formation of solid ice over the marsh in the winter. Frequently several layers of thin ice are formed, with air spaces in between.

The following climatological data were collected at Monroe, Michigan, and published by the U. S. Weather Bureau (1936, 1931-1950). The mean annual precipitation of 30.71 inches is distributed fairly evenly throughout the year. Fifty-eight per cent of the precipitation occurs during the months from April to September, inclusive. The average period between killing frosts is 169 days, from April 28 to October 14, but killing frosts have occurred as late as May 31 and as early as September 23. Snowfall averages 28.2 inches per year, the greatest snowfall occurring in January.

The mean annual temperature is 50° F., and the extremes are 106° and -21°. The prevailing wind is southwest. Snow is apt to be melted by warm or rainy weather so that the ground is usually bare for a part of each winter.

Climate During Period of Study

During the period 1947-1950 the climate has shown much variation (Figure 7). In 1947 the spring and early summer were cooler and late summer was much warmer than average. Precipitation was very high in the spring and again in late summer. A very severe northwest storm occurred in September. The first frost was recorded on October 1, the total frost-free season (146 days) being much shorter than normal (169 days). Ice formation over the marsh was delayed until December; then an extremely severe storm on January 1, 1948, raised the water beyond all remembered levels and broke up the ice, forcing large floes inland and raising a high ridge of cracked ice on the beach. Temperatures below zero soon resulted in a new layer of solid ice, which remained until heavy rains caused its destruction early in March. Snow covered the ground from December to March.

The early spring of 1948 was above normal in temperature, the last frost occurring on April 17, but the rest of the year was very near average. Rainfall was high till midsummer, then below average during the fall, and high in the winter. The first frost in the fall came on October 17, stopping the frost-free season at 184 days. Temperatures were above normal during the winter of 1948-1949 and no strong ice

TABLE 2

CLIMATIC SUMMARY, MONROE, MICHIGAN[a] (U. S. Weather Bureau, 1936, 1931-1950)

	Temperature in degrees F.			Precipitation in inches			Snowfall, inches
	Monthly mean	Maximum	Minimum	Monthly mean	Maximum	Minimum	Monthly mean
Jan.	25.7	70	-16	1.75	4.63	0.22	9.7
Feb.	28.1	70	-21	1.49	3.86	0.35	5.3
Mar.	36.7	83	-2	2.45	5.09	0.85	3.3
Apr.	46.1	91	13	3.14	7.27	0.66	1.6
May	58.8	95	28	3.03	9.29	0.57	0.1
June	69.4	104	35	3.50	6.63	1.21	...
July	73.9	106	35	2.68	8.46	0.76	...
Aug.	72.1	103	38	2.78	6.37	0.74	...
Sep.	65.5	103	27	3.17	6.56	0.98	...
Oct.	53.2	92	22	2.27	5.53	0.31	0.2
Nov.	40.3	79	1	2.09	6.04	0.55	1.8
Dec.	29.5	64	-11	1.97	4.11	0.43	6.2
Annual mean	50.0			30.71	41.41[b]	20.97[b]	28.2

[a]Thirty-four year record.

[b]Annual extremes, not means.



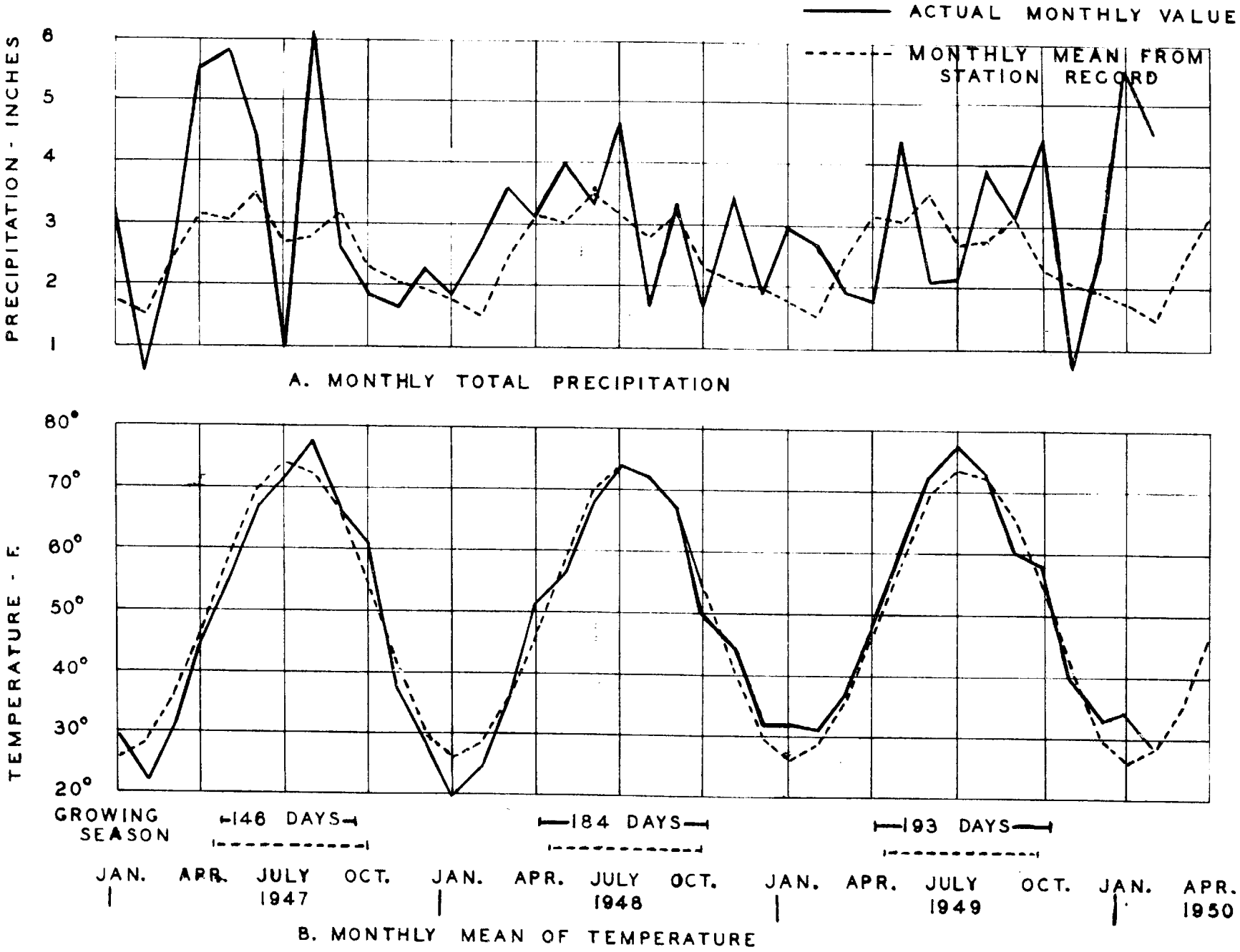


FIG. 7 MONTHLY MEANS OF PRECIPITATION AND TEMPERATURE, MONROE, MICH

sheet was formed over the marsh. The ground was bare of snow most of the winter.

Temperatures were again above average in the spring of 1949; the last frost occurred on April 17. The summer was hot, and the fall was warmer than usual. Rainfall was low in the spring and summer but high in the fall. The first frost came on October 27, ending the frost-free season at 193 days. The winter temperatures were above normal. Only thin ice formed at first and this was almost entirely removed by warm weather and heavy rains in late January of 1950. Cold weather in February froze the marsh solid for about a month, but it opened in March. The ground was bare of snow most of the winter, except during the cold period.

History of Exploitation

The first white explorers reached this locality in the late 1600's. In their journals they emphasized the large amount of game in the region, mentioning particularly the Monroe marshes, which are twelve miles away from this area. They described groups of swans so thick that they resembled patches of white water lilies, and one quotes an Indian guide as saying that the waterfowl had to line up in order to make room for their canoes to pass by (Bulkley, 1913). Undoubtedly the same conditions were true of the Mouillée marsh.

By 1725 the French were well acquainted with the Lake Erie marshes below Detroit and most of the place names were established. Many of these have either been retained or translated into the English equivalent--Riviere aux Hurons (Huron

River), Pointe Mouillée, Riviere aux Signes (Swan Creek), Pointe aux Peaux, Pointe aux Roches (Stony Point), et cetera. A way of life based on exploitation of the lake and marshes was developed by a group of people, mainly of French descent; and this group persisted up to recent times. The individuals lived in cabins on the islands and beaches, and traveled by canoe or punt through the marsh channels, portaging across the narrow beaches.

Some of the men became market hunters, and others acted as guides and punters for the city sportsmen. Beginning about 1850, sportsmen began forming private clubs, to obtain exclusive shooting or "feather" rights to private marshes. At the same time, following a legislative act in 1869, fishing firms began buying up lake shore property in order to secure the fishing rights in the adjacent waters. These two activities gave the first real value to marsh land. The marsh men fitted easily into these pursuits.

Shortly after 1869 a commercial fishery firm of Erie, Michigan, bought most of the shore line area (350 acres) of the Mouillée marsh and established the Pointe Mouillée Fishery (Bulkley, 1913). The first purchase of land by sportsmen (about 1200 acres) was made in 1875 (Barbour, 1940). The two men involved organized a club in 1876, and in 1879 it was reorganized under the name of the Pointe Mouillée Shooting Club, a name which was retained until the state bought the marsh in 1945. Additional purchases of land were made by the club from time to time; these included the land owned by the fishery concern. The club had ten members, and the initial

membership fee was $75. In 1882 a membership was sold for $1000 (Barbour, 1940). In 1945 the state paid $195,000 for the property, an average of $75 per acre or $19,500 per club share.

Thirty buildings (cabins, recreation hall, and boat-houses) were constructed by the club on a section of the barrier beach, and a small farmstead and garden were maintained. The club area was landscaped into a lawn, and piling was erected in front to protect it from the lake. Three cabins were built on high ground at the mouth of the river. The fields in the vicinity of the boat landing, now headquarters for the State Game Area, were farmed until the state bought the land. Two other small pieces of the club property were farmed sometime in the past (Figure 6).

Several physical changes in the marsh resulted from the club's management program. A canal was dredged behind the barrier beach from the Huron River to Mouillée Creek, and one channel into the lake, Ruddy Creek, was closed. A breakthrough occurred near this creek some years ago and was repaired, but the lake broke through again in 1942 or 1943. A number of channels were cleaned out each summer by hand, the men pulling up the vegetation and throwing it aside (Barbour, 1940). Most of these channels have since become permanent. Some stands of cat-tail blocking the main channel were removed by mowing. Three pond holes were dug out by hand on the inner side of the marsh, and water gates were built on Bad Creek and another water passage to retard drainage in dry years. On the north side of the river several canals were dug and used as carp ponds;

the carp were confined in them and fattened for the market. Fires in the peat are reported to have burned down to the clay during a dry summer forming several ponds (Barbour, 1940); one of these is known locally as the "Fire Hole."

Use of the marsh was confined mostly to the fall. A limited amount of fishing, particularly carp seining, was done in the summer, but in late summer the area was closed until the hunting season. Although no exact record of the kill from the marsh is available, the name "One Hundred and Twelve Pond," given after a bag of 112 ducks in two hours, may be indicative. Another bag of ninety-six was described to the author by a former punter. Mention has been made of eighty-five sora, seven yellowlegs, six coot, and fifteen perch being used in one day for food (Barbour, 1940). Baiting with grain was done extensively for both geese and ducks. Every year a "Coot Roundup" was held when the coots, which were not hunted by the club members, were driven into one great flock and as many as possible killed by the punters, in order to save the grain bait for the ducks. This was the only occasion when the punters got to shoot on the marsh. Other wildlife utilized included snipe, reed-birds (red-wings and bobolinks), bull-frogs, and snapping turtles (Barbour, 1940).

Changes in the wildlife of the marsh during this period include the reduction of waterfowl and shore-birds present during migration, and the introduction of the carp, goldfish, and starling. Those animals which breed in the marsh are probably as abundant as ever, with the possible exception of the waterfowl and some fish. While many

plants were introduced around the old club area, only two aquatic plants have entered the marsh. These are Butomus umbellatus, the flowering rush, which has spread from the St. Lawrence River in the past twenty-five years, and Potamogeton crispus, curled pondweed, first collected in Michigan in 1910 in the Lake Michigan area (Oosting, 1932). The club spent much money on aquatic plants but little is known of the species purchased. At least once a plant was introduced which was already abundant, when fifty bushels of coontail, Ceratophyllum demersum, were planted, although a carp seiner complained that he had been trying to eradicate it from the marsh for twenty years. A species of Sagittaria and wild rice were also planted.

In 1945 the marsh was purchased by the state and set up as a public hunting grounds. Eighteen hundred acres were marked off as a limited hunting area, with 300 hunters admitted per day; this number was chosen to give an area of 6 acres per man. About 500 acres of the marsh are marked off as a refuge, and the lake also serves as a refuge and reservoir of waterfowl for the marsh. From 4000 to 7200 hunters have used the marsh each fall since 1946, and the annual kill has varied from 3434 to 5866 birds. The area is divided into sixteen sections for trapping, and the trapping rights are auctioned off in the fall. During the spring and summer a large amount of fishing is done in the marsh, with an average of 950 fishermen present per week. Some turtle trapping and frog gigging is done, and in the spring there is much carp seining and spearing.

The increased shooting under state administration has perhaps resulted in an increase in the numbers of cripples and dead birds available to predators. Crippled birds unable to fly are very common in the marsh immediately after the hunting season. The numbers dwindle rapidly in early winter, but at least a few usually survive until the next year. Carcasses are frequent in the marsh and on the beach in late fall and are eaten by gulls, crows, raccoons, and probably other carnivorous animals. However, such conditions also existed when the club owned the marsh, and the name "Cripple Point," given to the sandspit, indicates that cripples were common along the beach at that time.

CHAPTER II

BIOTA OF MARSH

Plants

The marsh area is divided into three major groups of biotic communities: the marsh proper (2215 acres), the barrier beach (47 acres), and the permanent islands (11.2 acres). The remaining acres are now covered by Lake Erie. The marsh and islands show stages in a hydrosere leading to the lake plain forest, and the barrier beach shows stages leading from loose sand to the same forest. Secondary marsh seres from mud banks and floating islands are also present. The islands show the stages of wet meadow and meadow thicket. Probably at least two of the islands have never been covered by marsh, but started with bare clay. The last two stages of the hydrosere, swamp thicket and forest, are not present on state property.

A total of 396 species of plants (Table 12) have been identified from the State Game Area, exclusive of the dry land and roadsides around the Area Headquarters. One hundred and thirty-four of these species belong to the hydrosere; 189 are found on the beach; and 138 are found on the permanent islands. Fifty-nine of these are found in both the latter areas. The list includes 78 introduced plants, which are distributed very unequally: 5 are found in the marsh (3.8 per cent of the

species present), 69 on the beach (36.5 per cent of its species), and 16 on the islands (11.6 per cent of the species present there). The beach, of course, may readily catch drifting seeds, and many open spots are available for their establishment. Of the introduced marsh plants, 3 occur on floating islands, 1 is a reed-marsh plant of shallow water, and 1 grows submerged. Thirty-six species (19.0 per cent) of the plants found on the beach were found only in the old club area, a narrow strip about one hundred yards long. This greater variety is due partly to introductions during the club days, but probably mostly to the richer soil developed there. During this study the number of species on the club area declined as sand washed in. An interesting feature of the islands is the presence of a number of prairie plants, notably prairie dock (Silphium terebinthinaceum).

When the plant list is examined with regard to distribution of woody plants, we find that the islands have 4 species of woody vines, 19 shrubs and small trees of thickets, and 6 species of forest trees. The beach has 3 kinds of woody vines, 9 shrubs and small trees, and 13 species of forest trees. The marsh has 5 shrubs; and 2 trees, red elm (Ulmus rubra) and cottonwood (Populus deltoides), occasionally occur out of place in the sedge-meadow. The shrubs in the marsh are scattered in reed-marsh or sedge-meadow.

As would be expected, the aquatic vegetation is that typical of alkaline or hard waters. In the classification of plants of alkaline waters given by Moyle (1945)--present in softer waters only, present in harder waters only, or tolerant

of both soft and alkali-waters--we find 4 Mouillée species in the first group, 13 in the second, and 17 in the third. Four species are intermediate between hard and soft waters in requirements, 1 species is given as a soft water form ranging into harder waters with low pH (below 7.7), and 2 species are listed by Moyle as probably members of the alkali-water flora.

Vertebrates

Altogether 162 species of birds were observed in the marsh area during the period of this study, and 9 more were seen above it or around the Game Area Headquarters (Table 13). Ninety of these used the marsh communities, 84 used the beach, and 12 used the islands. Sixty-five species were found only in the marsh and 64 restricted themselves to the beach and islands. The sand and mud banks along the beach were also used by a number of birds classed as marsh-dwellers rather than as members of the drier communities of the beach. Four of the birds observed (House Sparrow, Starling, Ring-necked Pheasant, Rock Dove) were introduced by man.

Nests of 17 species of birds were observed, and 19 more probably nested here. Putting these two groups together, 14 species nested in the marsh, 15 on the barrier beach, and 10 on the islands. Twenty-two species would have found no nesting habitat were it not for the beach and islands. Two birds nested in buildings which are no longer present; these species are not included in the above totals.

Eleven mammals were observed in the Mouillée district

(Table 13). Although 7 species used the marsh, only 1 of these (Muskrat) lived exclusively in the marsh habitat. Eight species of mammals were observed on the beach, and 5 were seen on the islands. One of the mammals (Brown Rat) was introduced.

Records were kept of the lower vertebrates observed, but they were not studied in detail. Four species of snakes were observed on the beach, and 1 of these was also seen on an island. Turtles of 3 species were seen in the marsh; 1 of these nested on the islands and on the beach, the other 2 nested in muskrat houses. Six amphibians were recorded, 3 in the marsh and 3 associated with the beach and islands; all of these reproduced in the marsh. Many fish were seen in anglers' catches or observed in the water, but detailed records were not kept. The dominant species of fish in the shallow marsh communities was the carp.

Thus we see that the beach and the islands contributed greatly to the variety of life in the area. Two hundred and sixty-six additional species of plants were found on the beach and islands. The additional vertebrates attracted by the beach and islands included 64 birds, 5 mammals, 4 snakes, and 3 amphibians. Nesting habitat is available only through the presence of the beach and islands for 22 species of birds, 7 species of mammals, the 4 snakes, and 1 turtle.

Numbers of Mammals and Birds

An attempt was made to keep track of the numbers of birds and mammals using the marsh, but the success of this attempt was very irregular. The only mammal present in numbers

in this area is the muskrat. The population of the muskrat had undergone a precipitate drop just before this study was started. Shortly before the decrease in muskrats a die-off of marsh vegetation occurred, so that much less area was available, but they were only thinly scattered through the remaining habitat. The decline in numbers is reflected in Table 3, which shows the trappers' reported take and the relation to acreage of reed-marsh and cat-tail, the staple food of muskrats.

TABLE 3

NUMBER OF MUSKRATS TRAPPED ON PTE. MOUILLÉE STATE GAME AREA

Season	No. of muskrats taken	No. of muskrats per acre of reed-marsh	No. of muskrats per acre of cat-tail
1945-46	1094	.68	.82
1946-47	3012	4.30	4.57
1947-48	295	.45	.50
1948-49	629	.87	.96
1949-50	466	.53	.63

In the spring of 1946 a muskrat house count by the Game Area staff disclosed an estimated 2839 houses in the state marsh, of which 345 were washed out in a May storm. During the next trapping season dead muskrats were found by the trappers and the Game Area staff. In the summer of 1947 the old houses were very abundant, but few muskrats were observed and little evidence of activity noticed. A house count by the author in the spring of 1948 over part of the

area gave a count of 280 houses in a section for which 1139 had been reported two years before. In 1949 muskrat sign was much more abundant.

The reported muskrat take, except in the best year, does not approach the numbers that should be produced in this habitat. A marsh in Ontario managed for muskrats produced 6.5 muskrats per acre for four years (Hewitt, 1942), and small glacial marshes in Illinois produced 2.37 per acre (Yeager, 1945).

The number of birds in the marsh is poorly known; some species could be counted easily, others could not be counted at all. Table 4 shows the numbers observed on individual days at two-week intervals. Most of the more abundant and important birds of the marsh are shown here, but a few are not included. The red-wings were too abundant and gathered in huge flocks which could not be counted. Marsh wrens, bitterns, rails, night herons, grebes, and some other birds were so solitary or secretive that the numbers seen gave little idea of the numbers actually present. When this study was made, it was not planned to present this material, so no attempt was made to get comparative data, such as numbers observed per unit of time.

The information in this table is very incomplete and full of gaps. Virtually no observations were made in the spring, and occasional periods were missed during the remainder of each year. The dates when no observations were made are shown at the beginning of the table. The smaller numbers are complete counts, the larger ones are estimates based on partial

TABLE 4

NUMBERS OF BIRDS OBSERVED ON PTE. MOUILLÉE STATE GAME AREA AT TWO-WEEK INTERVALS, 1947 - 1949

		Jan.			Feb.		Mar.		Apr.		May		June		July			Aug.		Sep.		Oct.		Nov.		Dec.	
		1	15	29	12	26	12	26	9	23	7	21	4	18	2	16	30	13	27	10	24	8	22	5	19	3	17
Dates when no observations were made	1947	x	x	x	x	x	x	x	x	x	x	x	x	x													
	1948	x	x				x																				
	1949	x	x	x	x	x	x	x	x	x												x	x	x		x	x
Great Blue Heron	1947														+	13	+	14	12	16	6	4	14	5	1	1	...
	1948			...	...	...		...	7	+	6	+	11	9	+	-	+	+	+	6	+				...		
	1949										+	23	20	+	+	11	31	+	+	+	39	+	+	5	1	...	1
American Egret	1947														2	...	2	1	1	...	...	...	...	...	...	...	...
	1948			...	...	...		...	...	...	...	...	...	...	...	...	...	12	6	+	25				...		
	1949										...	...	...	...	...	6	16	15	32	20	50	2	...	...	...	...	...
Whistling Swan	1947						1200								...	...	...	...	...	...	...	...	...	...	250	330	300
	1948			...	...	...	20		...	...	2	...	1	1	...	...	...	...	...	...	...				35		
	1949										2	...	2	1	1	1	1	...	...	1	...	...	...	+	+	300	325
Mallard and Black Duck	1947														19	31	167	+	210	2100	3000	+	+	+	3000	1200	+
	1948			...	...	150	300		9	17	52	8	8	30	+	+	+	1000	2000	2750	+				4000		
	1949										8	40	75	125	26	130	75	1000	2800	7000	4000	2200	90	55	+	+	1200
Pintail	1947														...	...	...	...	...	...	200	+	+	+	1000	7	...
	1948			...	...	...	50		...	...	...	...	...	...	...	...	...	3	100	300	+				+		
	1949										...	...	...	...	1	1	3	...	50	1000	500	100	...	15	...	...	...
Baldpate	1947														...	...	...	...	...	55	1000	+	+	+	500	5	...
	1948			...	...	...	30		...	...	...	...	1	2	...	...	...	...	25	3000	+				+		
	1949										17	...	...	...	...	...	...	...	25	2000	1500	700	30	30	+	1	...
Blue-winged Teal	1947														+	+	156	+	+	300	500	+	+	40	15	1	...
	1948			...	...	...	...		2	4	2	4	4	1	+	+	+	100	300	+	+				...		
	1949										16	4	2	+	4	15	+	150	250	300	200	12	...	...	...	...	...
Miscellaneous Dabbling Ducks	1947														1	5	8	10	10	12	60	+	+	+	50	1	...
	1948			...	...	...	...		...	4	...	14	2	4	...	...	...	...	3	6	+				+		
	1949										...	...	...	...	...	11	5	15	22	60	70	40	10	50	1	...	...
Diving Ducks	1947														...	...	4	3	1	1	50	28	4	1	5000	320	200
	1948			...	...	...	300		40	64	15	1	...	...	...	...	1	...	...	...	...				700		
	1949										4	12	...	...	1	2	...	1	...	...	20	23	5	...	+	+	+
Hawks	1947														2	3	1	4	2	4	16	5	2	1	3	4	1
	1948			...	...	2	1		...	1	2	3	...	...	...	...	...	3	1	19	1				1		
	1949										2	...	...	...	1	2	1	3	2	9	4	2	1	1	3	4	4
Florida Gallinule	1947														+	+	+	34	+	28	54	22	...	...	...	...	...
	1948			...	...	...	...		+	+	+	+	+	+	+	+	+	+	+	105	+				...		
	1949										+	+	+	+	+	+	+	+	37	222	106	4	...	...	...	...	...

TABLE 4--Continued

		Jan. 1	15	29	Feb. 12	26	Mar. 12	26	Apr. 9	23	May 7	21	June 4	18	July 2	16	30	Aug. 13	27	Sep. 10	24	Oct. 8	22	Nov. 5	19	Dec. 3	17
Coot	1947														+	+	69	182	+	227	800	2000	2000	120	+	30	12
	1948			...	...	...	100		+	+	+	+	+	+	+	+	+	+	+	425	-				+		
	1949										+	+	+	+	+	85	65	70	+	1158	2000	700	100	200	50	...	...
Shore-birds	1947														12	14	41	68	40	42	24	121	47	14	...	...	...
	1948			...	...	...	...		...	3	2	36	68	17	+	+	25	40	56	110	15				100		
	1949										25	800	10	+	+	24	12	+	145	80	45	50	45	65	5	...	...
Gulls	1947														+	90	125	125	290	150	150	240	125	400	500	1000	1000
	1948			...	...	31	100		+	+	130	+	76	+	+	+	+	250	+	+	+				220		
	1949										56	23	+	+	50	116	100	+	+	76	+	300	+	50	+	3500	3000
Black Tern	1947														+	140	50	120	8	31	...	...	...	...	...	...	...
	1948			...	...	...	...		...	...	13	+	+	+	+	+	30	20	...	...	...				...		
	1949										+	+	+	+	+	112	+	6	...	...	...	...	...	...	...	...	...
Other Terns	1947														+	60	35	250	15	94	70	11	...	...	...	...	...
	1948			...	...	...	...		5	4	32	20	25	+	+	+	+	240	36	25	1				...		
	1949										5	25	+	...	30	35	50	9	+	3	4	...	...	...	...	...	...

counts. In the case of the waterfowl the numbers indicate what was believed to be the total marsh population. With other groups the number given is the total numbers of birds observed at one time or in one day and known to be different. The herons, gallinule, coot, and black tern were usually widely dispersed and could not be counted. However, the groups or flocks which these species form at some seasons were counted.

Most of these birds are transients in the marsh, breeding somewhere else, so that changes in the marsh can affect them only through their food supply. It was not possible to get summer population figures of the three species breeding in the marsh which are included in the table--the gallinule, coot, and black tern. Some data were obtained on nest densities, but the author believes there are also non-breeding black terns and coots present. Populations of all three of these species may have been affected by the die-off of marsh vegetation, as will be shown later on. The greater numbers of shore-birds in the spring and early fall of 1949 may have been due to the larger expanse of mud flats available.

Some interesting changes in numbers are evident from this chart. The great blue heron increased by two to three times from 1947 to 1949, and egrets increased from two individuals to fifty. In 1949 the waterfowl were about five times as abundant in early summer as they were in the early summer of 1947, and numbers of waterfowl in September of 1949 were again greatly swollen over 1947 and 1948. Two species showing

a particularly noticeable increase in the fall of 1949 were wood ducks and gadwalls, included in the table under the designation "Miscellaneous dabbling ducks." Coot numbers built up rapidly in the early fall of 1949, then abruptly fell off during the hunting season, so that very few were killed by the hunters. All species of birds remained later in the summer and fall of 1947 than in 1948 and 1949.

The variety as well as the number of animals changed greatly with the seasons. Most of the vertebrates are active in this region for only a part of the year. Of the 214 vertebrates listed in Table 13, 23 mammals and birds and perhaps all 18 fish were active in the State Game Area throughout the year. Twenty-one birds and 2 mammals were found in the Game Area as winter visitors; and 51 birds, 1 mammal, and the 13 reptiles and amphibians were summer residents. Eighty-four birds were present only while passing through on migration. The period of occurrence or activity of summer and winter residents overlapped, and occasional individuals remained out of season; but a minimum of 64 species of vertebrates occurred in the winter, 106 in the summer, and 84 in the spring and fall only.

CHAPTER III

HISTORY OF SUCCESSION OF VEGETATION

Since the waters of the glacial lake first drained off the area, it has undoubtedly undergone continual change, following the changes in lake level. The first definite record we have, however, is the government survey made in 1817 (Figure 8). This survey showed the lake shore line as continuous from Estral Beach, south of Pointe Mouillée, to the Huron River, with one break at Mouillée Creek. Most of this shore line was marsh, with a sand ridge with scattered trees along part of the south side. Trees were also present at the mouth of the Huron River and on the river bank at the present headquarters, according to Hubbard (1818). The interior of the marsh was recorded as "swampy prairie," with water one to two feet deep, with "ponds, sink-holes, and everything that is disagreeable" "inhabited only by musk-rats."

The central part of this area was probably incompletely mapped due to "impassable ponds," as other maps of the period (Greeley, 1810; Hubbard, 1818) show a large pond or channel from the river to Mouillée Creek. Narrow channels, at least, may have been present elsewhere. The inner side of the marsh changed rather abruptly into mature beech-maple forest.

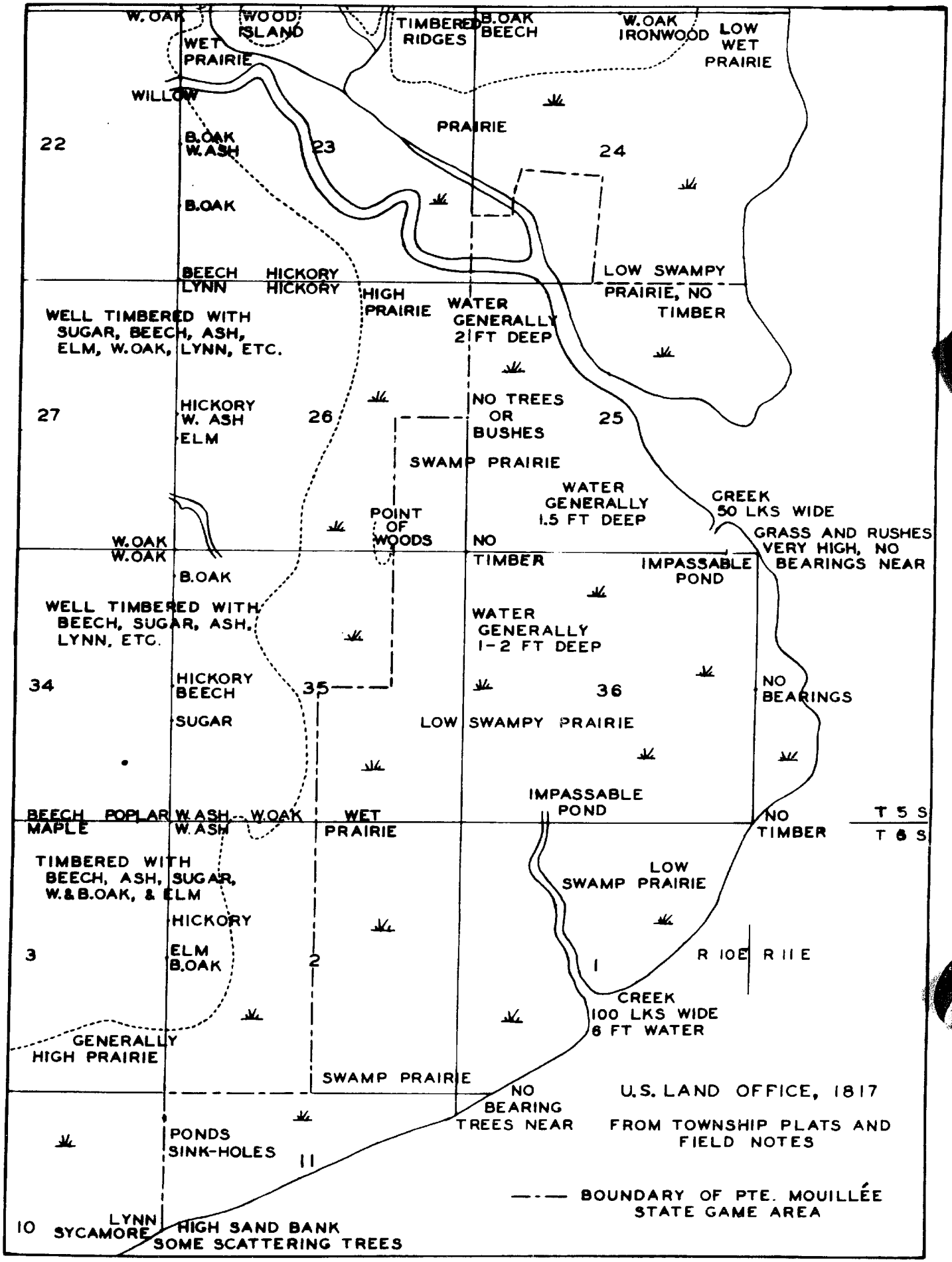


FIG. 8. LAND SURVEY MAP, MOUILLÉE DISTRICT, 1817

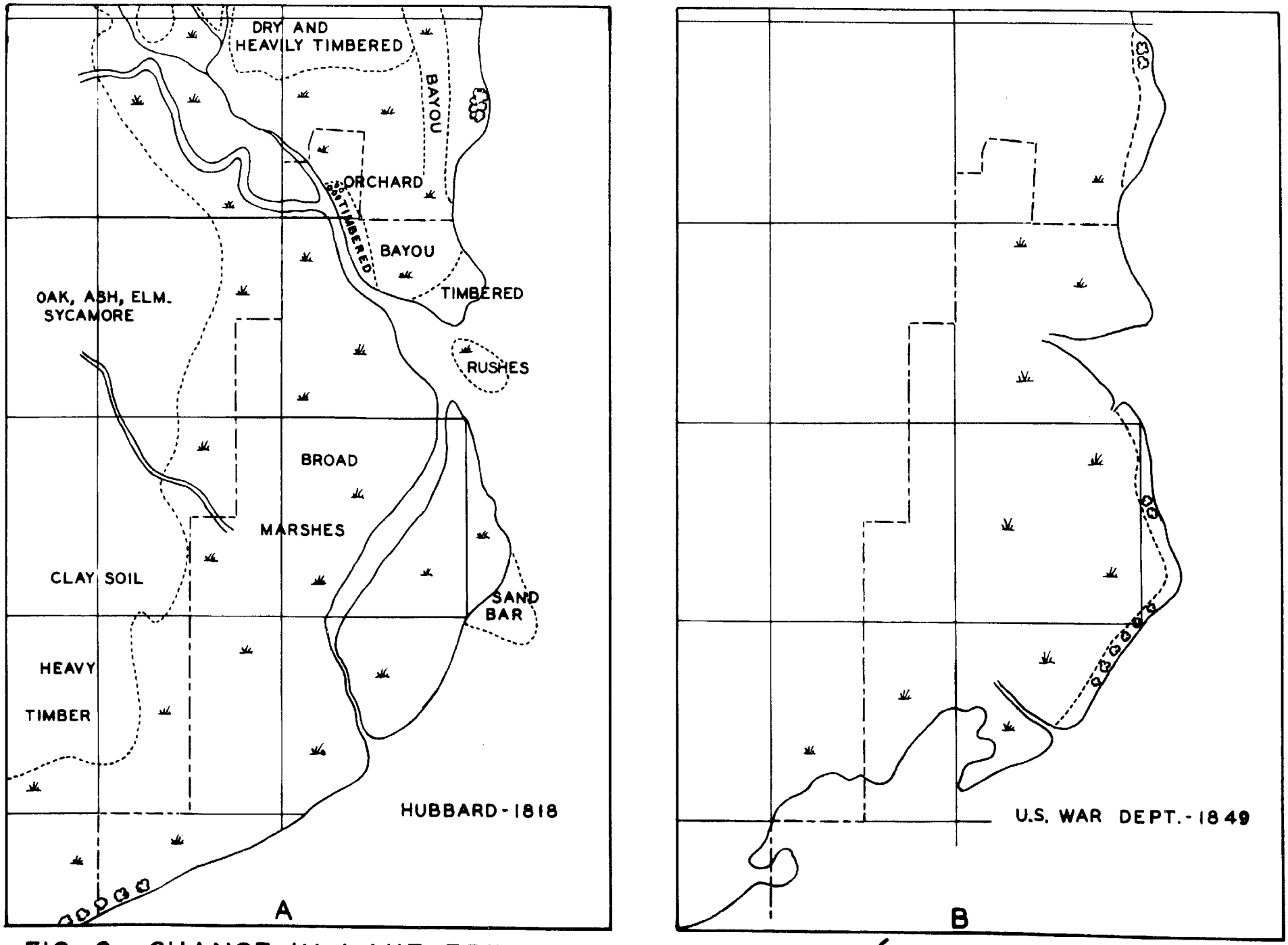


FIG. 9. CHANGE IN LAKE ERIE SHORE LINE, MOUILLÉE DISTRICT.

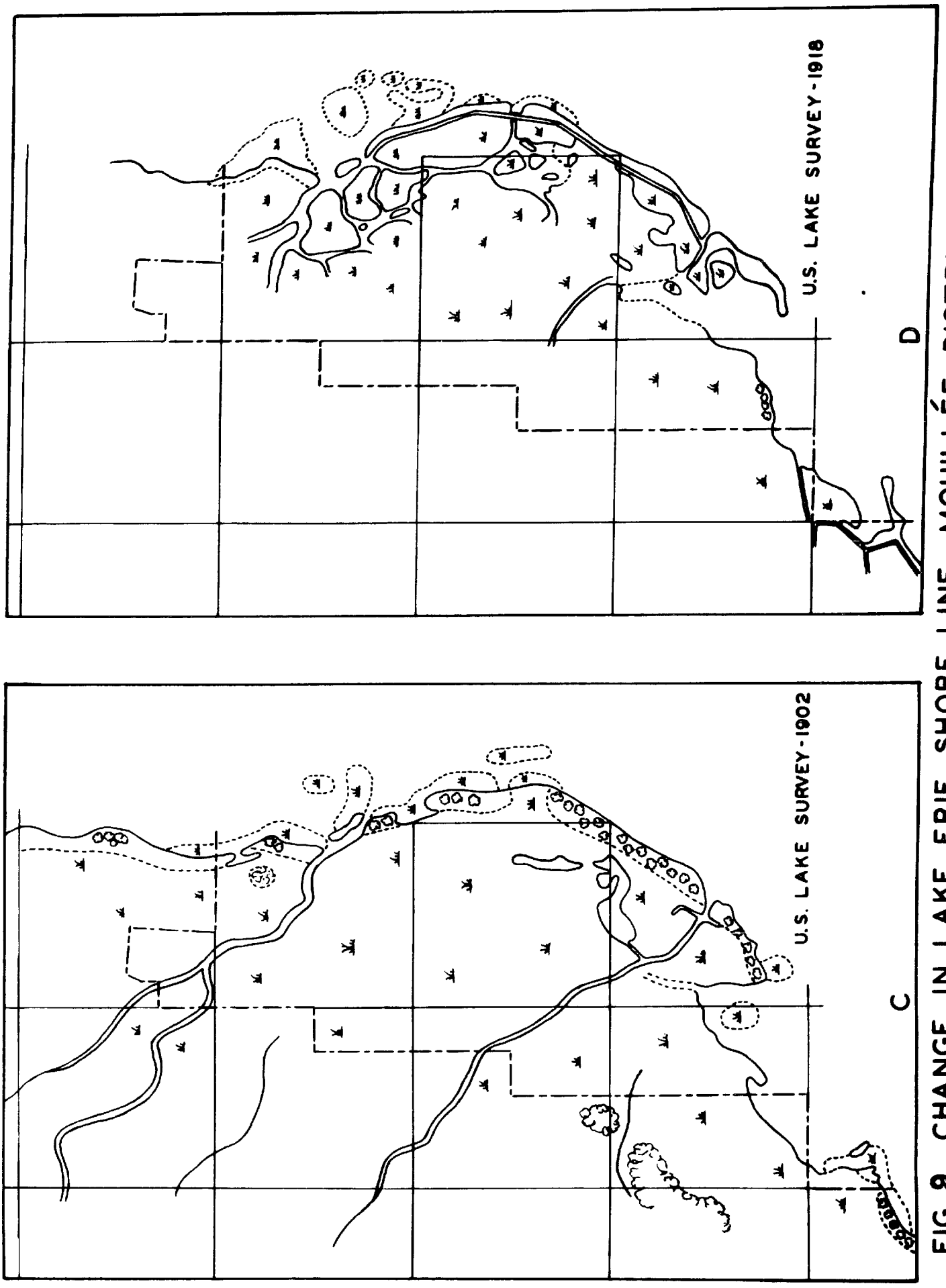


FIG. 9. CHANGE IN LAKE ERIE SHORE LINE, MOUILLÉE DISTRICT.

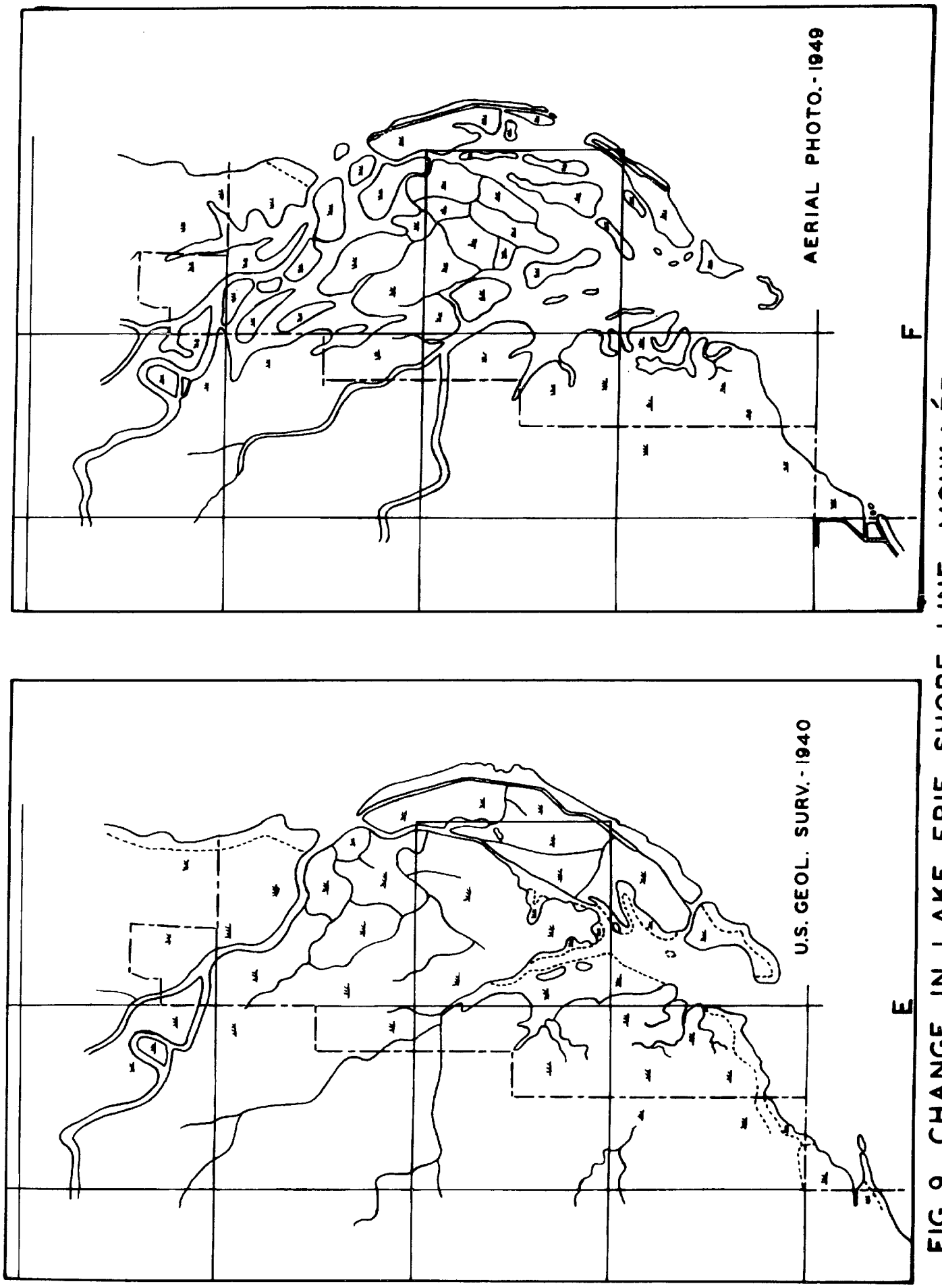


FIG. 9. CHANGE IN LAKE ERIE SHORE LINE, MOUILLÉE DISTRICT.

Change in Shore Lines

Since 1817 the lake has steadily washed away the marsh on the south, extending a bay northward which captured Mouillée Creek and submerged the old channel leading east to the lake. A curved sandspit was formed at the mouth of this bay. The barrier beach extending northeast from Estral Beach has washed back into the marsh, until now it is about 700 yards from the 1817 location. This rate of erosion is somewhat more rapid than the rate in Maumee Bay in Ohio, where the average erosion has been 11.78 feet per year, or 522 yards in the same period (White, 1944). During this time the lake level has risen twelve to sixteen inches (applying the rate described earlier in this paper), offsetting the rise in land produced by deposition of soil and organic materials by growth of the marsh vegetation.

During the period the erosion described above was occurring the shore was extended into the lake on the section from Pointe Mouillée to the Huron River, so that that shore is now located some 350 yards farther out than in 1817. The maps of 1817, 1849, 1902, 1918, and 1940 show stages in these changes (Figure 9, A-F). (Figure 9, B [U. S. War Dept., 1849] perhaps shows only an approximation of the true coast line. The original was one-third this size and had no section lines marked; the streams were used as check points for the enlargement but were somewhat distorted. The other maps were based on careful ground surveys and were found to be accurate.) Probably most of the erosive activity took place during short periods; in Maumee Bay forty feet of erosion occurred in

1940 (White, 1944), and at Pointe Mouillée it was certainly accelerated during the years 1944-1949, when 51.8 acres were transferred from marsh and beach to lake.

Vegetation before 1944

The general vegetation during the early period is not known. One notation at the mouth of the river in 1817 mentioned "grass and rushes being high, no object could be seen across river," and Hubbard's map, 1818, indicates rushes on an island at the mouth of the river. Trees are indicated on an additional portion of the barrier beach in the 1849 map (Figure 9, B) and by 1902 (Figure 9, C) were well distributed along the beach.

The first map which names the vegetation of the marsh is a sketch map made by one of the club members in 1910 (Newell, 1910). This map (Figure 10) shows wild rice, Zizania aquatica, as covering the greater part of the marsh, with cat-tail massed on the inner side and in scattered patches elsewhere. When a cover map of the area was made by the Game Division in 1944, the wild rice had declined to a rather small area and had been largely replaced by cat-tail. According to Mr. Edward Lezotte, in 1936 cat-tail extended several hundred yards into the lake from the mouth of the river to the club area, on a muck bottom. In 1944 the shoal in front of the marsh was firm sand, and the cat-tail had been replaced by rush, Scirpus sp.

Succession Following the Die-off of Marsh Vegetation

In 1946 it became apparent that the cat-tail was

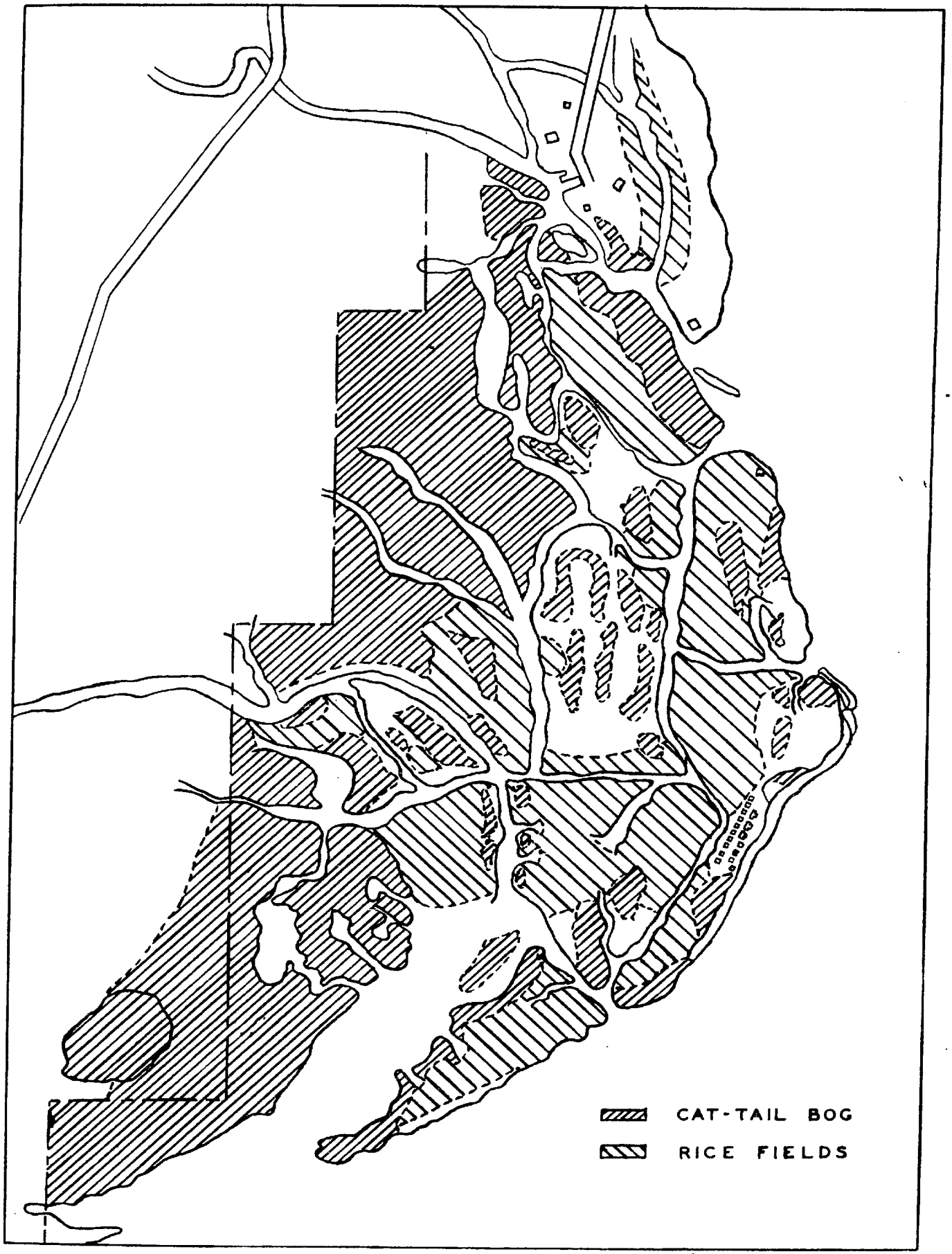


FIG. 10 SKETCH MAP OF POINTE MOUILLÉE SHOOTING CLUB, 1910

Plate 4



Dead stand of Typha angustifolia. The formation of tussocks or clumps is shown here.



Dead stand of Typha glauca. The stems are uniformly distributed.

Plate 5



Dead stand of Scirpus validus.



Dead stand of Scirpus fluviatilis. One shoot is growing from old rhizomes.

Plate 6



Dead stand of Phragmites communis.



Dead stand of Cephalanthus occidentalis.

dying out over extensive areas, and this study was undertaken the following year. Two forms of cat-tail were involved, Typha angustifolia and T. glauca (T. angustifolia var. elongata). At the same time relatively large patches of river bulrush, Scirpus fluviatilis, and reed, Phragmites communis var. Berlandieri, died out as well as much smaller stands of three-square, Scirpus americanus, tussock sedge, Carex stricta, hard-stem bulrush, Scirpus acutus, and soft-stem bulrush, Scirpus validus var. creber (Table 6). Patches of dead stubs of buttonbush, Cephalanthus occidentalis, and perhaps willow, Salix sp., are very common in the marsh and cover a total area of sixty-two acres (Figure 31). Some of these are known to have been alive in 1944, but most of them cannot be recalled by the men familiar with the marsh. A few scattered bushes are present now, and some died during the period of the study.

The conditions and extent of the vegetation types and species during the period from 1944 to 1949 are shown in a series of tables and figures. The changes in extent of the cover types for Pointe Mouillée State Game Area and the Mouillée District are shown in Tables 5 and 14, and Figure 11. Specific shifts in cover types are shown in Tables 15 and 16. Cover maps of the district, made in 1944, 1947, and 1949, are inserted in the back. These provided most of the data for the other figures and tables. The distribution of individual marsh and aquatic plant species is shown in Figures 18 to 31.

The coincident rise of water and die-off of emergent marsh plants resulted in large areas being taken over by submerged species. A succession of these species occurred. The

first forms, especially bladderwort, Utricularia vulgaris, were those already present in the emergent stands before the die-off. Other species entered and took their place, and during the three years there was a very pronounced spread and increase of virtually all submerged aquatics (Figure 19) except Utricularia. The increase of wild celery, Vallisneria americana, and sago pondweed, Potamogeton pectinatus, was particularly marked. This change is very similar to that described as occurring in Illinois River lakes after stabilization of water levels (Bellrose, 1941). The floating-leaf forms also spread into this newly available territory, in many cases probably from small pools formerly enclosed within the stands of cat-tail.

In some locations the upper layers of muck are very unstable, and the emergent vegetation almost forms a floating mat. After the emergent vegetation died and decayed, many sections of this muck bottom broke loose and floated at the surface. Such floating masses were common in 1947 and more continually appeared until the falling water levels in 1949 grounded them. Some of these islands drifted considerable distances.

As the loose sections of bottom floated to the surface, they were colonized by plants characteristic of mud banks, in a succession leading to the reed-marsh. The reed-marsh species also became established immediately on these masses by seeding, and some of these islands were taken over directly by Scirpus, Typha, and other emergents. The species first developing depended on the time in the summer when the islands appeared;

TABLE 5

COVER TYPES OF PTE. MOUILLÉE STATE GAME AREA

	1944 Acres	1947 Acres	1949 Acres
Cultivated land	26.2	17.0	26.2
Waste grassland	26.5	23.6	14.4
Meadow thicket	5.8	7.3	7.3
Wooded	64.3	34.7	33.9
Swamp thicket	0.4	0.9	0.9
Sedge-meadow	194.8	150.4	144.0
Reed-marsh	1604.4	650.8	884.0
Aestival reed-marsh	82.1	102.2	81.5
Sand beach	1.3	7.8	12.5
Inland water	483.5	1299.8	1078.3
Lake Erie	171.8	366.6	378.1

MARSH VEGETATION, STATE GAME AREA

Carex-Calamagrostis	184.4	110.1	102.4
Scirpus-Typha	10.4	40.3	41.6
Phragmites	127.4	31.9	34.4
Typha glauca	966.9	502.8	628.3
Typha angustifolia	362.1	92.2	113.0
Scirpus fluviatilis	47.8	0	32.1
Scirpus spp.	0	1.9	49.5
Sagittaria rigida	16.8	23.6	22.7
Zizania	65.3	78.6	58.8
Swamp thicket	0.4	0.9	0.9

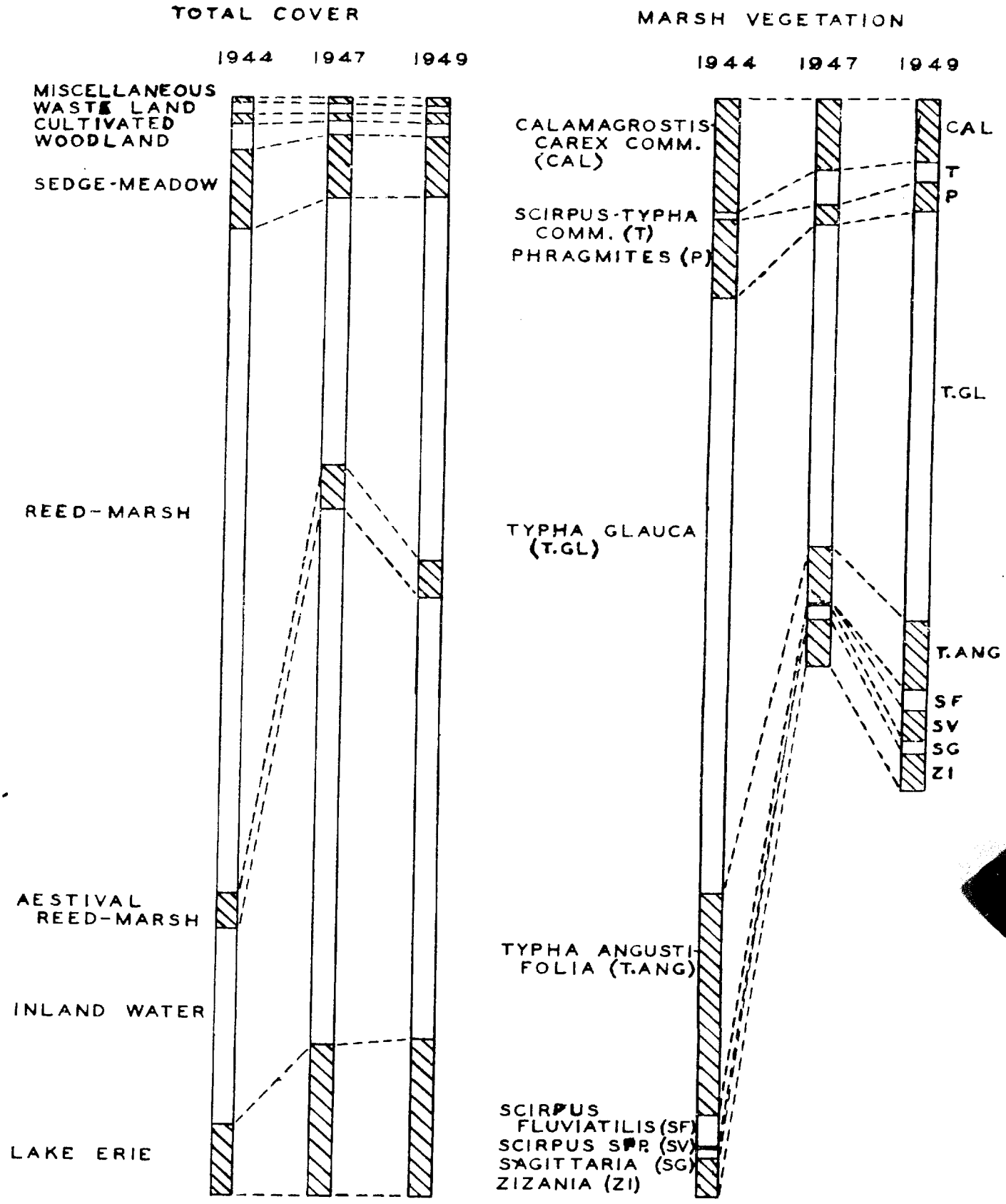


FIG. 11 RELATIVE EXTENT OF COVER TYPES, PTE. MOUILLÉE STATE GAME AREA

TABLE 6

AMOUNT OF DIE-OFF AND RECOVERY, PTE. MOUILLÉE DISTRICT

Species	Amount of death-1944 to 1947		Amount regained 1949	
	Acres	Per cent	Acres	Per cent
Cephalanthus occidentalis	62.0[a]	96.6	0	0
Carex stricta	21.0+	5.9	7.6	36.2
Phragmites communis var. Berlandieri	99.5+	51.8	2.2	2.2
Typha glauca	644.7±	54.7	152.5	23.7
Typha angustifolia	272.4±	74.3	20.4	7.5
Scirpus fluviatilis	54.1+[b]	100.0	45.9	84.8
Scirpus validus var. creber and S. acutus (marsh stands)	+	?	+	?
Scirpus sp. (lake stands)	167.5±	79.6	4.2	2.5
Zizania aquatica	48.4	74.1	0[c]	0
Sagittaria rigida	7.0	41.7	0[c]	0

[a] Some died before 1944

[b] Some dormant, not dead

[c] Additional amount of 1944 area lost

stick-tights, Bidens spp., were frequently the only plants present the first summer. As the waters receded in late 1948 and in 1949, exposing mud banks and flats, new patches of Scirpus, Sagittaria, and Lophotocarpus were established (Figures 21, 22, and 27).

Typha was much less successful in colonizing by seeding, but relict stems and patches scattered here and there through the die-off area showed renewed vigor in 1948. By 1949 they had spread over large areas by vegetative growth, with the spread still continuing. Figure 12 shows how the vegetation closed in on one transect from 1947 to 1949. River bulrush, Scirpus fluviatilis, did not colonize new stations but in 1948 reappeared in weak growth in some of the areas it had formerly covered. In 1949 these patches were very dense and additional stands also showed recovery. Apparently some of the rhizomes had survived several years of submergence in deep water even though no emergent growth appeared during that time. Scirpus americanus spread extensively in 1949 on the new sand beaches.

In 1947 many colonies of wild rice were scattered through the marsh outside of its previous recent distribution, in areas formerly covered by cat-tail. Apparently it was inhibited in these areas at first by the pure peat soils, and could only become established where the peat had disintegrated into muck or the top fibrous material had washed away. In 1948 it became increasingly abundant, but by 1949 was again being crowded out by cat-tail in its new stations. In 1949 some small stands were unable to produce seed due to complete cutting of the stems by muskrats.

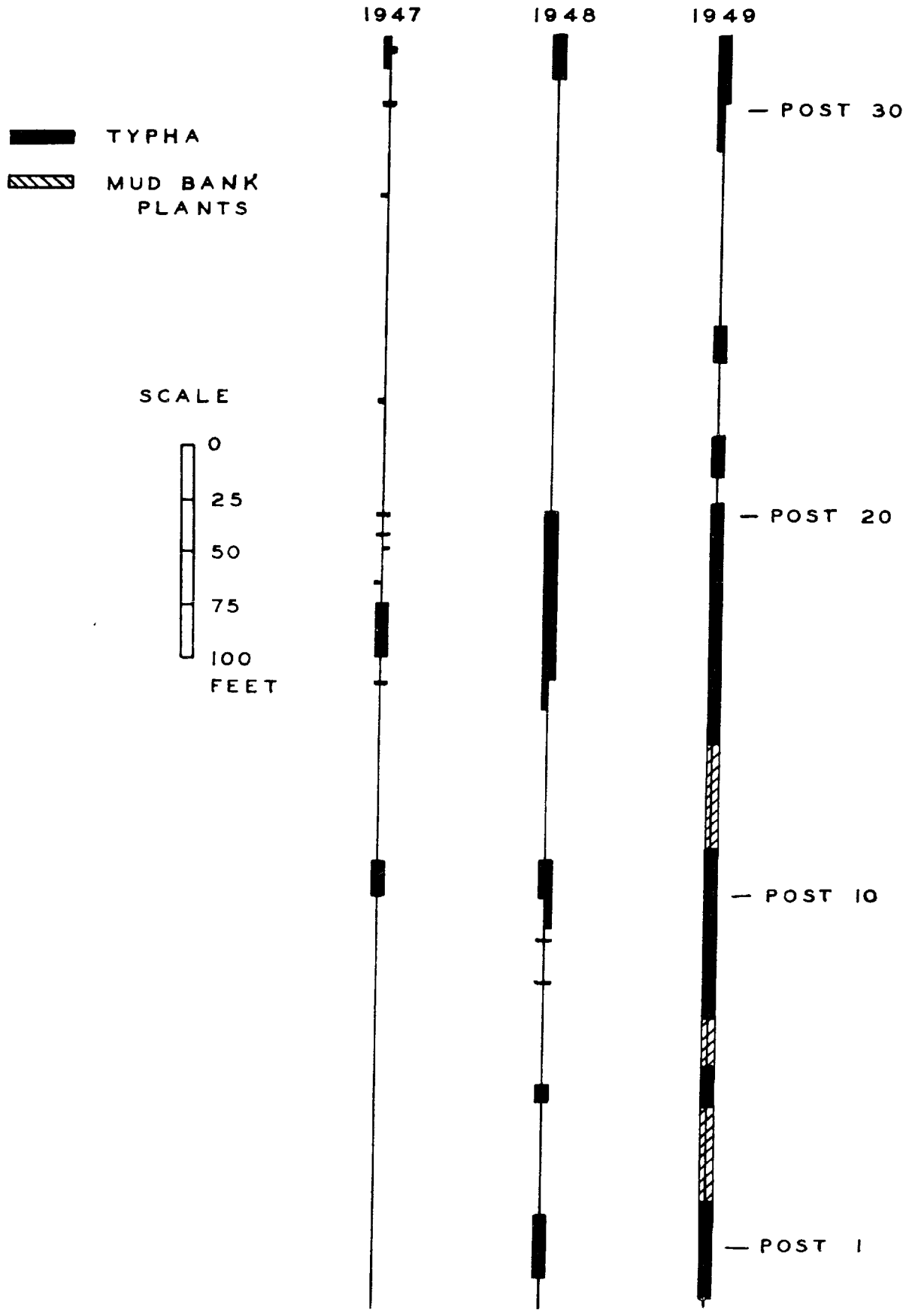
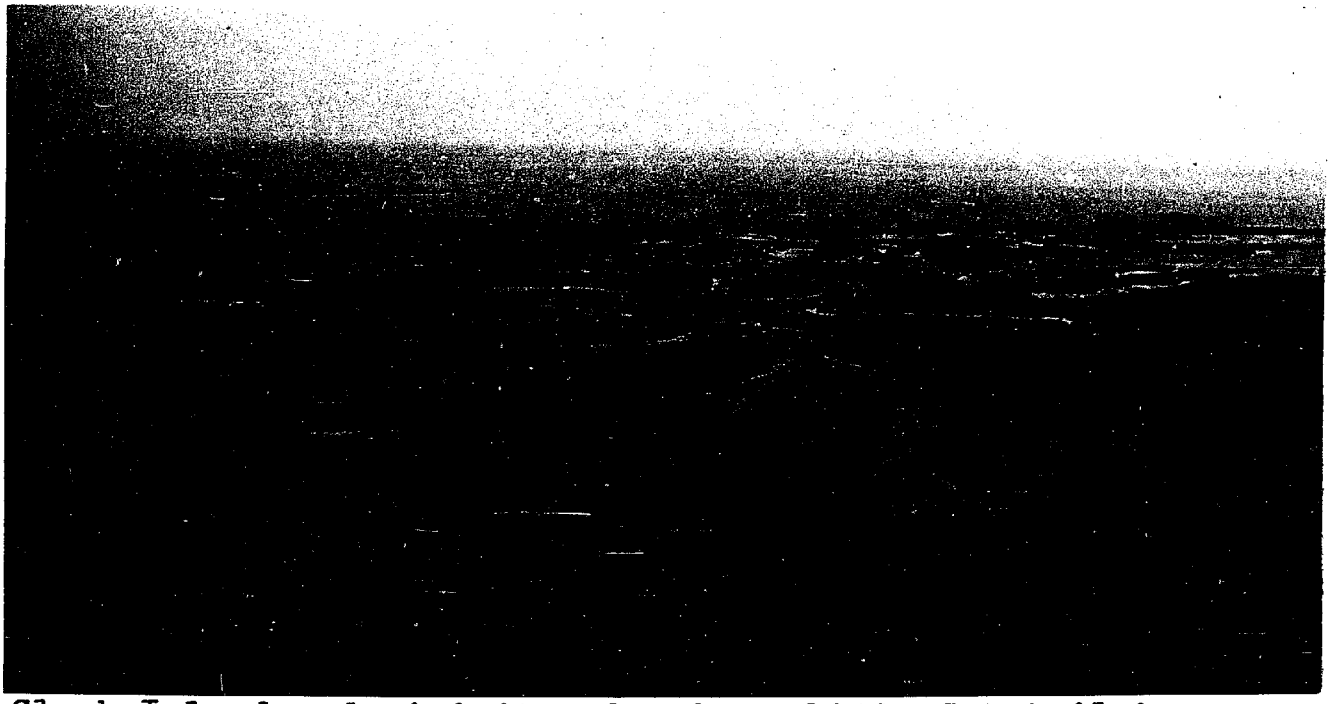


FIG. 12 CHANGES ON LINE TRANSECT, DIE-OFF AREA

Plate 7



Clark Island and vicinity, September, 1947.



Clark Island and vicinity, October, 1949. Cat-tail has closed in much of the exposed area. Mud banks are evident.

Plate 8



View of Horse-shoe, September, 1947. This is one of the major cat-tail die-off areas. Isolated surviving stems can be seen.



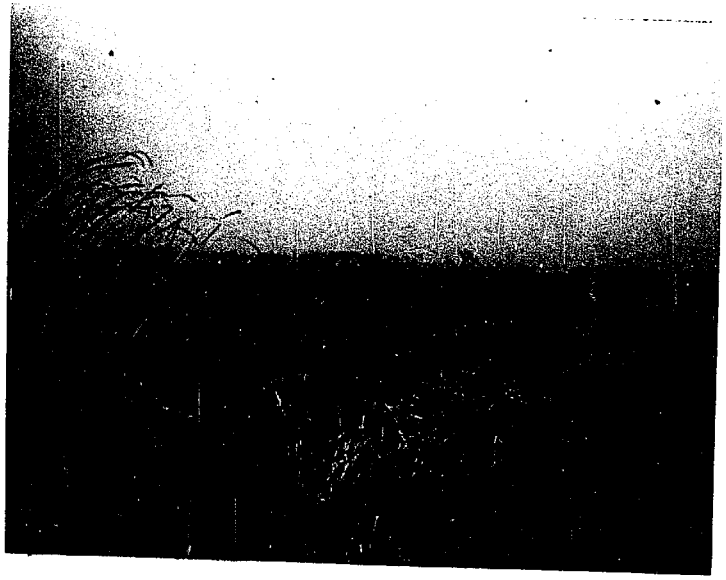
View of Horse-shoe, October, 1949, from opposite side. Spread of cat-tail is very evident.



1947



1948

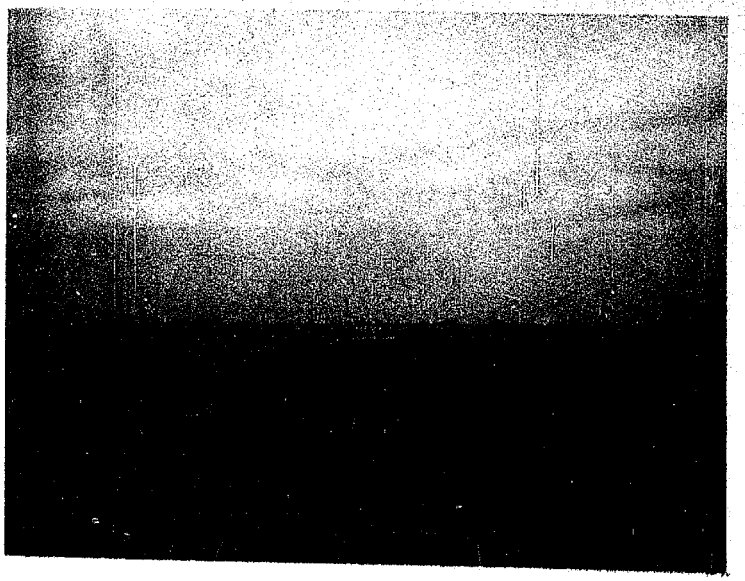


1949

View north from Post 1 on transect. Bidens and other mud bank plants prominent in 1949.



1947



1948



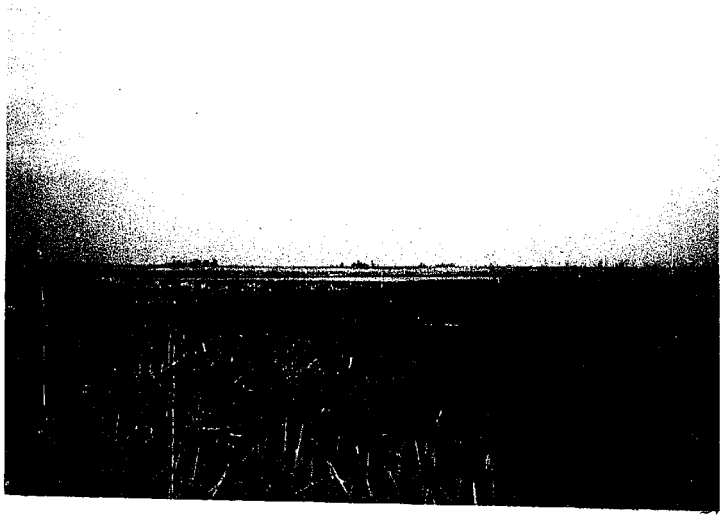
1949

View northeast from Post 10 on transect, showing closing in of cat-tail.





1947



1948



1949

View northeast from Post 10 on transect, showing closing in of cat-tail.



1947



1948



1949

View west from Post 60 on transect, showing formation of open pool as a result of the cat-tail die-off.

Another plant which survived the period of high water but did not thrive was American lotus, Nelumbo lutea. It was reported as present in the marsh several years ago, and two patches were found in 1948 which probably represented relict stands. They did not bloom in 1947 or 1948 and the leaves did not lift out of the water, but remained floating at the surface, in three feet of water. In 1949, when the water level was 1.2 feet lower, the plants of one stand became very vigorous, lifted their leaves up above the surface, and flowered abundantly. The other patch remained as it was.

While the reed-marsh died out on the water side it extended its domain on the land side. The cat-tail, by vegetative reproduction, and possibly also by seeding, invaded the inner sedge-meadow. In addition a wide band of farmland which was rendered too wet for cultivation was seeded in by cat-tail and other wet-land species, extending the marsh nearly a quarter of a mile. This extension was governed by the amount of drainage, and the farmers drained additional fields each year by dyking them and pumping out the water.

A zonation of marsh plants developed from the first on this newly flooded land. That which was actually under water was seeded in almost entirely by bur-reed, Sparganium eurycarpum. The cat-tail seeded in on the wet fields and pastures which were not actually submerged. Most cultivated fields apparently had a border or edge of river bulrush, which survived and formed a border for the new stands of cat-tail established in the fields.

The cat-tail which seeded in on these higher fields

was mostly narrow-leaved cat-tail, Typha angustifolia, with scattered stems of broad-leaved cat-tail, T. latifolia. This resulted in a peculiar zonation of the Typha species. Typha angustifolia is present in the deeper waters of the central area of the marsh, and also in the high meadows at the edge of the cultivated land (Figure 28), while blue flag, Typha glauca, forms a wide belt on the flats between these two groups (Figure 29). The T. angustifolia in the high meadows is depauperate. Whether this small form is a response to an unfavorable environment or represents a distinct genetic type is not clear. The pistillate spike, however, shows some constant differences in structure from the deep water form. The presence or distribution of this small form previous to 1947 is not known.

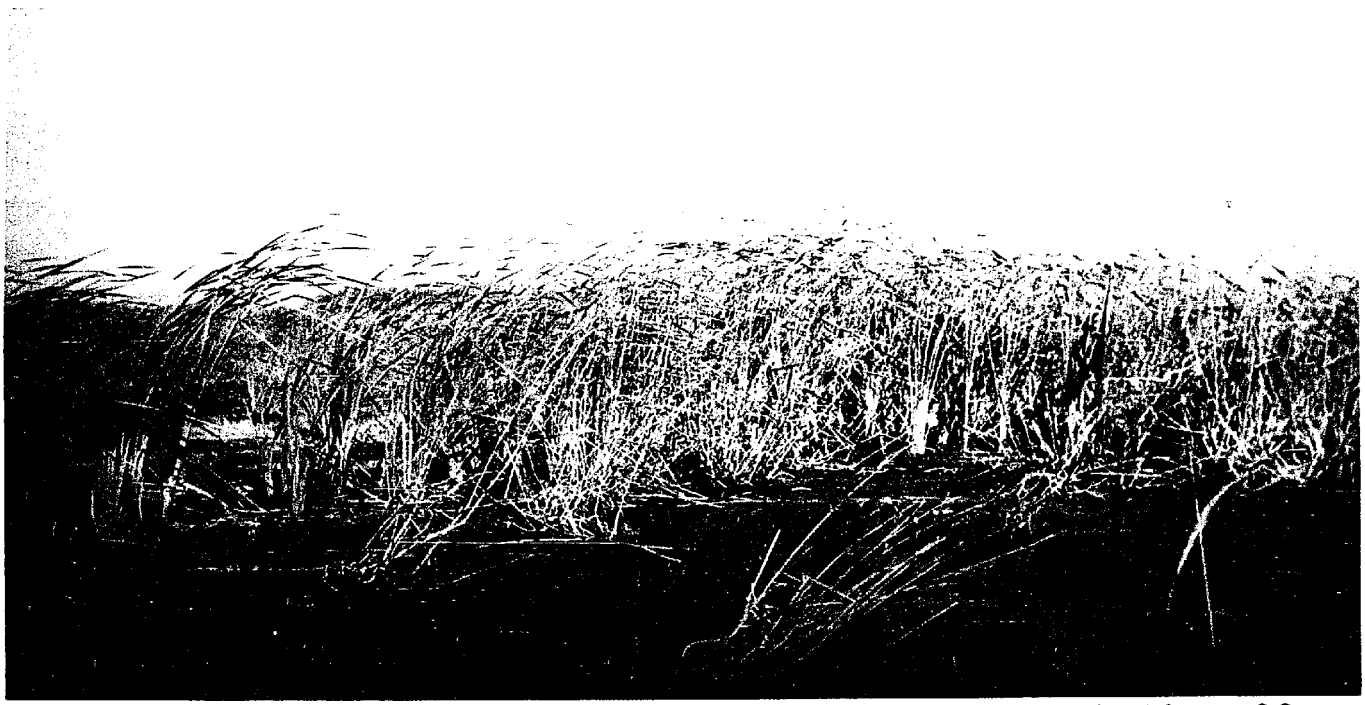
To sum up the changes which took place in the vegetation, the marsh in 1944 presented a nearly solid growth of cat-tail, traversed by winding channels, bordered on the outer side by a tree-covered barrier beach. Considerable areas were covered by wild rice, but it had been declining in amount. Outside the beach, bands of cat-tail and bulrush extended into the lake. A zone of sedge-meadow stretched along the inner side of the marsh, with stands of reed thrusting out into the cat-tail. Large patches of swamp thicket were either present in the cat-tail or had been present shortly before.

In 1946 nearly two-thirds of the reed-marsh vegetation (involving seven species) disappeared, and the area was taken over by submerged aquatic plants, with a lesser increase of floating-leaf forms. The barrier beach was partially destroyed

Plate 12



Band of seedlings on exposed mud bank, July. These plants include Typha, Scirpus, Sagittaria; mud bank exposed in early summer.



Cat-tail invading stand of wild rice, in cat-tail die-off area.

and pushed back during a period of high water and a great many of the trees on it killed. The marsh extended inward from the lake at the expense of sedge-meadow and farmland.

In 1948 the emergent vegetation began coming back in the marsh, first on sections of bottom which floated up, then on the mud flats exposed by decreasing water levels. After a brief resurgence, wild rice declined to its 1944 extent. In two years, 1948 and 1949, the emergent plants regained 18.5 per cent of the area they had lost (Table 6). Some, but not all, of the cultivated land was reclaimed by the farmers.

Ecological Consequences of the Die-off

A greater diversity existed than before the die-off, as Scirpus and Sagittaria were established in locations formerly covered by Typha and Phragmites, and mud bank plants covered rather large expanses. There was a shift in the relative importance of the two species of Typha; in 1944 the percentage of T. glauca was 76 per cent and that of T. angustifolia was 24 per cent. In 1949 T. glauca included 88 per cent of the area in cat-tail, and T. angustifolia, 12 per cent. The shift will continue for a while since T. glauca is regaining its former distribution three times as fast as T. angustifolia; in 1949, 23.7 per cent of the lost ground had been recovered by one, 7.5 per cent by the other. Probably Typha will continue to spread until it covers nearly all its former extent, except some places where the bottom has been eroded. It will probably crowd out the Sagittaria but the new stands of Scirpus will very likely survive.

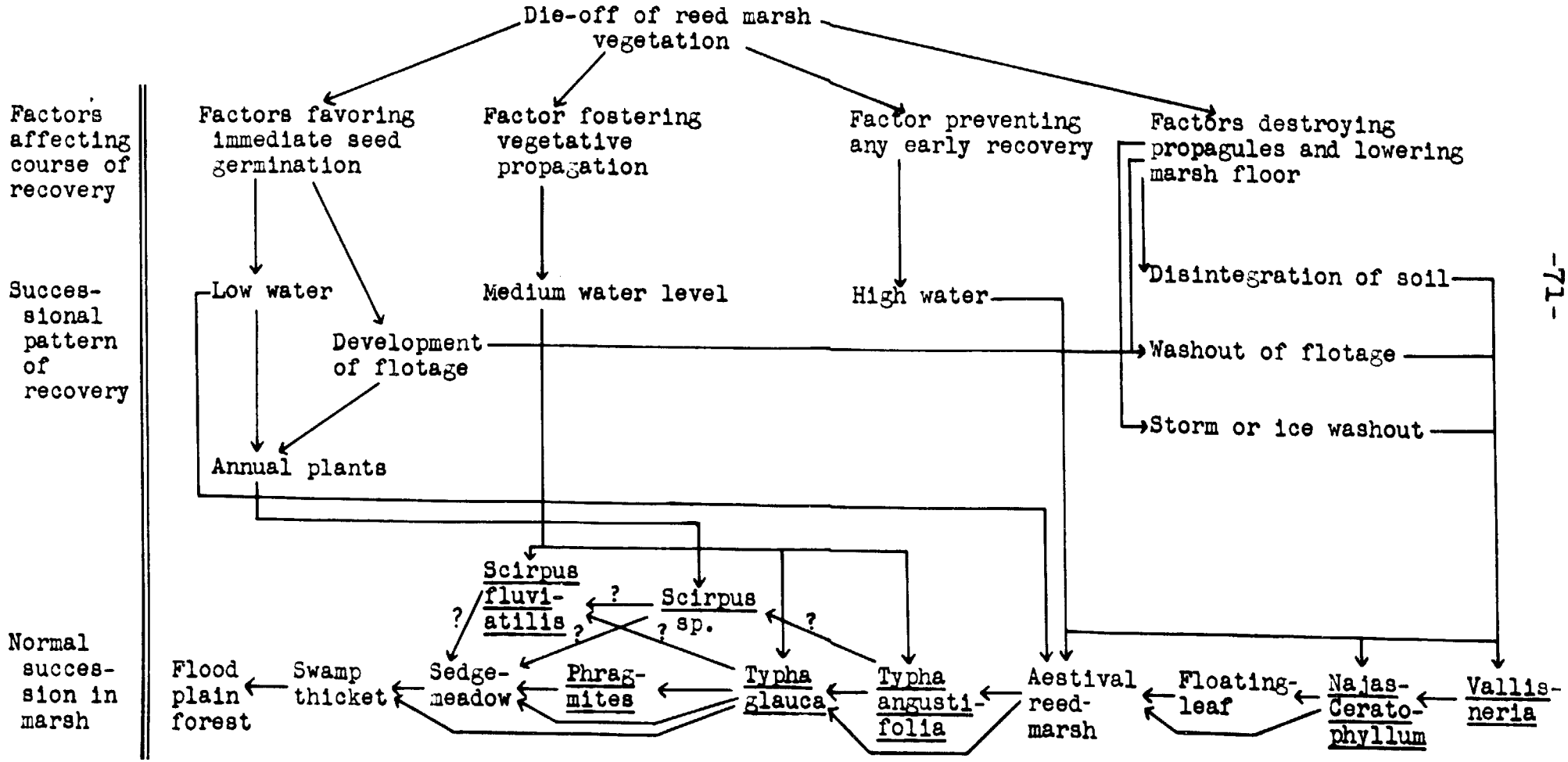
The succession patterns described above may be summarized according to the presence and operations of various factors which speed up recovery, slow down recovery, or prevent it entirely. Figure 13 presents such a summary, showing the various stages of succession produced by operation of any one factor. These factors and much of their operation are the same as those described as following muskrat "eat-outs" in Louisiana (Lynch, O'Neil, and Lay, 1947), and Figure 13 is an adaptation of one given in the above paper. This similarity is to be expected even though the cause of destruction and the climax vegetation is different, as marshes have the same physical conditions and marsh vegetation has the same manner of growth, so that there are only a limited number of possible reactions.

The marsh was actually improved for waterfowl during the die-off period. Large blocks of non-productive cat-tail were transformed into open flats which produced plants used as food by waterfowl. The increase in acreage of submerged aquatic plants was all gain as far as waterfowl were concerned. In addition the amount of wild rice was increased. Although red-wings and bobolinks take a large portion of the wild rice crop, some is left which the waterfowl may take.

At the present time the emergent vegetation is in much smaller units or segments than before the die-off, so that the amount of edge, particularly that in contact with open water, is greatly increased. Table 7 shows the comparative numbers of units in 1944, as far as is known, and in 1949. The total number increased 2.8 times, and the average size declined from

Figure 13

Ecological Consequences of Major Die-off of Marsh Vegetation





11.0 to 2.9 acres. During the period of high water this change could have had a great effect on the nesting of coots and gallinules, which ordinarily require open water near the nest. New nesting habitat was available to them as a result of this breaking up of large blocks. Black terns require for nesting a substrate rising above the water, near cover; they often use muskrat houses. The lack of muskrat houses for their nesting was compensated by the presence of flotage in the newly formed openings.

TABLE 7

NUMBER AND SIZE OF UNITS OF COVER, MOUILLÉE DISTRICT

Cover Type	1944			1949		
	No. of Units	Avg. Size Acres	Max. Size Acres	No. of Units	Avg. Size Acres	Max. Size Acres
Carex-Calamagrostis	34	10.4	80.6	47	4.7	37.3
Scirpus-Typha	2	7.8	12.0	31	6.7	20.4
Phragmites	20	9.6?	46.5?	90	0.7	3.0
Scirpus sp.	...	...	...	40	1.3	38.0
Typha glauca	82	14.4	282.0	208	4.0	201.0
Typha angustifolia	58	6.3	55.0	105	1.1	10.0
Zizania	2	32.7	40.9	21	2.9	41.4

The amount of cover available for waterfowl was reduced little; it was just shifted in location. The rear portions of the cat-tail stands had been too solid and unbroken to be of value; the die-off penetrated them in many little spots and tongues which were readily available under the conditions of

higher water levels. An area was thereby opened up in partial compensation for the area that had been destroyed. This new tract was available for shelter to river ducks as well as for nesting of coots and gallinules. Duck nesting habitat on high ground was perhaps made more accessible by the high waters which reached into the meadows and ditches behind the cat-tail and by the new ditches dredged in the farm lands.

Since 1947 the emergent aquatic plants have been closing in the shallow flats, and have reduced the expanse producing submergent waterfowl food plants. However, to a large extent these invading emergents have also produced waterfowl foods. The Scirpus and Sagittaria, as well as many of the mud bank annuals, are important food plants and have covered areas formerly dominated by cat-tail. Typha will recover some of this area but probably not all of it, leaving a gain in acreage of emergent plants furnishing waterfowl foods.

Habitat for muskrats was greatly reduced by the die-off. It seems probable that the large population of muskrats in 1946 would have made heavy inroads on the cat-tail that was left if this population had not been reduced by disease. Since then the muskrats have slowly increased, but they are still far from filling up the available habitat.

CHAPTER IV

BIOTIC COMMUNITIES OF MOUILLÉE MARSH

Previous Studies on Marsh Communities

A number of studies have been made which treated some phase of the ecology of marsh communities. Most such studies have dealt with succession of the plant communities of a large area which included marsh or aquatic habitats. Gates (1912) reported on the vegetation and plant succession of a beach area near Lake Michigan. Sampson (1921) investigated the prairie communities in Illinois, including the hydrosere leading to prairie. Detmers (1912) described in detail the aquatic and marsh plant communities of Buckeye Lake, Ohio. The development and succession of aquatic communities in the English lakes was worked out by Pearsall (1920) and Misra (1938), with special attention to the influence of soil and bottom types.

The stratification in reed-marsh vegetation was described by Yapp (1909), and the resulting differences of air temperature and humidity within the community measured. Sherff (1912, 1913) also measured the differences in humidity at various levels of marsh vegetation. The interrelationships of the subterranean organs of reed-marsh plants were worked out by Sherff (1912). The distribution of some species of aquatic plants in Michigan in relation to soils was analyzed by Veatch (1933). The relationships of aquatic plants of the Illinois

River Valley to fluctuating and stable water levels has been described by Bellrose (1941).

The weight or mass of aquatic plants in some lakes in Wisconsin was measured by Rickett (1922, 1924) and Wilson (1937). Low and Bellrose (1944) measured the seed and vegetative yield of waterfowl food plants in Illinois, including many marsh as well as strictly aquatic plants. The weight of rhizomes in a cat-tail marsh was recorded by Claassen (1919).

A very few studies have considered both plant and animal relationships within marsh communities. Hankinson (1933) classified the fishes of the inland lakes of Michigan as to their habitat, listing the species associated with various bottom types and plant communities. The bottom communities of western Lake Erie were described by Shelford and Boesel (1942). Although no plants were included in these communities and the habitats dominated by plants were regarded as stages of succession leading to land, the importance of the larger plants to the lake communities was emphasized.

The plant communities of the hydrosere on Lake Cayuga in New York were studied by Allen (1914) and the vertebrates associated with the various zones were listed. Aldrich (1943) made a biological survey of the bogs and swamps of northeastern Ohio and determined the breeding bird and small mammal populations of each zone. Beecher (1942) made a breeding bird census of a glaciated area in northern Illinois which included lake marsh and a kettlehole pond. His report included a description of the succession of plant communities on the area and the species and numbers of birds nesting in each community. The

insects of particular marsh plants have been recorded by Claassen (1921), A. C. Cole (1931), and Frohne (1938); the last paper refers to other studies of insects of aquatic plants as well.

Many studies have been made of the life history or breeding of individual species of animals, and in such studies the habitat is described in more or less detail. Such investigations include examples from all major groups of animals. All species of marsh and aquatic birds are treated in the series of life histories of North American birds by Bent (1919-1929). Accounts of nesting and other activities of marsh birds have been given by Provost (1947) and Saunders (1926) and individual species of birds have been treated by other authors.

Numerous papers have been written on various aspects of the ecology and life history of waterfowl. Studies which have emphasized the habitat relationships include nesting studies in the Bear River marshes (Williams and Marshall, 1938), the life history of the blue-winged teal (Bennett, 1938), the ecology of the red-head (Low, 1940), and the life history of the canvasback (Hochbaum, 1944). The utilization of aquatic plants as food by waterfowl has been summarized by Martin and Uhler (1939) and McAtee (1939).

There is a large amount of literature concerning the muskrat. Its life history and relation to marshes have been treated at length by Johnson (1925). Errington (1943, 1948) has discussed many phases of the life history and ecology of the muskrat. Food habits have been treated by Butler (1940)

and Enders (1932) among others. The productivity of muskrats and other fur animals of small marshes in Illinois was calculated by Yeager (1945), and some relationships of muskrats to marsh and river conditions described by Bellrose and Brown (1941).

The ecological relationships and effects of carp on vegetation in large lakes were studied by L. J. Cole (1905) and Struthers (1930). The effects of carp on aquatic vegetation when confined in small bodies of water have been described by Black (1946), Titcomb (1923), Cahn (1929), and Anderson (1950). Carp were shown to control the aquatic vegetation in such enclosed ponds but not that of large lakes. Ricker and Gottschalk (1941), Bellrose (1941), and Anderson (1950) have described the development of aquatic vegetation following removal of carp and other rough fish.

There is great variation in the makeup of the communities described in the papers mentioned above. The plant communities fall into the major groups classified as associes by Weaver and Clements (1938), but the minor divisions of these associes differ with each study. The divisions of the vertebrate animals correspond to the plant associes, and they do not show the minor groups recognized among the plants. The physical conditions, especially depth of water, and the form and density of the vegetation seem much more important to the vertebrates than do the species of plants, except from the standpoint of use of plants as food.

Communities of Mouillée Marsh

The plant communities evident in the Mouillée District are listed in Table 8. Following each community is given the designation according to the classification of Weaver and Clements (1938). The succession of the marsh communities is shown in Figure 13, and the conditions and relationships of these communities will be discussed in detail. In addition the distribution by associes for all the plants identified on the state marsh is given in Table 12. Although listed in Table 8, the climax beech-maple forest is not now present in this district, having been destroyed since 1817. The flood-plain forest does not occur on the State Game Area.

TABLE 8

PLANT COMMUNITIES OF THE MOUILLÉE DISTRICT

Hydrosere

Submerged plants (associes)

Wild celery, Vallisneria (facies)

Bushy pondweed-Coontail, Najas-Ceratophyllum (facies)

Bladderwort-Coontail, Utricularia-Ceratophyllum (relict)

Floating-leaf (associes)

Water-lily, Nymphaea-Nuphar (facies)

Aestival reed-marsh (ecotone)

Stiff wapato, Sagittaria rigida (consocies)

Wild rice, Zizania (consocies)

Reed-marsh (associes)

Narrow-leaved cat-tail, Typha angustifolia (consocies)

Blue flag, Typha glauca (consocies)

Round-stem bulrush, Scirpus sp. (consocies)

River bulrush, Scirpus fluviatilis (consocies)

Reed, Phragmites (consocies)

Sedge-meadow (associes)

Bulrush--cat-tail, Scirpus-Typha (facies)

Sedge--blue-joint grass, Carex-Calamagrostis (facies)

Wet meadow (associes)

Swamp thicket (associes)

Flood-plain forest (associes)

Beech-maple forest (climax association)

Hydrosere--mud bank

Mud bank (colony)

Flotage (colony)

Islands

Wet meadow (associes)

Meadow thicket (associes)

Beach

Sand beach (colony)

Sand meadow (associes)

Sand-bar thicket (associes)

Cottonwood-willow, Populus-Salix, grove (associes)

Abandoned fields

Spoil banks

The vertebrate animals are not restricted to these minor divisions, nor even to the associes, but range across them or go outside the marsh entirely. Some animals may use one community for shelter, food supply, and place of

reproduction, while others utilize two or three communities for these necessities. For example, the coot and gallinule nest in the reed-marsh communities and seek shelter there, but feed in the submerged plant and floating-leaf communities; the marsh wren nests, hides, and feeds within the reed-marsh community. The red-wing nests and roosts in the reed-marsh communities; feeds in the floating-leaf, reed-marsh, and sedge-meadow communities for a part of the time; but at certain seasons procures all its food in fields beyond the marsh. Swallows are an example of species which have most of their activity away from the marsh, but feed in the air over the marsh communities and at certain seasons roost in the reed-marsh.

Description of Individual Communities

Wild Celery (Vallisneria) or Open Water Community

This community is present in the channels and the bay almost everywhere that any current is present or strong exposure to winds occurs (Figure 18). The soil is fine silt, clay, or sand, and the community is absent or less vigorous in areas of deposition of plant debris in the bay and channels. The depth of water ranges from one to eight feet. The plants reach the surface in late summer in four feet of water or less, and the ends of the leaves and the fruits float at the surface.

Extensive spread of this community in recent years has taken place up the channels and in deeper areas where the emergents died out. The total extent in 1949 was approximately 416

acres, and at least 110 acres of this represents recent spread into the die-off section. The extent previous to the die-off is not known. This group of species is largely the same as that in the deeper waters of stabilized lakes in the Illinois River Valley and the succession is similar to that occurring after stabilization of those lakes (Bellrose, 1941).

The dominant plant is Vallisneria americana, with Heteranthera dubia common as a subdominant, particularly in looser soil. Potamogetons and other plants are present along the edges and in shallower spots. The frequency of occurrence of submerged aquatics growing with Vallisneria in the die-off area is shown in Table 9; these samples, however, are not typical of the older stands in deeper water.

TABLE 9

FREQUENCY OF AQUATIC PLANTS FOUND WITH VALLISNERIA, DIE-OFF AREA, 1949 (52 samples, 0.076 sq. m. per sample)

Vallisneria americana	100
Ceratophyllum demersum	35
Najas minor	27
Heteranthera dubia	21
Spirodela polyrhiza	17
Lemna minor	15
Potamogeton crispus	8
Najas flexilis	4
Elodea canadensis	4
Potamogeton pectinatus	4
Potamogeton Richardsonii	4

Small fish, especially brook silversides, are common at the surface in this community. Larger fish, particularly predators, are frequent. The community furnishes food to many birds, particularly in the winter months. Great numbers of diving ducks and swans feed in this community during the late fall and early spring, eating the rhizomes and winter buds of Vallisneria. Many flocks of ducks simply rest on the surface, using the area for refuge. In the shallower areas coots commonly dive for food in the late summer. Other birds feed on the small fish of this community, plunging for them from the air (gulls, terns, and kingfisher), or, like the mergansers, pursuing them under water. The gulls very frequently take fish from the mergansers when the latter emerge at the surface. Mergansers are abundant and characteristic of this community from late fall till early spring, whenever the surface is unfrozen. The ducks help keep small areas open until midwinter by their activity.

Species of birds observed here were: Horned Grebe, Pied-billed Grebe, Whistling Swan, Canada Goose, Mallard, Black Duck, Baldpate, Red-head, Canvas-back, Greater Scaup, Lesser Scaup, Ring-necked Duck, American Golden-eye, Buffle-head, Ruddy Duck, Hooded Merganser, American Merganser, Red-breasted Merganser, Coot, Herring Gull, Ring-billed Gull, Common Tern, Caspian Tern, Kingfisher, Barn Swallow, Bank Swallow, and Tree Swallow.

Bushy Pondweed-Coontail (Najas-Ceratophyllum) Community

This community occurs in protected ponds, shallow

flats, and at edges of channels. The soil is soft silt or muck, with much organic matter. Water depth is six inches to four feet; very little current is present. The growth is very dense, with vegetation thick at the surface, and usually a very mixed assortment of plants is present.

During the period of the study this community spread to cover nearly all the area left bare by the die-off of emergent plants. The community covered 473 acres in the Mouillee District in 1949, of which 379 acres were in the die-off area and represented this recent spread. The extent in 1944 is not known, but the extent of the two submergent plant communities together was about 400 acres in 1944, contrasted with 890 acres in 1949. Table 10 gives the frequency of occurence of species in samples in the die-off area in 1949; these samples appeared typical of the community. The stands of the floating-leaf pondweeds are so small that they could not be mapped separately, and are included in this community. The species of plants are much the same as those in the semistabilized lakes of the Illinois River Valley and the development of the community here is similiar to the development in those lakes following a change from a fluctuating to a semistabilized type (Bellrose, 1941).

This community serves the fish particularly as a nursery. During the summer months schools of small fish are present everywhere among the fronds of vegetation. Larger predacious fish may enter this habitat at night to feed (Hankinson, 1933). The carp is always present in numbers, rooting up the mud or noisily sucking in food at the surface. In the late summer young carp are common here, hiding beneath the dense mats of

vegetation or buried in the mud. No effect on the vegetation by activity of the carp was observed during this study. Snapping turtles and painted turtles are frequently seen.

TABLE 10

FREQUENCY OF AQUATIC PLANTS IN NAJAS-CERATOPHYLLUM COMMUNITY, DIE-OFF AREA, 1949 (236 samples, 0.076 sq. m. per sample)

Ceratophyllum demersum	67
Najas minor	62
Heteranthera dubia	26
Elodea canadensis	20
Lemna minor	11
Potamogeton foliosus	11
Potamogeton crispus	11
Spirodela polyrhiza	9
Potamogeton pectinatus	9
Najas flexilis	5
Myriophyllum verticillatum var. pectinatum	5
Utricularia vulgaris	5
Potamogeton zosteriformis	2
Potamogeton Richardsonii	1
Potamogeton amplifolius	1
Zannichellia palustris	1
Chara sp.	Not found in samples, present elsewhere in community.
Potamogeton nodosus	
Sagittaria latifolia	
Potamogeton natans	
Wolffia columbiana	

As far as birds are concerned, this community is used primarily for a feeding place. Throughout the summer it is the most important feeding area for coots, gallinules, grebes, and herons. These birds, except the herons, feed both on the plants and on the animals associated with them. The dabbling ducks begin congregating here in early summer, first only the males from breeding pairs in the vicinity, then later mixed flocks of locally breeding species, and in late August flocks of migrating ducks from the north. Gulls and terns, particularly the black tern, pick up their food from the air, and the duck hawk pursues the other birds in the area. Some shore birds wade about in the shallow water, probing in the mud, or feeding on small fish in the case of the greater yellowlegs.

In 1949 several nests of the pied-billed grebe were found in this community, floating in the open. This is interpreted by the author as a response to the lowered water levels, since most of the cat-tail patches in their vicinity were out of the water and therefore presumably unavailable. Such exposed nests were not found the two previous summers, when all reed-marsh species were standing in water. The material used in these nests included water-lily pads as well as plants from this community.

Species of birds seen here include: Pied-billed Grebe, Great Blue Heron, American Egret, Little Blue Heron, Whistling Swan, Mute Swan, Canada Goose, White Pelican, Mallard, Black Duck, Gadwall, Pintail, Blue-winged Teal, Green-winged Teal, Baldpate, Shoveller, Wood Duck, Red-head, Bald Eagle, Duck Hawk, Florida Gallinule, Coot, Greater Yellowlegs, Lesser

Yellowlegs, Pectoral Sandpiper, Red-backed Sandpiper, Northern Phalarope, Herring Gull, Ring-billed Gull, Common Tern, Black Tern, Barn Swallow, Tree Swallow, and Bank Swallow.

Bladderwort-Coontail (Utricularia-Ceratophyllum) Community

This stage was present on the die-off area in 1947, and represents a retrogression, or a relict of the former vegetation. Utricularia vulgaris is normally present in the water within the cat-tail or other emergent types, and this species remained and flourished for two summers after the disappearance of the emergent growth. It then disappeared, however, and in 1949 Utricularia was very rare in locations where it had been dominant in 1947; its place was taken by the Najas-Ceratophyllum community.

The disappearance of the Utricularia was perhaps hastened by the activity of the carp. They swam and fed through the area, stirring up the loose fibrous debris on the bottom and tearing the bladderwort loose, until in late summer many patches were free of vegetation. The habitat was probably not entirely suitable, however, as the Utricularia survived in more shady areas--in the vicinity of water-lily pads, for example. Utricularia is tolerant of high organic acid content (Steenis and Cottam, 1945), and this adaptation may also contribute to its survival in the cat-tail.

The vertebrate relationships of the Utricularia-Ceratophyllum community are the same as those in the Najas-Ceratophyllum community, with the same species present, although perhaps in reduced numbers.

Floating-leaf (Nymphaea-Nuphar) Community

This community grows in scattered patches, in pools and channels with very little current. The soil is very fine soft muck, and the water is six inches to five feet deep. The leaves are easily torn by wind or wave action, which restricts growth to protected areas.

The floating-leaf community regularly covers the surface of the small pools so typical of the narrow-leaved cat-tail stands. Protected channels are usually lined or even covered by this group (Figure 20). It spread extensively following the cat-tail die-off. The total extent in 1949 was about 115 acres, not counting the pools within cat-tail stands; the extent on the die-off area was 87 acres.

The dominant species of this community is fragrant water-lily, Nymphaea odorata, with scattered patches of spatterdock, Nuphar variegatum and Nuphar advena, and American lotus, Nelumbo lutea. In all cases the community forms a close, almost continuous cover over the surface, with the water relatively open below. Nuphar and Nelumbo frequently extend six inches to two feet out of the water, to form a dense patch of low-growing leaves. Submerged aquatic plants are present, and Utricularia vulgaris is characteristic here. The duckweeds are abundant, filling up the spaces on the surface between the lily pads. Table 11 shows the frequency of occurrence of aquatic plants in some samples taken at the edge of this community in the die-off area.

TABLE 11

FREQUENCY OF AQUATIC PLANTS OCCURRING WITH NYMPHAEA, DIE-OFF AREA, 1949 (12 samples, 0.076 sq. m. per sample)

Nymphaea odorata	100
Spirodela polyrhiza	100
Lemna minor	92
Ceratophyllum demersum	58
Najas minor	50
Utricularia vulgaris	42
Heteranthia dubia	25
Elodea canadensis	25
Potamogeton crispus	17
Vallisneria americana	8
Wolffia columbiana	Not present in samples but found elsewhere in community
Nuphar advena	
Nuphar variegatum	
Nelumbo lutea	

Vigor of the lotus, Nelumbo lutea, was reduced by deep water in 1947 and 1948; the leaves floated on the surface instead of lifting out of the water, and no flowers were present. In Tennessee Nelumbo is reported to thrive and spread in 6 feet of water (Hall and Penfound, 1944), and in 5.5 feet in Ohio (Detmers, 1912), but here it just survived in 3 feet of water. In 1949, in 1.5 feet of water, it produced large numbers of flowers and spread considerably. At some time in the past, according to Mr. Edward Lezotte, lotus covered an extensive area around the spot known as Jackson's Island, a former muck island lately under four to five feet of water. No lotus is

present at this station now.

Since this community occurs only in small patches or narrow strips it does not have many vertebrates associated with it. Large predacious fish commonly seek shelter under the floating leaves. The presence of the leaves at the surface or in the air above it gives support to birds that cannot enter the water. The spotted sandpiper is very frequently seen running over the floating leaves, and red-wings, bobolinks, and least bitterns light on these leaves to feed. Flocks of red-wings and bobolinks are particularly common on Nelumbo in late summer, perhaps attracted by the large number of insects present. Coots, gallinules, and grebes regularly feed in this community, especially where it adjoins or borders other habitats of theirs. Many of the dabbling ducks are common here, in the pools and channels.

At night coots and gallinules regularly roost among the emergent leaves of Nelumbo and Nuphar. Grebes also spend the night in such patches. Grebes use lily pads as part of the material in their nest masses; this was especially noticeable in the nests built out in the open.

Stiff Wapato (Sagittaria rigida) Community

The stiff wapato community occurs along the edges of some channels and in relatively protected open areas (Figure 21), in water one to four feet deep. The soil is soft muck or silt and muck. At most locations there is a very slight current.

This community can be regarded as a transition type or ecotone between the submergent and emergent aquatic plants.

The leaves are emergent but do not develop until late June or July and are cut down by the first frosts, so that cover is provided only during late summer and early fall. For this reason it has been placed in a group called aestival reed-marsh.

The dominant species is Sagittaria rigida, but two patches of duck potato, Sagittaria latifolia, are also included. The leaves of S. rigida reach a height of four feet above the soil and those of S. latifolia a height of five feet. Since no emergent growth occurs until early summer the submerged aquatics flourish at first, and the common aquatic plants of the Najas-Ceratophyllum community are present. Duckweeds, Spirodela and Lemna, are abundant on the surface among the stalks of wapato.

Some stands disappeared during the period from 1944 to 1947, but extensive colonization occurred during the same period, so that new stands developed. The community covered 16.8 acres in 1944, 23.6 acres in 1947, and 24.2 acres in 1949.

Relatively few birds utilize this community, especially in the summer. The coot and gallinule and their broods feed in the area and roost among the thick leaves in late summer. The least bittern and great blue heron use the masses of leaves as stations for feeding, and the night heron occasionally does so. The red-wing climbs over the leaves looking for food. Wood ducks are present in these patches during the day in the late summer. In the fall and winter swans and diving ducks feed in this area in numbers, presumably at least partly on the rhizomes of the dominant plant in the community. Late summer nests of the coot

are sometimes found here, floating among the leaves.

Wild Rice (*Zizania aquatica*) Community

Wild rice is present along the edges of some channels and in shallow open areas, in water six inches to three feet deep. The soil is deep soft muck with little fibrous organic matter.

This community also presents emergent cover only during late summer and early fall. The leaves first appear floating on the surface in late June, and lift up into the air in July. The plant flowers in late July. A dense, continuous cover is never formed, but in a good stand the cover is medium dense to a height of three feet, and the flowering stems reach a height of six feet. The stems are broken down by birds and late summer storms and have disappeared by the first frosts. The submerged aquatic plants of the *Najas-Ceratophyllum* community have a good development here, and are almost as abundant as in areas devoid of wild rice.

In 1910, as shown in Figure 10, wild rice covered nearly all the area of the marsh. Between that time and 1944 it was largely replaced by cat-tail. In 1947, the second summer after the disappearance of the cat-tail, the wild rice was spreading into the vacant areas, and many new colonies appeared. This spread has been slowed down or stopped by the revival of the cat-tail and the increase in muskrat population. The area covered by this community was 65.3 acres in 1944, 78.6 acres in 1947, and 58.8 acres in 1949.

Large numbers of birds feed in this area. Coots and gallinules feed here extensively, and many dabbling ducks are

present in late summer and fall. Immense flocks of red-wings and bobolinks feed on the grain in late summer while it is still on the stalks, and break down the stems. Coots occasionally use the stems in making a so-called courting platform or false nest in late summer. The green stems are cropped by muskrats (and the leaves perhaps by coots), entire patches being cut in the summer of 1949. Many stems were uprooted during the early part of the growing season, perhaps by action of carp. This uprooting, however, was not extensive enough to prevent spread of the stands, and it did not appear that carp could be blamed for the disappearance of wild rice during the past few years, even though carp have been shown to quickly destroy wild rice in experimental ponds (Black, 1946).

In 1900, twenty years after the introduction of the carp, complaints and claims were common that this fish was responsible for destruction and disappearance of aquatic vegetation, especially wild rice and wild celery. Such complaints were particularly strong in the western Lake Erie region, and a special investigation was made by the Bureau of Fisheries (L. J. Cole, 1905). The general conclusion of the investigation was that such destruction of vegetation by the carp was probable but not proven. Carp fisheries, and perhaps carp populations, reached their greatest tonnage in 1908 (Koelz, 1926), yet, as we have seen, wild rice covered most of this marsh in 1910.

It seems more likely that successional changes are responsible here for the disappearance of wild rice, with fluctuating water levels important in some years. It has been

stated that wild rice is probably the most sensitive of the important waterfowl food plants, as a rise of six inches during June or July frequently will greatly reduce the crop, and a rise of a foot will nearly eliminate it (Moyle and Hotchkiss, 1945). The water level of Lake Erie rises two inches on the average from May to June, and rises as much as six inches in some years (U. S. Lake Survey, 1950).

Narrow-leaved Cat-tail (Typha angustifolia) Community

This community is present on Houghton muck, in one to four feet of water. It covers the central portion of the marsh, in the deeper water.

The narrow-leaved cat-tail community consists of exclusive stands of Typha angustifolia, a tall emergent species of the reed-marsh. Although the plant is herbaceous, the stems are sturdy and remain standing through the winter and summer following their death.

This species of cat-tail grows in clumps one to three feet in diameter, which rise six to twelve inches above the soil surface and are six inches to two feet apart. These tussocks are shown in Figure 16, which gives the surface profile on transects progressing from T. angustifolia to T. glauca. The soil between the clumps is very soft muck, and there is little spread by rhizomes between the clumps. Frequently tussocks at the edges of stands break loose from the soil. These clumps may drift and take root some other place, or else tip over and die. The tips of the leaves rise to an average level ten feet above the soil or six to nine feet above the water surface. In the winter the dry leaves and stems break off at

an average height of 4.5 feet above the soil surface.

The stands are characterized by many small pools and openings scattered through the cat-tail, which close up only very slowly. Such pools are usually covered by water-lily (Nymphaea odorata). The submerged aquatic plants Utricularia vulgaris, Ceratophyllum demersum, and Najas minor are common in these pools, and the Utricularia grows in the water throughout the cat-tail stands.

The open character of this type was shown by the cover map of 1944, made by personnel of the Game Division, Michigan Department of Conservation. When this map was made, the species of cat-tail were not distinguished, but stands were marked according to density. The criteria for the three degrees of density used were: (1) Light stand, easily negotiable by boat; (2) Medium stand, with small pools interspersed; (3) Dense stand. Investigations by the author have shown that of the Typha angustifolia, 26 per cent was in type 1, 43 per cent in type 2, and 31 per cent in type 3. In contrast, of the other species of cat-tail present, Typha glauca, 0.7 per cent was in type 1, 23 per cent was in type 2, and 76.3 per cent was in type 3. There were sixty-five acres in types 2 and 3 that cannot now be identified as to species.

In 1944 narrow-leaved cat-tail covered 366.5 acres in the marsh. Much of this area was the portion shown as being covered by wild rice in 1910. In 1945, the cat-tail started dying out, and in 1947 this species of Typha covered only 94.1 acres. In 1948 cat-tail began regaining ground, but T. angustifolia spread very slowly, and covered only 114.5 acres in 1949.

For the first time in this series we have a community in which the old growth persists above the water to provide cover the year round. This is very important in regard to the animal relationships; indeed, this community provides more cover than food. It still furnishes food for many carp, which are found particularly in the pools; and turtles are occasionally seen. It is important as a nesting area for the coot, gallinule, pied-billed grebe, prairie marsh wren, and red-wing, and sometimes for the least bittern. The red-wing commonly fastens its nest to the old stubs, and the marsh wren frequently does so. The other birds use the new green shoots for anchorage or support, but they all use some old remains as nest material.

The growth habit makes this form particularly suitable for nesting by grebes, coots, and gallinules. These birds prefer nesting near open water (channels and pools) in medium dense growth, with the water twelve to eighteen inches deep. The presence of numerous interior pools and channels in a narrow-leaved cat-tail stand makes all the stand available for nesting. The average distance of 451 coot nests in Iowa from channels ten feet or more wide was 17.7 yards (Sooter, 1941). In the narrow-leaved cat-tail this distance is very nearly the maximum possible distance from such pools and channels, and the average distance of nests from such open water was much less.

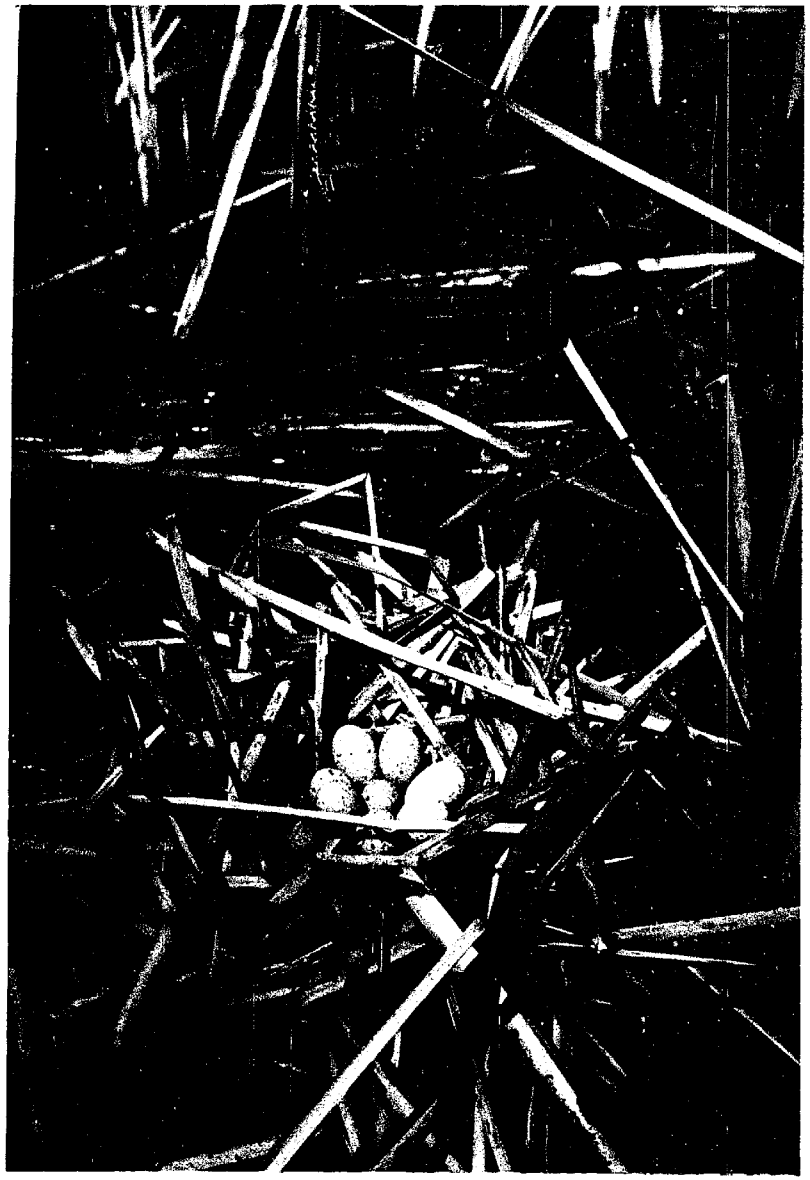
The least bittern and night heron use stands of narrow-leaved cat-tail for roosts and shelter, particularly in late summer. The red-wings and starlings form flocks after the nesting season and roost here, gathering by thousands in early

fall. The coots and gallinules use this community for brood shelter, taking their young out into the open to feed but fleeing quickly into the cat-tails when threatened; then later they roost here, breaking down the tops of the leaves to form a platform. The marsh hawk hunts regularly and habitually over this area; young coots and gallinules are frequently the objects of its attacks. The short-eared owl roosts here in fall and winter. Many ducks feed or hide in the sheltered pools; the wood duck, in particular, characteristically hides in the cat-tails during the day.

Species of birds seen here were: Pied-billed Grebe, Great Blue Heron, Black-crowned Night Heron, Least Bittern, Mallard, Black Duck, Blue-winged Teal, Wood Duck, Marsh Hawk, Ring-necked Pheasant, Sora, Florida Gallinule, Coot, Short-eared Owl, Tree Swallow, Bank Swallow, Prairie Marsh Wren, Starling, Bobolink, and Red-wing.

Muskrats are very active in this community. They feed on the rhizomes and shoots of the cat-tail, and build their houses here. Dozier (1945) believed that the muskrats in the Montezuma marsh of New York preferred Typha glauca to Typha angustifolia. No such preference for T. glauca can be detected here. The aerial photographs of September, 1940, show the muskrat houses almost exclusively confined to the T. angustifolia area, and those of May, 1949, show them about equal in the two types. The water level was about a foot lower at the time of the earlier photograph, which may have influenced the greater concentration of houses in the type growing in deeper water.

Plate 13



Coot nest built of cat-tail stems. The nest is floating, in a dead stand of cat-tail.



Pied-billed Grebe nest. A floating nest was constructed largely of cat-tail debris.

Blue Flag (*Typha glauca* or *T. angustifolia* var. *elongata*) Community

This cat-tail community occurs on the broad shallow flats on the inner side of the marsh and over clay ridges rising near the surface in deeper waters. It also forms a band around the islands and along the beach. The soil is Houghton muck, Clyde clay, or Griffin silty clay. In a few places the rhizomes of this cat-tail grow in a network over thin muck, but elsewhere the soil consists of a solid substrate. The water depth ranges from zero to about two feet.

The *Typha glauca* community is another reed-marsh community, with stems that remain standing after death and provide permanent cover. When the stems are green, dense cover is provided to a height of ten feet; after they become dry in the fall, they break off at a height of 4.5 feet above the soil. The dominant plant is *Typha glauca*, but a few small stands of *Typha latifolia* are present in higher portions of this community. Other common plants are *Utricularia vulgaris*, *Lemna trisulca*, *Lemna minor*, *Spirodela polyrhiza*, *Riccia fluitans*, *Ricciocarpus natans*, and occasionally *Polygonum coccineum*. On the inner border scattered plants of *Carex stricta*, *Calamagrostis canadensis*, and *Phragmites* are common, probably representing relicts from sedge-meadow and reed supplanted by cat-tail during the wet years. This species of cat-tail grows primarily in solid continuous stands, with few breaks except the permanent channels or openings cut by muskrats.

Typha glauca replaced wild rice in some areas between

1910 and 1944. The map of 1910 (Figure 10) shows cat-tail present along the inside of the marsh, in areas covered by this species today. If this is still the same species, some stands of cat-tail have persisted here for forty years. It is possible that a succession of Typha species occurred, as muck deposits are over five feet deep in many places here, suggesting much deeper water, such as is typical of T. angustifolia, at an earlier period.

A large expanse of this community died out during the period 1945-1947. In the summer of 1947 several of the shallower flats in the die-off area were spotted with individual stems of cat-tail. These spread extensively the next two summers, so that large areas were recovered by Typha glauca. The area covered by this community was 1178.3 acres in 1944, 665.6 in 1947, and 841.6 acres in 1949. Spread was almost entirely vegetative, although a small amount of floating muck was seeded in by cat-tail. Around some stands vegetative growth exceeded twenty-five feet in one year, and the average spread was eighteen feet. Typha glauca spread extensively during the wet years into sedge-meadow.

Wildlife relationships are much the same here as in the previous community, but some differences develop from the change in water depth and the difference in growth habit. Portions of the community in deeper water have the same vertebrates that occur in the narrow-leaved cat-tail, but additional species are seen in the shallower, inner portions. Just as in the narrow-leaved cat-tail, a few carp feed within the stands, and painted and Blanding's turtles occur along the channels.

Bullfrogs, green frogs, and cricket frogs are common along the edges at least.

Shelter and nesting sites are provided for many birds. The nesting birds include coot, gallinule, prairie marsh wren, red-wing, least bittern, and pied-billed grebe. Brood shelter is provided for coot, gallinule, wood duck, black duck, and probably other ducks. Night herons, least bitterns, swallows, red-wings, and bobolinks roost above the water on the cat-tail stems; the last three congregate in large numbers. The sora, Virginia rail, and king rail were all seen here, although no nests were found. The yellow-throat occurs along the inner edge where a bush or tree is growing. Marsh hawks hunt over this area, and the short-eared owl appears in winter.

Dabbling ducks of many species feed or rest in the openings and channels, and roost on the muskrat houses. Even the Wilson's snipe may roost on muskrat houses. The black tern nests on the muskrat houses in the openings, and in many years these are perhaps the only nesting sites available to this bird. In the winter pheasants move in for shelter, and many sparrows are then found along the edges.

This cat-tail community is not as favorable for the nesting of coots, gallinules, and grebes as the narrow-leaved cat-tail. The denser habit of growth combined with shallower water prevents the utilization of considerable areas of this community by these marsh birds. In 1948 and 1949 their nests were principally confined to a narrow band of vegetation representing the new spread of the year before. An occasional interior pool or muskrat cutting provided an opening for some

nests, but these were infrequent. The nesting habitat for these birds seemed greatly increased here by the combination of the higher water levels and breaking up of solid stands of cat-tail by the die-off.

Species of birds seen in this community were: Pied-billed Grebe, Great Blue Heron, Green Heron, Black-crowned Night Heron, Least Bittern, Mallard, Black Duck, Blue-winged Teal, Wood Duck, Marsh Hawk, Ring-necked Pheasant, King Rail, Virginia Rail, Sora, Florida Gallinule, Coot, Short-eared Owl, Tree Swallow, Bank Swallow, Barn Swallow, Prairie Marsh Wren, Starling, Yellow-throat, Bobolink, Red-wing, Yellow-headed Blackbird, Savannah Sparrow, Tree Sparrow, and Song Sparrow.

The muskrat is extremely active in this community. Cuttings are abundant and houses are common. Tunnels are very much a part of the habitat here, as the soil is much firmer than in the previous cat-tail community. The muskrat cuts the stems around the house and digs up the rhizomes, so that an open pool is formed with the house in the center. The edges of such pools are frequented by gallinules and rails.

Round-stem Bulrush (Scirpus spp.) Community

This reed-marsh community is present in two distinct habitats--mud banks and floating islands in the marsh, and sandy shoals out in the lake. The first type grows on soft decomposed muck or silty soils in zero to two feet of water; the second type on hard sand over clay, in two to five feet of water. It is not known whether these two types represent

different species.

Although classed in the reed-marsh associes, the round-stem bulrushes scarcely provide year-round cover. While green the stems rise to a level six feet above the soil, but quickly break over after death and form a loose mat on the ground. In water this mat is carried off by wave and ice action. The species of round-stem bulrush in the marsh are Scirpus acutus and Scirpus validus var. creber. The lake stands have not fruited the last three years and their identity is not known. Some stands of three-square, Scirpus americanus, are present in the sand along the beach, and these stands have increased in number and extent the past two years. The mature bulrush stands in the marsh are almost devoid of any other plants. Young stands of seedlings include mixtures of other plants of the mud bank or flotage community. The lake beds have Vallisneria americana growing among them.

The extent of this community in 1944 is not known. The rather extensive lake beds were mapped but no stands were shown in the marsh, although at least a few patches were present. The lake beds declined in extent but survived during the period of high water, and a few small stands were still present in the marsh in 1947. As floating islands and mud banks appeared at the surface they were seeded in very quickly by Scirpus, and the community had increased greatly by 1949. This spread was aided by the fact that the plants flower and produce fruit the first year. Patches that survived the period of high water also spread by vegetative growth, at a rate of five to six feet per year. The extent of this community in the marsh

Plate 14

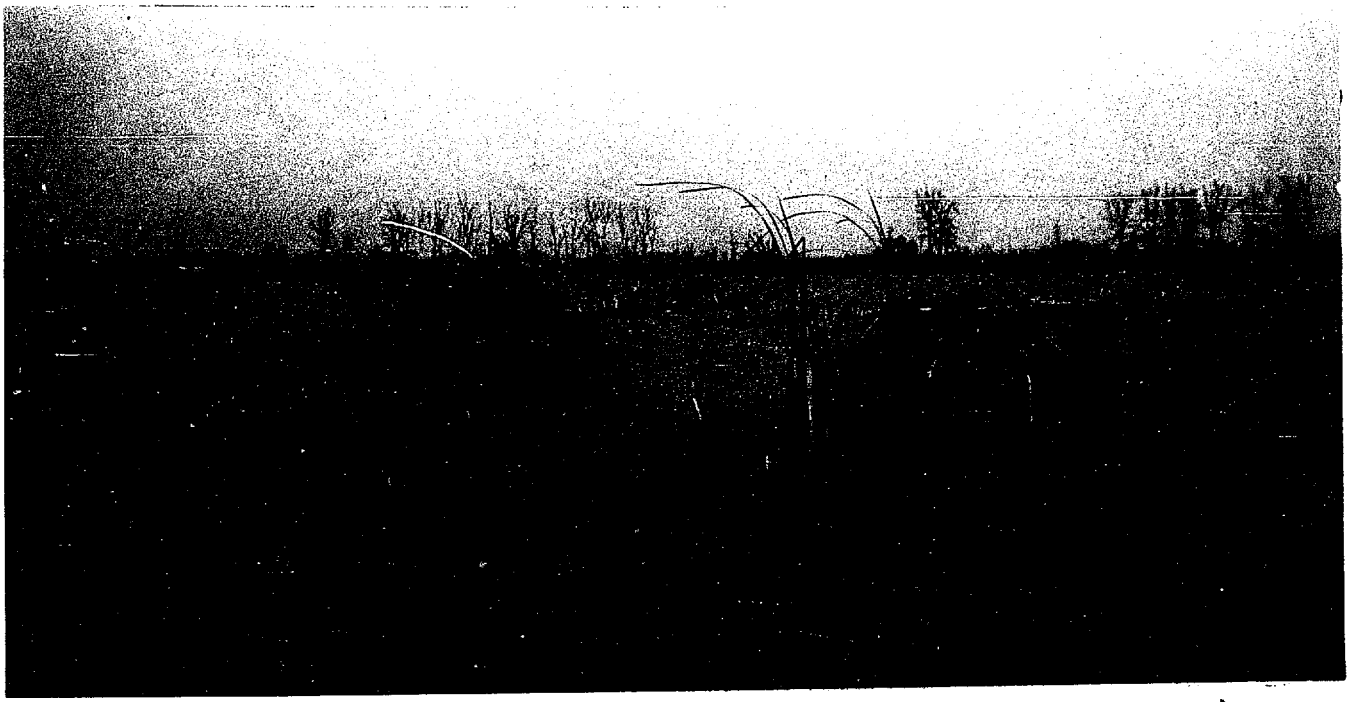
Cat-tail stem eaten at base by muskrat. This stem was left standing.

Muskrat feeding platform on cat-tail clump. Cut cat-tail stems and shreds of bases of stems can be seen.

Plate 15



Opening in cat-tail (Typha glauca) made by muskrat. Remains of old muskrat house are in center of opening.



Muskrat houses. Bases of cat-tails (Typha angustifolia) used in construction can be seen.

is unknown for 1944, amounted to 1.9 acres in 1947, and was 49.5 acres in 1949.

The relationships of wildlife to the bulrush beds in the lake have not been studied. Most of the stands in this marsh are too small or too young to have many special relationships, but elsewhere this community is the preferred nesting habitat of many birds (Provost, 1947). Coot and gallinule nests are found in this community, and rails are seen along mud banks covered by bulrush, especially in the early fall. Coots regularly feed in the seedling stands and gallinules do so occasionally. Muskrats cut large numbers of stems in the summer, and dig some rhizomes.

River Bulrush (Scirpus fluviatilis) Community

River bulrush occurs only on a silty or clay soil: Clyde clay, Griffin silty clay loam, or Brookston clay loam. In the marsh this community occurs on the flats along the river or behind the beach. The water depth ranges from zero to six inches; in one foot of water a very sparse growth occurred, in water deeper than one foot no growth occurred, although growth in water up to 3.5 feet deep has been described (Sigler, 1948). Bellrose (1941) states that river bulrush cannot tolerate water 30 inches deep during the growing period.

In the summer dense cover is provided by this community to a height of four feet. The dry stems provide cover during the winter to a height of three feet, except when they are beaten down by storms and ice. In the marsh no other species of plants are found in the river bulrush community, except

behind the beach, where a mixture of mud bank plants got a start before the Scirpus developed. Scirpus fluviatilis apparently rarely fruits in this locality; a few stems along a ditch fruited in 1948, and one stem of a stand in a swale fruited in 1949, but no other fruits were found.

During the period of high water river bulrush made no growth at all in the marsh and was not present in 1947. As the water level fell, however, growth began and some thick stands developed in 1949. These stands developed from rhizomes already present in the soil, rhizomes which had survived several years of flooding without emergent growth. No stands were mapped in 1944, but the distribution in 1949 covered the same areas in which dead stubs were found. On the basis of these dead stubs more than 54.1 acres were covered in 1944, while the area in 1949 was 45.9 acres.

In addition many small patches and stands of Scirpus fluviatilis are present in the farmland region. These are not extensive except for one field of ten acres covered by this species. The total extent of these small patches is more than twenty-three acres, all of which are included in the Scirpus-Typha facies of the sedge-meadow.

Few vertebrates occurred in this community. Coots and gallinules were observed using it for shelter several times during the late summer, and sparrows fed in it during the winter. Muskrats dug up rhizomes occasionally during the summer and cut off stems. Swans were reported locally to dig up the rhizomes, but no activity of this sort was observed by the author. No nests were found.

Reed (Phragmites communis var. Berlandieri) Community

This reed-marsh community occurs in shallow areas of the marsh, inside the band of cat-tails, on Clyde clay or Brookston clay loam, or along the river on Griffin silty clay. The water depth ranges from zero to two feet. The community frequently forms a band between the cat-tail and blue-joint grass, around the islands or on the tongues of higher ground extending into the marsh.

In water this community grows in isolated clumps, but where the soil is above the water line the growth is in continuous stands. The general vegetation height is nine feet in the summer, while the stems are broken down to about six feet during the winter. They are stiff and strong and remain standing for several years, forming a dense tangle. The only other plant noted in this community was Utricularia vulgaris, in stands growing in water.

Phragmites communis var. Berlandieri died out in one large stand and several smaller patches between 1944 and 1947. The water depth in the die-off area in 1947 varied from four feet down to two feet at the edges, although reed has been reported as growing in five feet of water in Iowa (Hayden, 1947). Ward (1942) stated that in Manitoba reed does not grow in permanent water or thrive in water over six inches deep, and this is also the case in the Mouillée marsh. The total extent in 1944 is not known, as it was not separately mapped, but it covered approximately 192 acres. In 1947 this community covered 51.9 acres, and in 1949, 59 acres. The spread in 1949 was primarily into stands of blue-joint grass; little spread

took place into the area formerly covered, although individual rhizomes twenty-four feet in length over soft mud indicate a rapid spread if water levels remain low.

Birds and mammals used the reed community comparatively little; a few gallinule nests were found, and many red-wing and prairie marsh wren nests were built here. The young shoots were eaten by cottontails on one island, and probably also by muskrat. Rails were seen several times on the mud along the edge of this community. The red-wings and bobolinks occasionally stopped here temporarily on their way to the roosts, but usually soon moved on into the cat-tails for the night. A few muskrat houses were seen in this community in 1947.

Bulrush--Cat-tail (Scirpus-Typha) Community

This community occurs on the inner side of the marsh, forming a belt or zone around farmlands, and in some cases a band just inside the cat-tail. The soil is Clyde clay, Brookston clay loam, or Conover clay loam. The depth of water ranges from zero to eighteen inches.

The plants of this community consist of a variety of wet-land species, with reed-like forms predominating. A stratification is noticeable in the vegetation, with dense cover present up to one foot, then a more open condition to an elevation of four feet. A complete list of plants is given in Table 12. Some of the more common species are: Typha spp., Sparganium eurycarpum, Alisma subcordatum, Eleocharis macrostachya, Scirpus fluviatilis, Scirpus validus var. creber, Carex vulpinoidea, Carex stricta, Acorus Calamus, Juncus

Torreyi, Iris virginica var. Shrevei, Polygonum coccineum, Sium suave, and Lycopus americanus. The Typha is a depauperate form of T. angustifolia and occasional plants of T. latifolia.

This community is probably the result of a disturbance in other communities and does not exist as a unit or stage in the same hydrosere as the others. In some cases it seems to represent areas where the next stage discussed, the sedge-meadow community, has died out; in others it represents part of the sequence in the transformation of abandoned farmland into marsh. It shows many variations and combinations of plants, each combination probably the result of a difference in conditions and availability of colonizers. Where the land was flooded the cover is usually Sparganium; on drier sites other plants are common. The scattered patches of Scirpus fluviatilis have been assigned to this community, as well as mixtures of Typha, Sparganium, Juncus, and other wet-land plants. The extent of this community in 1944 is not known but it probably covered some waste land and a narrow strip along some of the fields, and has been estimated at 15.6 acres. It covered 207.5 acres in 1947, and 203.4 acres in 1949. Most stands of this community developed on abandoned farmland.

Few vertebrates are found regularly in this zone. The carp penetrate here during the flood period of early summer and sometimes do much of their spawning here. Leopard frogs are abundant. Rails are commonly seen and heard, especially in the spring. The short-billed marsh wren is present, and perhaps nests in this community. Most of the birds seen here are more plentiful in the true sedge-meadow.

The muskrat feeds here, particularly in the early spring. Trails of meadow mice are abundant. The small cat-tail stalks are often shredded and torn at the base in the same manner that muskrats tear and eat the bases of cat-tail stems in the water, leaving them standing. However, in this case it is not muskrat work and it is thought by the author that meadow mice are responsible. Many of the Typha stems in this community are infested by boring insects, but none of the stems torn open had been infested, although tearing open of cat-tail stems by small mammals to get larval borers has been described (Walton, 1908).

Sedge-meadow (Carex-Calamagrostis) Community

This community is present on the inner side of the marsh on higher ground, bordering cultivated land, or on islands. The soil is Clyde clay, Brookston clay loam, or Conover clay loam. The water depth ranged from zero to a maximum of eighteen inches in 1947. The surface is permanently submerged only in the very wet years, however, and then the community does not flourish.

There is a definite zonation of the dominants within the community. Carex stricta is dominant in water or moist situations, Calamagrostis canadensis on the drier sites. The Carex grows in strong, high stools or tufts, so that spaces of bare mud are exposed, available for colonizing by other plants. Dense cover is provided in this community to a height of two feet, and less dense cover for an additional two feet. In the winter a dense mat of dry leaves and stems covers the ground.

The community may be invaded by a number of plants, including Typha.

In some places Typha glauca has invaded and supplanted this community by vegetative growth, in other places a form of T. angustifolia has apparently been established by seed, and survives as scattered plants. Some stands of this community died out during the high water period. The exact extent in 1944 is not known, but it was approximately 353 acres; the extent in 1947 was 249.5 acres, and in 1949, 223 acres.

The sedge-meadow approaches the wet meadow community, and has a greater number of species of plants than any community that has been discussed so far. The species present are listed in Table 12. Dominants and subdominants include Typha angustifolia, Phalaris arundinacea, Sparganium eurycarpum, Calamagrostis canadensis, Scirpus atrovirens, Carex stricta, Carex lanuginosa, Carex lacustris, Rumex orbiculatus, Polygonum coccineum, and Lycopus americanus.

The birds nesting here include the swamp sparrow, short-billed marsh wren, American bittern, an occasional gallinule, and probably the marsh hawk, bobolink, and some rails. A few dabbling ducks are seen in this community and nests have been found in other studies (Beecher, 1942). The least bittern is common here in the spring up to the last of June; then the birds spread or move into the cat-tail along the open channels and floating islands. The American bittern, swamp sparrow, and short-billed marsh wren are almost completely restricted to this habitat. Sparrows are abundant in this environment in winter, and pheasants roost here during this season of the

year. Meadow mice become quite numerous after the water has drained off the area, and other mammals probably enter this area.

Species of birds seen were: American Bittern, Least Bittern, Mallard, Black Duck, Blue-winged Teal, Marsh Hawk, Ring-necked Pheasant, Virginia Rail, Yellow Rail, Florida Gallinule, Barn Swallow, Short-billed Marsh Wren, Yellow-throat, Bobolink, Red-wing, Savannah Sparrow, Slate-colored Junco, Tree Sparrow, Swamp Sparrow, and Song Sparrow.

Flotage and Mud Bank Communities

While these two communities have an entirely different origin, the organisms forming them and the characteristic activities of the animals are so similar that they have been combined for discussion. They occur on Clyde clay, Griffin silty clay loam, and Houghton muck. The flotage community especially has highly organic soil, including old muskrat houses and floating driftwood as well as pieces or islands of the peaty muck. The water level is usually just at or below the surface of the soil. The islands occur throughout the central part of the marsh, in varying sizes, and the mud banks include all the higher portions of the die-off area not already recovered by reed-marsh vegetation.

The succession on these areas may take several different courses, but in all cases the final result seems to be a return to the reed-marsh condition. The time of year when the area is exposed, the amount of subsequent flooding that occurs, and the plants already in the vicinity are factors which

influence the course of development. Sagittaria, Lophotocarpus, Scirpus, and Typha usually dominate an area which is exposed from early spring; Cyperus, Polygonum, and Eleocharis dominate the areas first appearing in summer; Bidens may be alone on areas emerging in late summer. A carpet of needle spike rush (Eleocharis acicularis) often forms in the fall. If the area is under shallow water, Sagittaria latifolia or Lophotocarpus are more likely to develop; if the area is above water but frequently flooded, seedling Scirpus will survive while Typha will probably be destroyed. Most Sagittaria latifolia stands are mixed with Scirpus seedlings; the Scirpus dominates the stand the second year. In some areas, particularly those with Cyperus and Bidens, a thick growth of wild millet (Echinochloa Walteri) and rice cut-grass (Leersia oryzoides) develops the second year. An admixture of young Scirpus in such colonies indicates that here too Scirpus will become dominant. Flowering rush, Butomus umbellatus, is common but not dominant. Sparganium rarely occurs except on mud banks at the rear of the marsh. Apparently its seeds float so easily that they are driven to the highest strand-line, where they may lie in large drifts. The plants observed in these communities are shown in Table 12.

The full extent of these areas cannot be mapped, as the floating islands often consist of numerous individual cattail clumps. The main areas have been shown as Scirpus on the cover maps for 1947 and 1949. Virtually all stands of Scirpus represent new stands from seed, on islands or banks (Figure 27). The area mapped was 1.9 acres in 1947 and 53.4 acres in

1949. In addition a number of colonies of Lophotocarpus were present in 1948 and 1949 (17.5 acres in 1949, Figure 22), and new stands of Sagittaria latifolia (Figure 21). The earlier colonies of both have been taken over by Scirpus and it is likely that the remaining colonies will be also. Lophotocarpus was not observed at all in the marsh in 1947. It is the only common marsh plant which seems to have come in during this study.

These islands and banks have an importance to the animal life all out of proportion to their total area. They provide the places where mammals and birds can get out of the water--places to roost, preen, bring food, feed in the mud, and nest on the ground. From midsummer to fall the ducks congregate on these islands, at all times of the day. The gulls and Caspian and black terns rest on these islands in large numbers in the late summer and fall, changing from their roosts on the sand beach. Herons and bitterns, shore-birds, rails, gallinules, coots, blackbirds, and even mourning doves feed on these islands or in the shallow water around them. The number of shore birds particularly seemed to increase with the increase in extent of the islands and banks during the three years. The gulls, Caspian tern, and duck hawk carry food to these islands to eat.

The black tern was the only bird which depended on these locations for nesting. In this marsh no floating nests were built by the black tern as described for other places (Provost, 1947), but all nests were built on a substrate. During 1947 nests were found on the numerous old muskrat

Plate 16



Floating muck island just emerged. Island is strewn with aquatic plants.

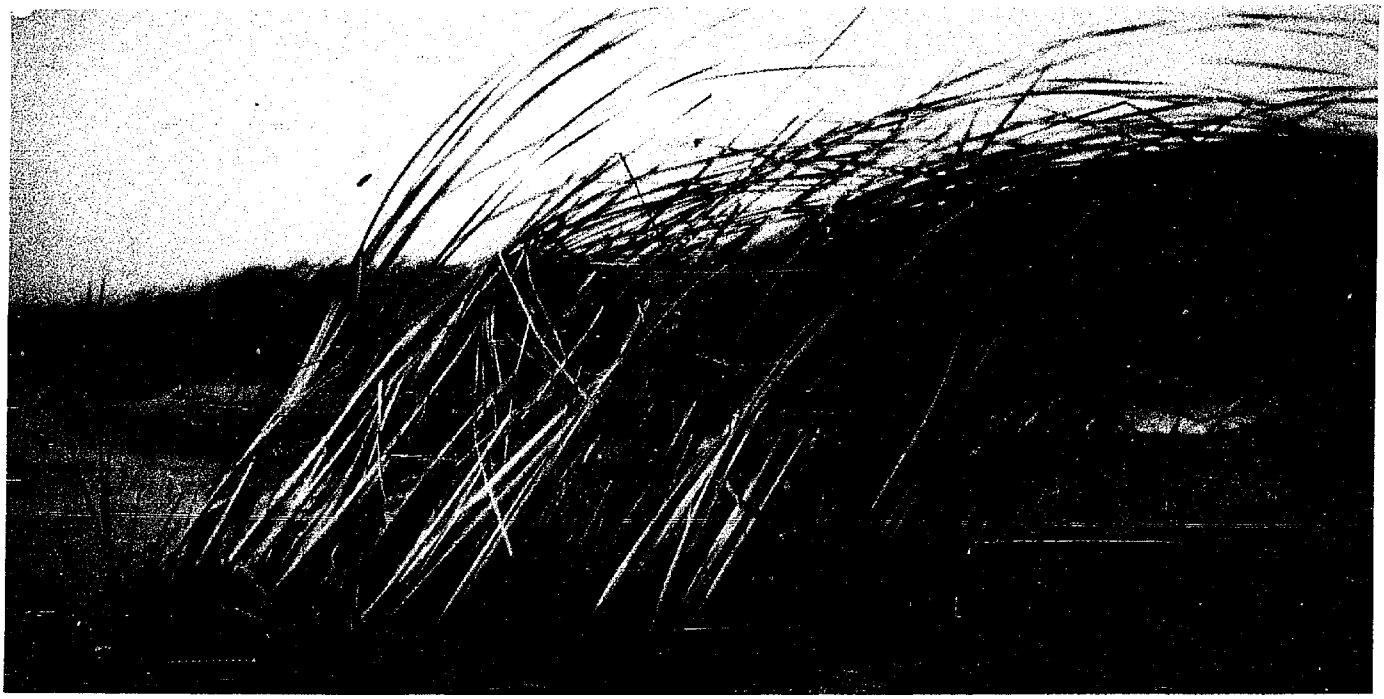


Floating muck island a year old, vegetation starting.

Plate 17



Floating muck island covered with vegetation. Besides cattail, Bidens and wild millet can be recognized.

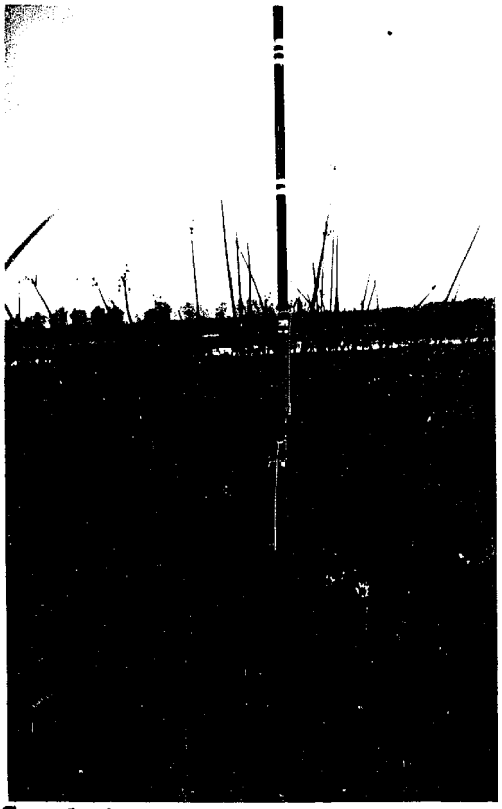


Loose clump of Typha angustifolia. This clump is tipping and will probably capsize and die.

Plate 18



Seedling Sagittaria and Scirpus, September. Three and four feet high.



Seedling Scirpus, September. Four feet high. Sagittaria and Bidens also visible.



Mature Scirpus validus, six feet high.

Contrast of seedlings and mature stand of Scirpus validus. (Marks on pole are one foot apart.)



houses and flotage, but all the nests in the summers after were built on floating islands. Saunders (1926) credits the muskrat with making some marshes habitable for the black tern, by creating openings and a nesting location. It certainly seems possible that this may have been true of this marsh in the years preceding the die-off. The openings were present in the narrow-leaved cat-tail, but the muskrat houses were quite likely the only nesting possibilities. Even on the islands the terns required tall vegetation nearby.

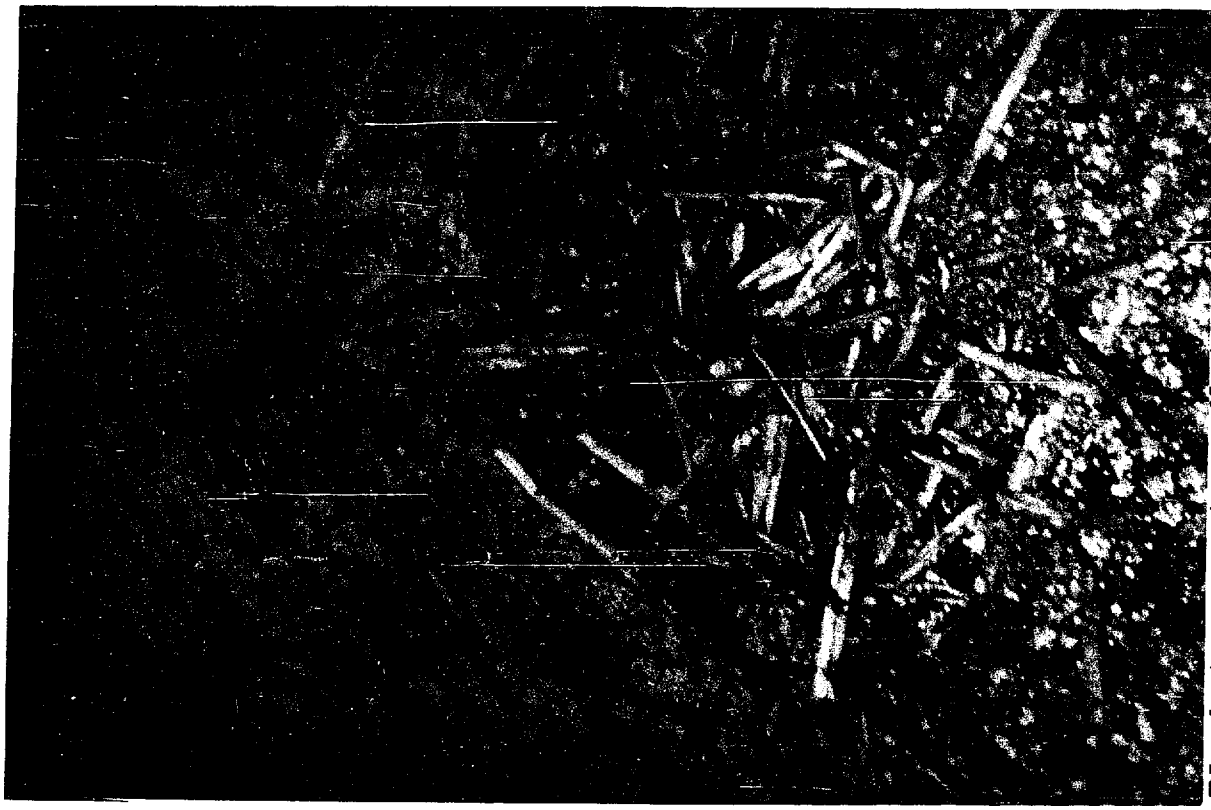
Coots or gallinules habitually built nest platforms on these islands, but in only one case was an occupied nest found. This was a gallinule nest on a floating clump at the base of a small tuft of cat-tail stems, in late summer. The unused platforms were nearly always out in the open, sometimes several yards from cover. Sooter (1941) mentions crude raft-like structures which are built by the coot during courtship activities, then later abandoned; these platforms may have represented the same thing. They were usually quite well made, but unlined. Unfinished nests or rafts were very frequent for both the coot and gallinule in the cat-tail, near the completed nests.

The species of birds observed on these islands and banks were: White Pelican, Great Blue Heron, American Egret, Black-crowned Night Heron, American Bittern, Least Bittern, Mute Swan, Whistling Swan, Mallard, Black Duck, Baldpate, Pintail, Green-winged Teal, Blue-winged Teal, Duck Hawk, Virginia Rail, Sora, Florida Gallinule, Coot, Semipalmated Plover, Killdeer, Golden Plover, Black-bellied Plover, Ruddy Turnstone,

Plate 19



Black tern nest on floating muck island.



Black tern nest on flotage of dead cattail.

Wilson's Snipe, Spotted Sandpiper, Solitary Sandpiper, Greater Yellowlegs, Lesser Yellowlegs, Pectoral Sandpiper, White-rumped Sandpiper, Least Sandpiper, Red-backed Sandpiper, Dowitcher, Semipalmated Sandpiper, Northern Phalarope, Herring Gull, Ring-billed Gull, Caspian Tern, Common Tern, Black Tern, Mourning Dove, Snowy Owl, Red-wing, Rusty Blackbird, and Savannah Sparrow.

Muskrats fed at the edges of these islands and tunneled beneath them. Tracks of raccoons were commonly seen; and tracks of opossums occasionally found on the mud banks near the mainland beach. House rats occurred along the beach, and their tracks were sometimes seen out on the mud banks.

CHAPTER V

BIOLOGY AND ECOLOGY OF CAT-TAIL (*TYPHA*)

The primary purpose of this study was to identify the factors responsible for the death of large stands of cat-tail. In order to do that the factors controlling the normal growth and life cycle of the cat-tail had to be determined. According to the most recent revision (Hotchkiss and Dozier, 1949), there are four species of *Typha* in the United States (*T. angustifolia*, *domingensis*, *glauca*, and *latifolia*). Although Hotchkiss and Dozier mention finding these four side by side in some places, they do have general differences in physiological and ecological requirements. Three of these species occur in the Mouillée District, and many of their ecological relationships have already been described in this paper.

Review of Literature on *Typha*

Most detailed laboratory studies, particularly in regard to physiology, have been carried out on *Typha latifolia* (broad-leaved cat-tail), and have only a general application to the other species. The two major species in the Pointe Mouillée marsh, *T. angustifolia* (narrow-leaved cat-tail) and *T. glauca* (blue flag) have been studied little and frequently not even separated. Sometimes it is doubtful as to what form of cat-tail was actually studied when the name *Typha angustifolia* is used in a paper.

The possible variations in form are indicated by the varieties and forms of Typha species listed by Kronfeld (1889) and Graebner (1900). Gèze (1912) shows that some normal variations have been made the basis of new varieties. Several hybrids are listed by Kronfeld and Graebner, and the form Typha glauca was included in this category. Hayden (1939) described some variations in Typha angustifolia and T. glauca which indicate hybridization with T. latifolia.

Site and habitat conditions of Typha have been described by a number of authors in the course of discussions of ecological communities. Some of the habitat and site conditions of T. latifolia have been described by Veatch (1933), Pearsall (1920), Detmers (1912), and Hayden (1947); those of T. angustifolia by Hayden (1939, 1947) and Detmers (1912). Hotchkiss and Dozier (1949) list the four species of North American cat-tails in the order of their salinity and alkalinity tolerances, and Penfound and Hathaway (1938) give the maximum salinity tolerance for T. latifolia and T. angustifolia. However, it would appear that their T. angustifolia was actually T. domingensis, on the basis of the distribution maps given by Hotchkiss and Dozier. Moyle (1945) gives the median and extremes of alkalinity, sulphate ion, and pH tolerances for T. latifolia in Minnesota. Some climatic limits to growth of T. angustifolia and T. domingensis are given by Gèze (1912), and the phenology and response of T. latifolia to a specific climate is described by Penfound, Hall, and Hess (1945).

The life history of the middle European species of Typha, including T. latifolia and T. angustifolia, has been

treated very fully by Loew (1908), with many references from the European literature. His discussion covers the anatomy, histology, embryology, and germination as well. Certain phases of these subjects are discussed more fully by Dietz (1887) and Kronfeld (1889). Brief discussions of the life history of T. latifolia are given by Claassen (1921) and Härdtl (1938a). The growth rate of the shoots of T. latifolia was measured by Allen (1914). Seed production of T. latifolia was calculated by Claassen (1921), and seed and pollen production of T. latifolia and T. angustifolia were calculated by Härdtl (1938a).

The process of germination in T. latifolia and T. angustifolia was described by Dietz (1887), Kronfeld (1889), and Loew (1908). Dietz also observed the effect of temperatures on the germination period. Morinaga (1926, 1926a) studied the effects of alternating temperature, reduced oxygen, and lack of light in inducing germination. The role of the seed coat in preventing germination was studied by Crocker (1907). Muenscher (1936) and Härdtl (1938a) recorded the percentage of germination.

Respiration and growth of the rhizomes and shoots of T. latifolia in relation to aerobic and anaerobic conditions were measured by Laing (1940, 1940a, 1940b, 1941). The relationships of root formation to aeration and water content of soils were studied by Weaver and Himmel (1930) and Dean (1933). Emerson (1921) studied the formation of rhizomes and roots of T. latifolia in bogs.

The anatomy and histology of Typha latifolia were described by Loew (1908). Other accounts are by Hayden (1919)

treated very fully by Loew (1908), with many references from the European literature. His discussion covers the anatomy, histology, embryology, and germination as well. Certain phases of these subjects are discussed more fully by Dietz (1887) and Kronfeld (1889). Brief discussions of the life history of T. latifolia are given by Claassen (1921) and Härdtl (1938a). The growth rate of the shoots of T. latifolia was measured by Allen (1914). Seed production of T. latifolia was calculated by Claassen (1921), and seed and pollen production of T. latifolia and T. angustifolia were calculated by Härdtl (1938a).

The process of germination in T. latifolia and T. angustifolia was described by Dietz (1887), Kronfeld (1889), and Loew (1908). Dietz also observed the effect of temperatures on the germination period. Morinaga (1926, 1926a) studied the effects of alternating temperature, reduced oxygen, and lack of light in inducing germination. The role of the seed coat in preventing germination was studied by Crocker (1907). Muenscher (1936) and Härdtl (1938a) recorded the percentage of germination.

Respiration and growth of the rhizomes and shoots of T. latifolia in relation to aerobic and anaerobic conditions were measured by Laing (1940, 1940a, 1940b, 1941). The relationships of root formation to aeration and water content of soils were studied by Weaver and Himmel (1930) and Dean (1933). Emerson (1921) studied the formation of rhizomes and roots of T. latifolia in bogs.

The anatomy and histology of Typha latifolia were described by Loew (1908). Other accounts are by Hayden (1919)

and by Weaver and Clements (1938). Meiosis in T. latifolia and T. angustifolia was investigated by Roscoe (1927), but here again there might be some doubt as to the correct identification of the form called T. angustifolia. It was described as having irregular meiosis and many malformed pollen grains, and the suggestion was advanced that this species had arisen by the crossing of two other species.

The chemical composition of the leaves of T. latifolia was determined by Harper and Daniel (1934), while the food value of the rhizomes was measured by Claassen (1919) and Freudenthal (1922). The use of Typha for food by man in times of stress or under primitive conditions is described by Sakharov (1927) and Yanovsky (1936). Other uses of Typha by man are given by Gèze (1912), Needham and Lloyd (1916), Johnson (1925), and Härdtl (1938a).

Role in Ecological Succession

Cat-tail is a dominant of the reed-marsh associes and has frequently been described as a subsere stage of the hydrosere, developing after interference by fires, grazing, silting, or flooding has removed or weakened existing vegetation. This condition is true for the northern bogs (Stallard, 1929), and the prairies (Sampson, 1921). In the Lake Erie marshes, and very often in marshes elsewhere, cat-tail appears as a regular stage in the prisere. This is partly due to the constantly fluctuating water levels, which produce the necessary condition of exposed barren soil, ready for establishment of cat-tail. Typha can, however, successfully invade open water by building

up a floating mat of interlacing rhizomes. Such a floating mat has been described as extending out over ten feet of water (Needham and Lloyd, 1916).

Apparently the narrow-leaved cat-tail and blue flag may represent successive stages in the reed-marsh. The narrow-leaved cat-tail tolerates deeper water than the other, and blue flag may not develop until the ground level has been built up by narrow-leaved cat-tail. Establishment of Typha angustifolia is probably almost entirely by drifting in of loose clumps or rhizomes, as exposed mud banks are almost a necessity for the development of seedlings, and these rarely occur in the Typha angustifolia habitat. Typha glauca may become established by seed germination, vegetative propagation and spread, or perhaps by drifting of rhizomes or clumps.

Habitat Requirements and Preferences

Pearsall (1920) regards the cat-tail form of the "reed-swamp" stage as developing in conditions of rather rapid silting, which keep the organic content lower and promote more rapid decay in the soil. Organic content of the soil in Typha (T. latifolia) communities is given as twenty to fifty per cent. However, Typha latifolia regularly grows in pure peat. In a study of the site conditions of Typha latifolia in Michigan this species showed its best growth on muds of high clay content associated with alkaline waters, although occuring on a variety of soils from sand to peat (Veatch, 1933).

In a comparison of the four species of Typha in regard to tolerance of salinity, the order of decreasing tolerance was

domingensis, angustifolia, latifolia, and glauca (Hotchkiss and Dozier, 1949). Typha domingensis is found only in saline waters. A form perhaps misidentified as Typha angustifolia tolerated up to 1.68 per cent salinity, and T. latifolia tolerated up to 1.13 per cent (Penfound and Hathaway, 1938). Typha angustifolia is found mostly in basic waters, and Moyle (1945) suggests that this species is probably typically a member of the alkali-water flora. T. glauca is found mostly in alluvial soil in basic waters, while T. latifolia is the only one that tolerates acidity, although it also does better in basic waters, as mentioned above (Hotchkiss and Dozier, 1949).

The ranges of the various species in North America, as shown by Hotchkiss and Dozier (1949), exhibit considerable differences. Typha latifolia is the most wide-ranging species of the genus, occurring throughout the United States and into Alaska and Mexico. Typha domingensis is a southern form, ranging from the southern half of the United States into South America. According to Gèze (1912) this species is found south of the line of "temperate zone with hot summers" (one month with average temperature of at least 72°F., all of them with average temperature exceeding 50°). Typha angustifolia is found primarily in the northeastern quarter of the United States, in the region of "temperate zone with temperate summers and cold winters" (one month with average temperature below 50°F., all others with average temperature exceeding 50°). The range of Typha glauca is almost completely included within the range of T. angustifolia. All of these species also occur in other parts of the world.

The general water-depth relationships of the Michigan species have already been described. In the Mouillée marsh the maximum depth for lingering survival of Typha angustifolia was four feet; three feet represents the maximum depth for flourishing stands. Flowering and fruiting occurred rarely in water over two feet deep, abundantly in one foot of water. In Ohio this species is described as growing in 2.5 feet of water (Detmers, 1912). In contrast, Loew quotes Warming to the effect that in Denmark T. angustifolia grows in water up to six feet deep (Loew, 1908). The maximum depth of survival of Typha glauca seemed to be about two feet. Some fruiting heads were formed in 1.5 feet of water but abundant flowering and fruiting occurred only in water less than six inches deep. The only patches of T. latifolia observed in this marsh survived in water up to 1.5 feet deep. A few heads were produced in one foot of water and many were produced in water a few inches or less deep.

Distribution in Southeastern Michigan

In southeastern Michigan Typha latifolia is everywhere present in wet places such as roadside ditches, shores of ponds, pot-holes, small marshes, and bog mats. It is very rare in the Lake Erie marshes but common along the Huron River two miles from the lake. Typha angustifolia is rarely found outside the Lake Erie marshes. The only stands found by the author near Ann Arbor are one small stand in the marginal ditch of a bog succession, one stand in a seepage marsh, and one stand just below the last in a marsh formed by an impoundment of the Huron

River. In all these cases it is associated with Typha latifolia. Typha glauca is very abundant in the Lake Erie marshes but has been found by the author outside them only once, in a roadside ditch ten miles from the lake.

Life History

The species of Typha are all perennial, living over the winter by means of rhizomes formed during the late summer. The ends of the rhizomes turn up in short shoots which grow up as much as six inches above the surface of the soil in the fall, then remain dormant in this climate from October to April.

In southeastern Michigan growth starts in April, when the mean daily temperature reaches about 45°F. (7°C.). Growth starts earlier in the water than on land, sometimes three to five weeks earlier (Dietz, 1887). At Pointe Mouillée in 1949, Typha angustifolia in water started growth about one week earlier than stands of T. glauca growing just at the water's edge, and about ten days earlier than Typha angustifolia growing in a meadow (Figure 14). The shoots elongate at the rate of one inch to 2.7 inches per day, and some of the sterile shoots reach a final height of eleven feet, while the fertile shoots reach seven feet.

Growth rates in 1949 are shown in Figure 15. The stands on land (station 1) or in very shallow water (stations 2 and 3) show growth rates varying directly with the mean daily temperature until about May 27, while those growing in deep water (stations 4 and 5) had a much more even growth

STATION 1 TYPHA ANGUSTIFOLIA - MEADOW
STATIONS 2 AND 3 T. GLAUCA - EDGE OF WATER
STATIONS 4 AND 5 T. ANGUSTIFOLIA - DEEP WATER

MOST STEMS BLOOMED AT STATIONS 2, 3, AND 5

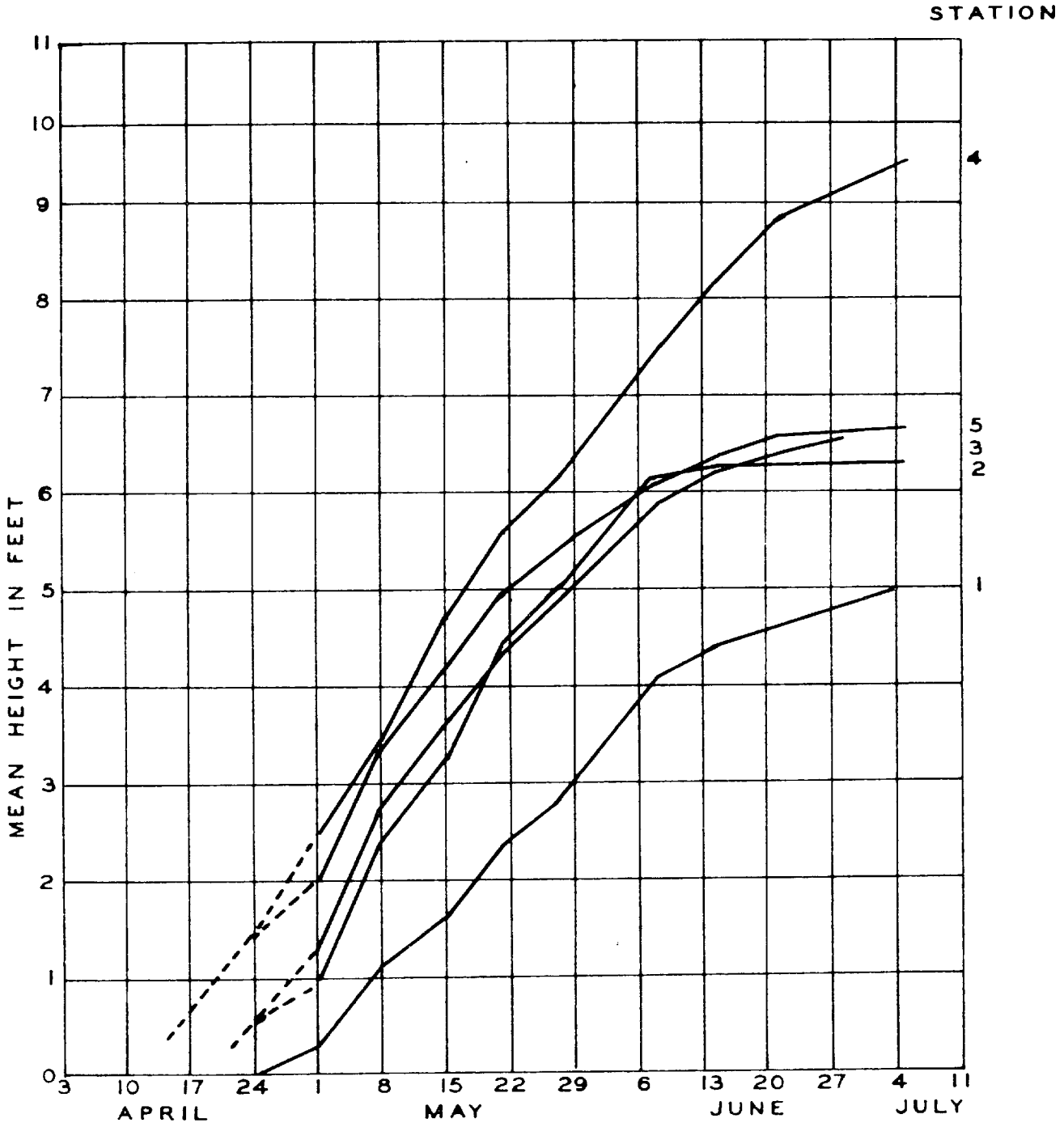
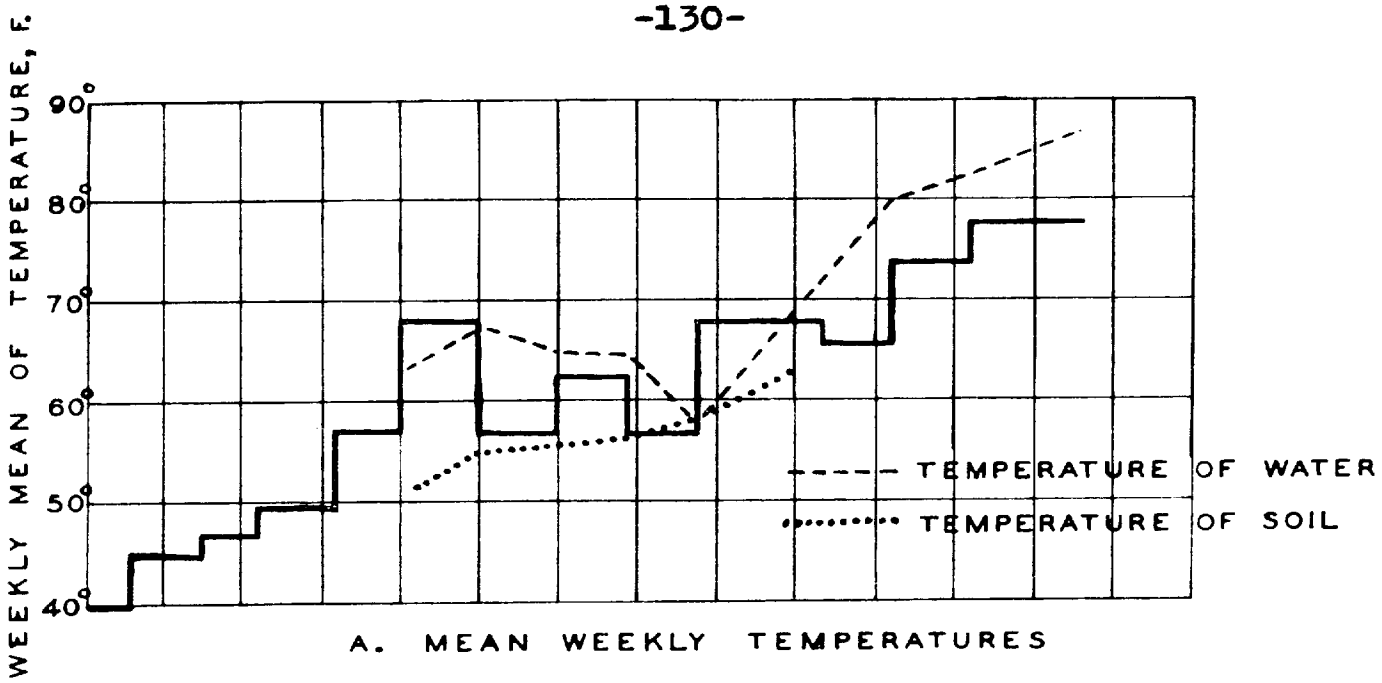
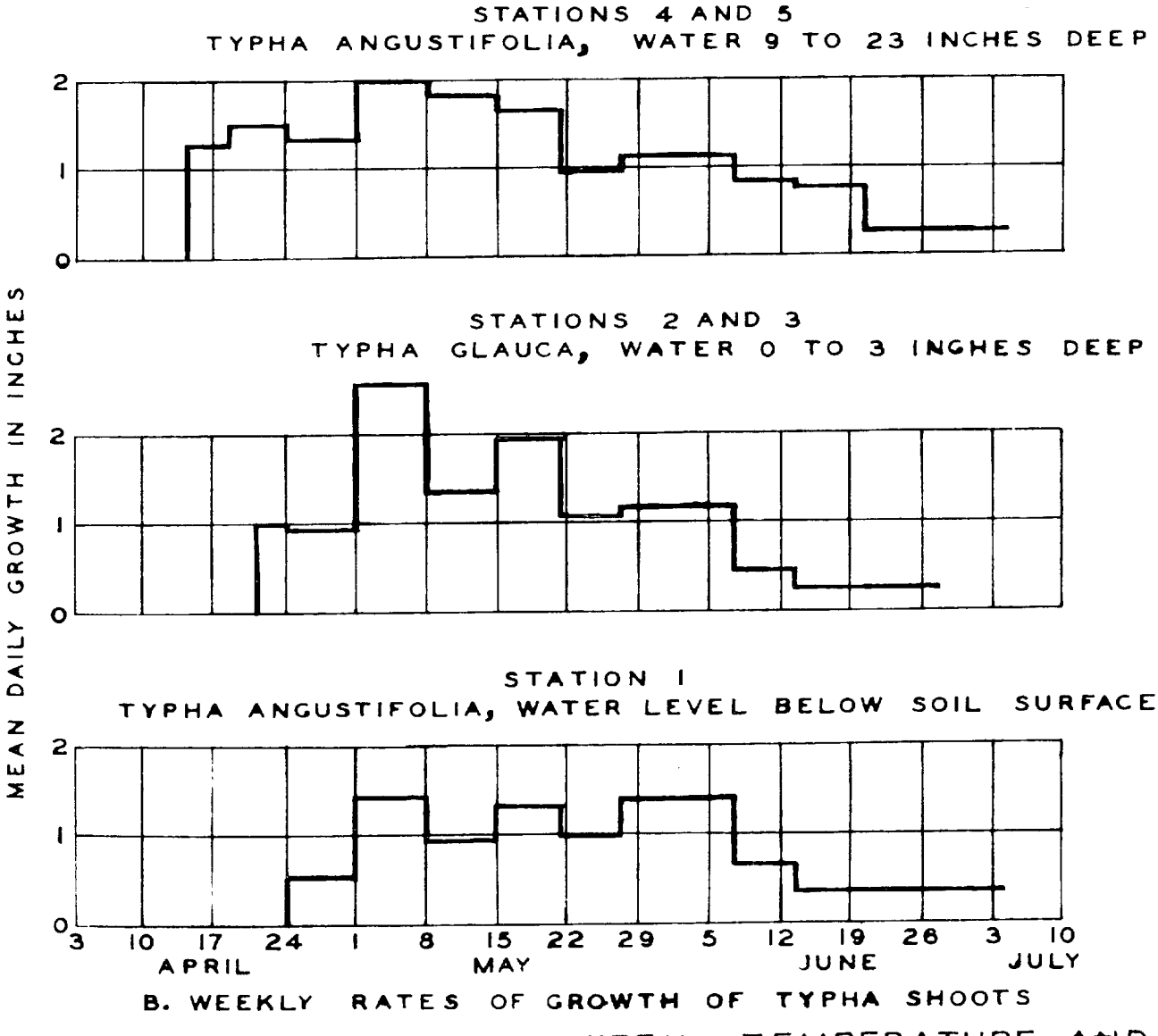


FIG. 14 GROWTH CURVES OF TYPHA SHOOTS, 1949



A. MEAN WEEKLY TEMPERATURES



B. WEEKLY RATES OF GROWTH OF TYPHA SHOOTS

FIG. 15 CORRELATION BETWEEN TEMPERATURE AND RATE OF GROWTH OF TYPHA, 1949

rate, varying with the temperature of the water. The flowering shoots lagged in growth after May 15 and ended growth shortly after June 6, while the sterile shoots continued growing until July.

Allen (1914) reports the growth rate of Typha latifolia at Ithaca, New York, from April 20 tb June 20, 1910, as one inch per day. However, on April 20 the shoots were already twenty-eight to forty-four inches high, at a time when growth is just beginning at Pointe Mouillée. The plants flowered at approximately the same time, so that the plants at Ithaca had a growing period about a month longer and consequently grew more slowly. In northern Alabama, where the lowest mean monthly temperature was 42.4°F. (5.8°C.), Typha latifolia shoots grew intermittantly throughout the winter (Penfound, Hall and Hess, 1945). Full foliage was reached about the first of May, about five weeks earlier than in Michigan, and flowering took place the last of May and the first part of June, about three weeks ahead of Michigan.

Some of the shoots are sterile; some bear flowers, in late June in Michigan. The inflorescence appears at the top of a stem which bears foliage leaves below. There is a somewhat gradual change from the typical foliage leaves below to an emarginate-tipped involucral leaf above, which encloses the entire inflorescence. The inflorescence stem elongates rapidly just before and during the flowering, raising the inflorescence out of the ensheathing foliage leaves. The involucral leaf withers and falls off with the beginning of bloom. The inflorescence is spike-like in appearance, with the staminate and

pistillate flowers in separate groups, the staminate above.

The development of the flowers takes up three stages. The first stage--that of staminate anthesis--begins with the falling away of the involucral leaf. The staminate inflorescence elongates, the flowers develop fully, and the pollen is released into the air. At this time the pistillate flowers extend one to three millimeters from the axis. The second stage is called that of pistillate anthesis by Kronfeld (1889). After the dusting of pollen the staminate flowers dry up and fall from the axis. The stipes of the pistillate flowers elongate so that they extend out to one centimeter beyond the axis in the case of T. latifolia. The relative time of ripeness of the stamens and pistils has not been precisely determined, so it is not known whether the plants are primarily self-fertilized or cross-fertilized. Hybrids do occur, however (Kronfeld, 1889; Graebner, 1900). Flowering is almost entirely completed within a two-week period.

In the fruit stage, which lasts from July to September, the spike grows somewhat more in thickness, then dries out in September after the ripening of the fruit, permitting the fruit to escape. The drying out of the fruit spike produces a tension between the many fruits squeezed together, so that in dry weather any slight jar causes their release. Each fruit contains a single seed and is borne on a long stipe, which has a few rings of fine hairs at the base. These hairs fluff out and cause the seed to drift in the air. Release of fruit continues through the fall and winter, and some spikes may not break up till spring.

At the time of flowering the starch content of the rhizomes reaches the lowest point (Claassen, 1921; Uhler, 1945). These old rhizomes die and slowly decay. New rhizomes begin growing out horizontally in the soil from buds at the bases of the outer leaves, and each bud splits the sheath of its subtending leaf as it extends outward. From one to four rhizomes may sprout from a single stem. These rhizomes become swollen and turn up at the end, usually after about six inches to two feet of growth (maximum observed in T. glauca was forty-four inches), and send up a shoot which elongates rapidly. This shoot in turn may send out another rhizome. Such growth of new shoots and rhizomes continues until October, when dormancy begins. The summer shoots are all sterile; flowers develop only from shoots ready for growth in the spring.

Growth of Rhizomes

The rhizomes of plants of Typha glauca and T. latifolia which are growing in exposed mud or very shallow water spread out in all directions, forming a dense network which is continually reinforced. At the edges of such a stand growth may extend out thirty feet in a single year, and stands regularly extended their boundaries twenty feet (Figure 17, A, B). Spaces of forty feet or more may thus be closed up in a single year by growth from each side. The constant growth of rhizomes results in one plant covering an extensive area, several acres in some cases. The network system of growth makes it almost impossible to detect the boundary of a clone. One very distinct type in the marsh covers an area of 1.2 acres, and is presumably an individual clone. Before the die-off it may have

covered an area two or three times as large; at least it is the remnant of a stand of about three acres, which was isolated by Phragmites.

Growth of the rhizomes of Typha angustifolia is much less than that of T. glauca. In the water there is little formation of new shoots during the summer, and those formed are at the ends of very short rhizomes. The rhizomes grow upward a short way, then remain dormant until spring. The result is the formation of a clump or tussock, rising above the soil level and added to by accumulation of cat-tail debris as well as by the growth of the rhizomes. Silt in the water may contribute to this tussock formation, as described by Hayden (1947), but it was not evident here. Similar tussocks are formed by Phragmites when growing in the water. The formation of tussocks in T. angustifolia stands and lack of them in T. glauca stands are shown in Figure 16, which gives profiles across stands of both species.

Even where Typha angustifolia was growing on exposed mud, the rhizome formation was less than that of T. glauca, and the tendency was to form clumps. One channel is bordered by Typha glauca on one side and Typha angustifolia on the other, with the soil at the same level. The soil under Typha glauca was firm, peat for one foot, then clay. That under T. angustifolia was very soft and fluid for two feet, then soft muck. The Typha glauca had advanced an average of 21.9 feet from the old growth of the previous year, T. angustifolia an average of 16.25 feet.

The old rhizomes and bases of the stems remain in

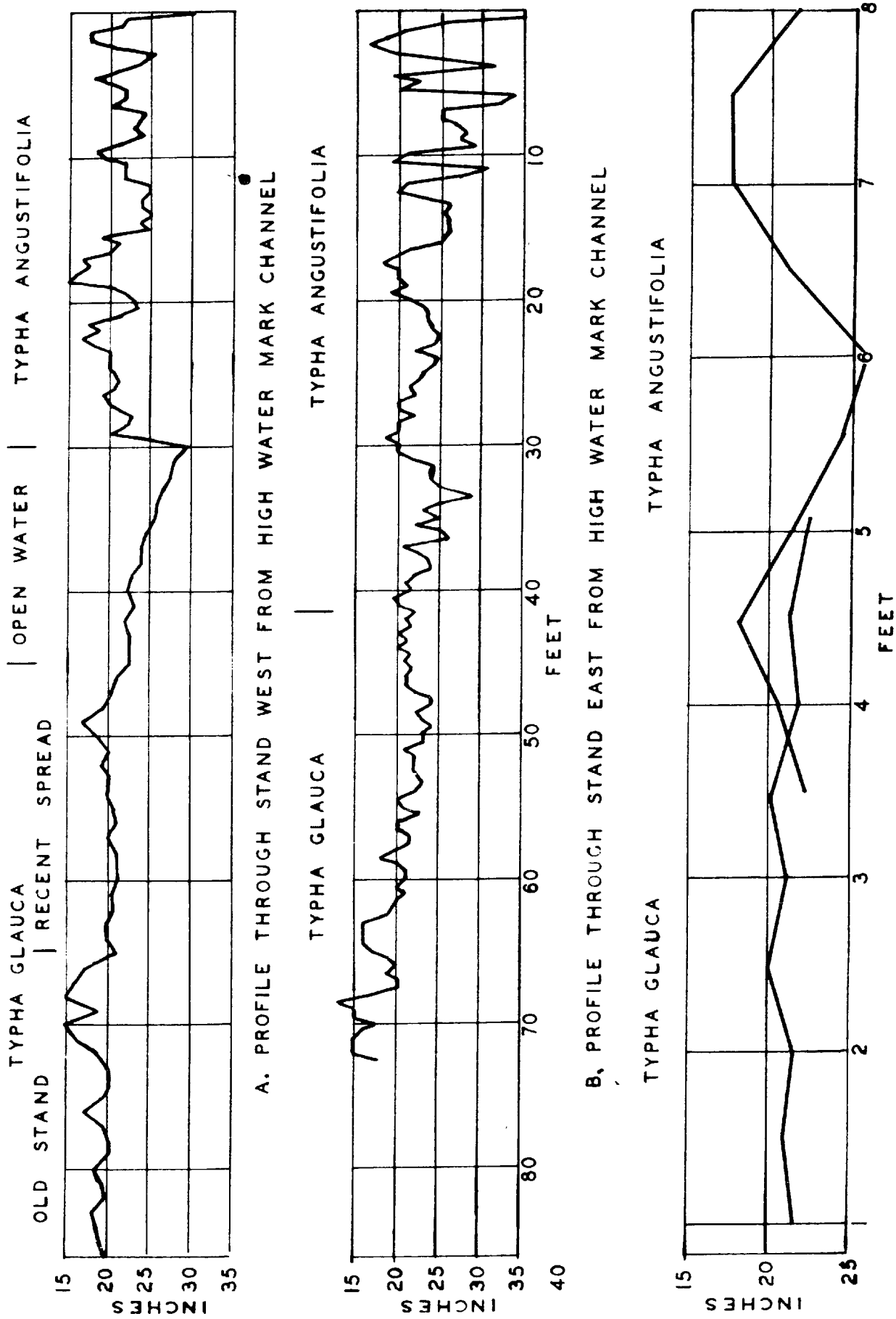


FIG. 16 COMPARISON OF SOIL SURFACE PROFILES IN TYPHA STANDS

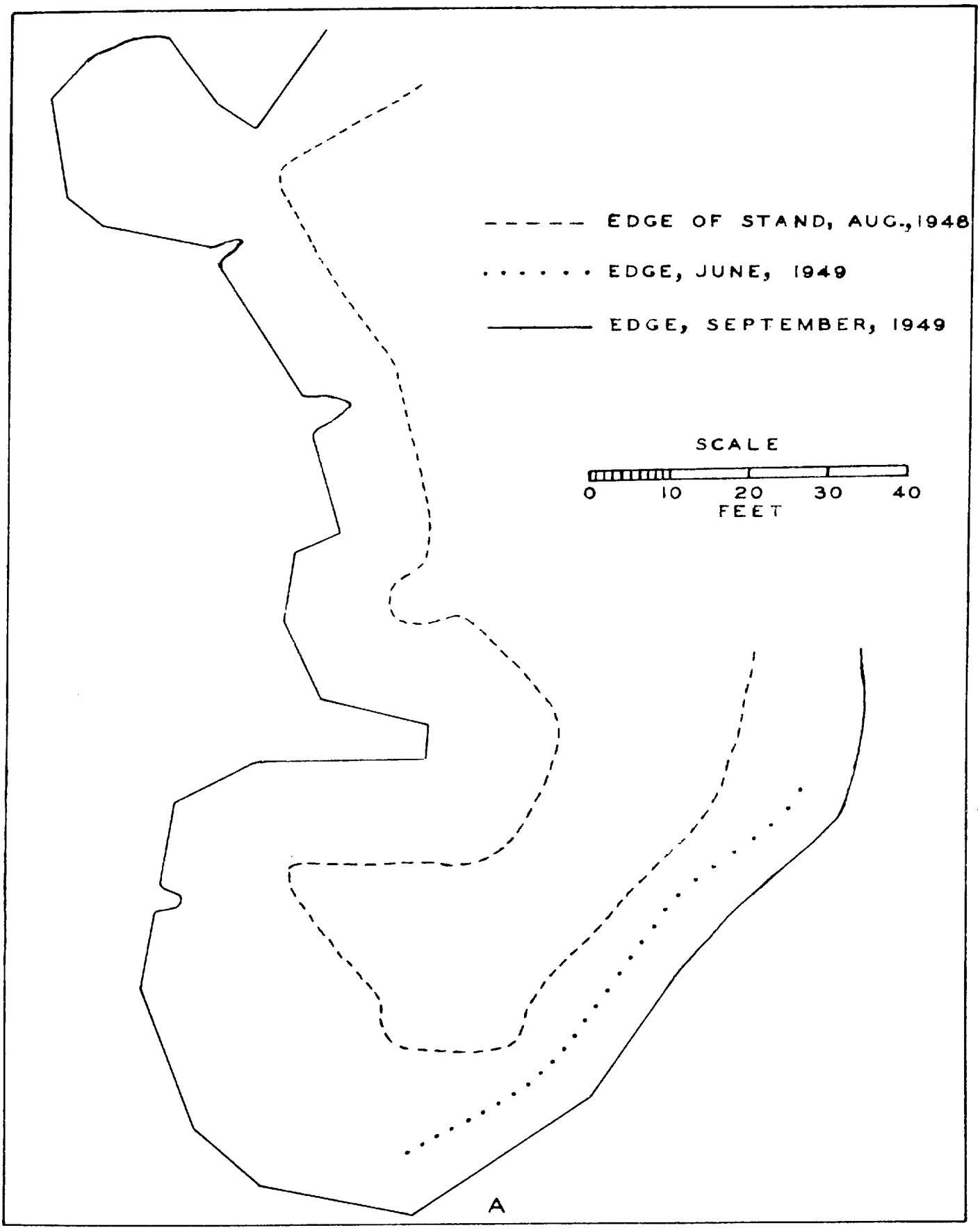


FIG. 17 SPREAD OF TYPHA GLAUCA BY VEGETATIVE REPRODUCTION

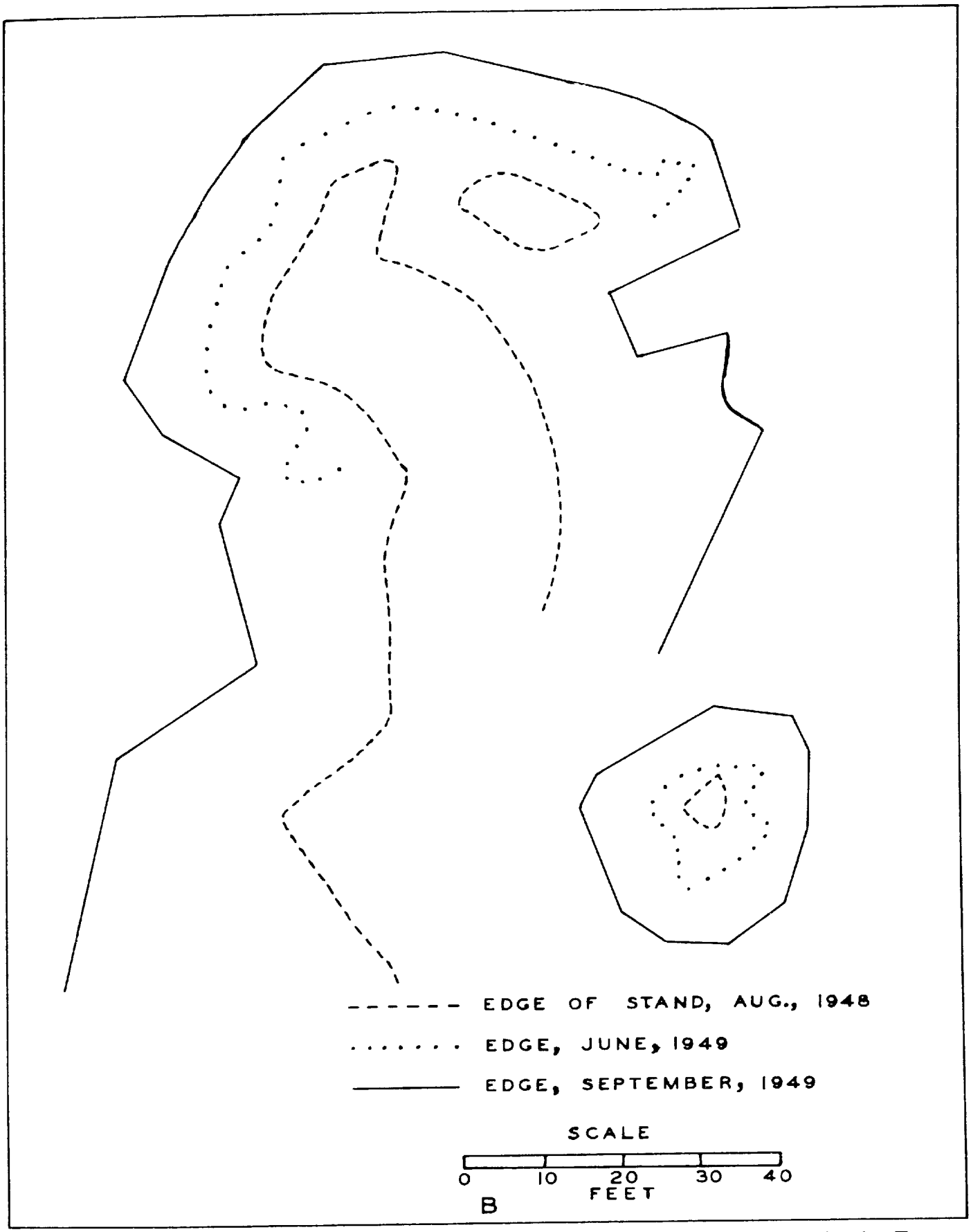


FIG. 17 SPREAD OF TYPHA GLAUCA BY VEGETATIVE REPRODUCTION

place, binding the soil together. An area of 209 square inches, in a Typha glauca stand, examined to a depth of 13 inches, contained 48 inches of living rhizomes and 300 inches of dead ones. There were 7 living stems and 20 old stubs. Dead stubs could still be recognized four years after the die-off of cat-tail.

Accumulation of organic debris is rather rapid, due to the large amount produced by the growth of cat-tail and its firm character and slow decay because of the presence of much supportive and conductive tissue. This rapid accumulation is shown by the fact that new rhizomes are 6 to 9 inches below the surface of the soil, but old decaying ones may be found 12 inches below the surface.

Roots

Roots grow out abundantly from the basal nodes of the stem, and some grow from the nodes of the rhizome. Three kinds of roots are formed in submerged soil--water roots, branched soil roots, and unbranched soil roots. The water roots grow upward to the surface, then branch out horizontally in the water. The branched soil roots grow in the upper two to four inches of soil, while the unbranched soil roots penetrate deeply. Twelve inches was the deepest any were followed in this study, but they have been recorded down to twenty-three inches in peat (Emerson, 1921). In aerated soils there are branched surface soil roots and deep vertically-growing branched soil roots. Root hairs are most abundant in aerated soils (Dean, 1933).

Germination and Growth of Seedlings

When the fruits break free of the spike they float on the wind for long distances. Fruits that light on the water float for a while, drifting over the surface; after a period of several days they absorb enough water to sink. In the meantime the seed likewise absorbs water, swells and splits open the fruit wall, falls out (in the case of Typha latifolia), and sinks, usually before the fruit itself has sunk. Typha angustifolia seeds as a rule do not fall out of the fruit. The seeds generally germinate on mud saturated with water. They can germinate under water as much as two feet deep and become established (Uhler, 1945), but are readily destroyed by wave action or turbidity. Experimental studies showed that germination was increased by reduced oxygen, light, and nitrogen compounds; and alternations of temperature were required (Morinaga, 1926, 1926a). Alternations of over 53°F. were apparently necessary.

Germination occurs from April to June or perhaps later. The period of germination depends upon the temperature. At 47°F., it took twenty-five to forty days, at 64° - 68°F., the period was eight to ten days, and at 82°F., it was seven to eight days, with T. latifolia (Dietz, 1887). In northern Alabama germination of T. latifolia was found to occur in the fall and perhaps in early spring (Penfound, Hall and Hess, 1944). The amount of germination has varied from 100 per cent to 20 per cent in experiments of various workers. Four-year-old seeds have germinated (Dietz, 1887).

At 62° - 68°F., it took 1.5 months from the opening of

Plate 20

Seedling cat-tail on dead sedge tussock. The tussock extends above water, giving seedlings a chance for survival.

Cat-tail stem growing in five feet of water. This is the last survivor of a once-extensive stand, on Jackson's Island.

Plate 21



Seedling cat-tail, September. Leaves $3\frac{1}{2}$ feet high.



End of second summer. Leaves just over five feet.



Mature stand, narrow-leaved cat-tail. Leaves over ten feet high.

Comparison of height of seedling and mature cat-tail. (Marks on pole are one foot apart. Pole seven feet long.)



the operculum of the seed to the appearance of the first leaf blade, and at four months there were three to four foliage leaves (Kronfeld, 1889). By September of the first summer, Typha glauca seedlings had some leaves 42 inches long and had rhizomes with secondary shoots 26 inches long. In the second year some leaves were 63 inches in length. The plants bloom the fourth year of life, and sometimes the third year (Loew, 1908).

Oxygen Requirements

Typha latifolia, and presumably the other species of Typha also, requires considerable oxygen. Experimentally, no growth of shoots occurred in oxygen concentrations below 3 per cent by volume; rapid growth took place in concentrations of 4.6 per cent (Laing, 1940, 1941). Roots grew best in oxygen concentrations of 20 per cent, and practically ceased growth in concentrations of 1.5 per cent. Both buds and rhizomes were able to survive periods of exposure (seven to thirteen days) to anaerobic conditions; respiration took place in the rhizomes, but not growth (Laing, 1941). While the oxygen content within a submerged soft stolon was 9.7 per cent by volume, that in a young rhizome of the stolon was 2.1 per cent ten inches from the parent plant (Laing, 1940b). This plant was growing in six to eight inches of water, in full sunshine. The oxygen concentration in a lake was about 1.09 per cent by volume (15.5 p.p.m.) near the surface, and 0.09 per cent (1.3 p.p.m.) in water just over the bottom (Oosting, 1933); it was 0.075 per cent (0.75 cc. per l.) four inches down in mud under eight feet of water (A. E. Cole, 1932). Respiration must be largely anaerobic

in the rhizomes, even during the full photosynthesis of summer.

The growth of Typha latifolia in deep water is probably controlled by the amount of oxygen available (Laing, 1941). The structure of the leaves and stem serves to conduct air readily down the stem, but apparently this air does not easily pass into the rhizome. The growth of water roots is a response to low oxygen content (Dean, 1933), but these may not help the rhizomes much since they grow out from the base of the stem and the oxygen content of water is below the threshhold of growth of Typha shoots. New rhizomes are fewer in unaerated soils, and the aerial shoots are fewer (Dean, 1933).

The lack of oxygen in muck soils of high organic content may limit growth in such soils. Typha angustifolia may be able to grow in deeper water than T. latifolia by tolerating lower concentrations of oxygen, or perhaps by greater anaerobic respiration. The limited growth of the rhizomes of Typha angustifolia in deep water and the lack of productivity of summer shoots is probably a response to lack of oxygen. During the winter the dormant shoots are in contact with air much of the time due to the low water during that period.

Adaptive Modifications of Structure

The morphological and anatomical structures of Typha show several modifications of direct significance to the plant in relation to its habitat. The distinctive feature is the large internal air chambers connected by pervious diaphragms, so that air may pass to the submerged parts. Mechanical and

conductive tissues are well developed, which enables the plants to grow erect without support by water. The extensive, rapid-spreading underground stems with large amounts of storage parenchyma are important to carry the plant over the winter and propagate it over a longer period.

Finer details of structure are just as well adapted to the needs of the plant. The leaf blades show a screwed torsion, making a rotation of one to one and a half times on their axes, in such a way that a portion of the edge of a leaf is always directed against the wind and the breaking over of the leaves is made more difficult. The internal structure and buttressing of the air passages is such that the leaves are very flexible. Another modification is the great amount of slime produced on the inner sides of the sheaths by special groups of epidermal cells. This slime probably reduces friction and permits the sheaths to slide over one another as the stem is bent back and forth by wind pressure (Loew, 1908). It may also serve to protect the young shoot tip from being penetrated by harmful enemies and parasites (Loew, 1908).

On the growing fruit spike a large number of the flowers produce no seed. Many of these produce abortive ovaries, swollen structures developed at the top of the stipe. These serve to equalize the pressure in the spike, and leave room below for the developing seeds. The water absorbing power of the fruit spike, particularly of the fine hairs, also has a protective action. It prevents rain from washing down the spike and stripping away the seed, keeps the fruit moist during the ripening period, and permits the fruit to escape

only during fine dry weather. It has been suggested that seeds of Typha may stick to birds by the fine hairs and be carried by them (Loew, 1908).

Insects and Typha

Like other aquatic plants, cat-tail has a large and rather varied assortment of insects which utilize some part of the plant for food. Two detailed reports are available concerning them (Claassen, 1921; A. C. Cole, 1931) as well as a number of random observations (see Table 17). The biology of the forms is particularly stressed by Claassen. Altogether 43 insects and 1 mite are reported from the United States as feeding upon cat-tail tissue, and at least 20 parasitic insects have been collected from them. These insects are listed in Table 17, in the appendix.

All parts of the plant are subject to attack. Twenty species of insects are reported from the leaves, 14 on the stem, 2 on the rhizomes, 2 on the roots, 7 on the head, 2 on moist petioles, and 3 from burrows in the stem. Some attack more than one portion of the plant. Virtually all reports have referred to Typha latifolia, 32 species having been reported on it while only 3 are reported from T. angustifolia. Typha glauca evidently was not recognized as a separate entity as no insects are reported on it, although it is quite abundant at least in the Monroe, Michigan, marsh, where Cole made part of his collections.

Most of these insects seem relatively unimportant to the well-being of the cat-tail. The most destructive forms are

the stem borers, five species of owlet moths or noctuids and two weevils. The moth larvae tunnel in the center of the stalk, and very frequently cut the central cylinder so that the central leaves turn yellow and die. Occasionally they may attack a flowering stem, preventing the fruit from developing by cutting through the central cylinder. Plants thus attacked are not killed, and often the injured shoot starts growth again, below the injury. A severe attack by an owlet moth (Nonagria Typhae Esp.) in Germany resulted in breaking over of nearly all the stems of the stand, but new shoots were formed and the stand maintained its existence (Härdtl, 1938). The larvae of some of these moths are adapted to survive at least a short period of submergence, but none of them infest plants growing in very deep water.

The two weevils (Notaris and Sphenophorus) are more generally rhizome borers than stem borers, although they frequently bore into the crown at least. Often a number of larvae will bore in one rhizome, and they cause considerable destruction. The adults gnaw large holes resembling rodent work at the base of the stems (Satterthwait, 1920). The infested plant may be stunted and fail to flower, and the central leaves frequently die. One small stand which declined greatly over a two-year period was found by the author to have every rhizome infested, and every stem also contained a stem borer. These forms are infrequent in submerged areas and probably cannot survive permanent submergence. The larvae may bore up the stem to pupate above ground if the area is covered by water.

A few of the insects feeding on leaves cause considerable damage to individual leaves, but rarely more than one leaf per plant is infested. Conocephalus and Arsilonche eat the leaf, while some of the noctuids mine it and cause it to break across. A number of aphids have been reported from cattail but no information is available concerning the effect on the plant. In two instances observed by the author no effect could be detected; vigor and color of the leaves of the infested plants were the same as in those free of infestation.

Three insects are regularly and commonly found in the heads. Two of these, Lymnaecia and Dicymolomia, burrow through the center of the head, destroying seeds and weaving a layer of silk which holds the head together and keeps it from disintegrating during the fall and winter. Thus these insects prevent the distribution of the seed from some heads, sometimes from every head in a stand. Another insect, Ischnorrhynchus resedae, is commonly found on theee old heads in the summer, feeding on the seeds.

A number of flies breed in the decaying material in burrows of the noctuid moths or in the decaying bases of the yellowing stems. Three such have been reported, and three others mentioned only as emerging from or living in stalks may also actually have developed in such a habitat. The decaying bases of stems partially cut through by muskrats are also commonly infested by these or similar forms. One, Chaetopsis aenea, has been reported from these burrows a number of times, and was regularly found by the author, along with two other flies not yet identified.

During this investigation observations were made of the insects on cat-tail. The observation of Cole and Claassen was confirmed, that a higher amount of infestation occurs in small stands. However, in the experience of the author, the controlling factors seem to be depth of water and species of cat-tail. Four species of insects--2 leaf eaters (Arsilonche and Conocephalus), a stem borer (Nonagria oblonga), and a head borer (Lymnaecia)--were found in the flooded marshes at Pointe Mouillée on Typha glauca and T. angustifolia, while 7 species--2 aphids, 1 rhizome borer (Sphenophorus), 1 stem borer (Nonagria oblonga), 2 head borers (Lymnaecia and Dicymolomia), and 1 seed eater (Ischnorrhynchus)--were found on the small stands of Typha latifolia around Ann Arbor. The latter plants frequently had two or three species infesting them, while infested plants at Pointe Mouillée were quite scarce and never carried more than one species. The most abundant infestation at Mouillée was by Nonagria oblonga in Typha of meadows and edges of the marsh. The species of insects found, as far as identified, are all common and well-known forms on cat-tail.

CHAPTER VI

DIE-OFF OF EMERGENT VEGETATION

Review of Literature

Little specific work has been done on die-offs of aquatic vegetation, particularly emergent vegetation. Sporadic occurrences have been recorded here and there, sometimes assigned to a cause, sometimes not. Usually only a casual record is made, and the exact mechanism and conditions of the die-off are not known or described. A number of these observations deal with cat-tail, and the assigned causes have included high water, siltation and flooding, insects, micro-organisms, and goose and muskrat damage.

Oosting (1933) mentions a lake which was nearly dry for two years. During the next year it filled up nearly to the spring level, and the emergent vegetation, mostly cat-tail, died out. Uhler (1944, 1945) states that cat-tail can be controlled or eliminated by regulation of water level, and recommends a permenent depth of one and one-half feet as aiding greatly in eliminating cat-tail, presumably Typha latifolia. Similarly, maintenance of levels at one foot is recommended by him as useful in controlling reed. Errington (1948) states that Typha latifolia seems unable to tolerate a depth over about four feet, and when deep water stands started dying the die-off continued into shallow water. This is the same

die-off described by Hayden (1939, 1947) and discussed further on in this paper.

Emergent vegetation, including cat-tail, was destroyed in an impoundment of the Illinois River by extreme flood conditions during the early growing season for three years (Yeager, 1949). The flood waters were very silt-laden and a smothering effect was ascribed to them. Recovery was rapid the next year. In Iowa year-old seedling growth of bulrush and cat-tail was destroyed by flooding with turbid water (Hayden, 1948).

Destruction of large amounts of cat-tail by insects, including one marsh of 1100 acres, is described by Pancoast (1937). The plants were destroyed by the action of an insect boring in the stems and crown, sometimes as many as six in one stem. The infestation occurred during a drought year when the marshes were entirely dry, and was stopped or relieved by flooding. Two years after recovery the marshes were again attacked. It was found that raising the water level a foot would destroy the insects and stop the infestation (Pancoast, 1942). A heavy attack on Typha latifolia by insects in Germany is described by Härdtl (1938). The insect larvae (Nonagria Typhae Esp.) mined the leaves, then tunneled in the stem, so that both leaves and stems turned yellow and broke over. The plants were not killed, however, and new growth came up later in the summer. Destruction of cat-tail around the shores of marshes by insects boring in the rhizomes and stems is mentioned by Hayden (1947). Similar destruction of Scirpus colonies is also described. Remnants of Phragmites colonies which

had died out were heavily infested with mealy plant aphis, Hyalopteris pruni, and the deaths tentatively ascribed to this species (Hayden, 1947). No aphids were found on cat-tail, which had died out with the reed.

Overutilization of marshes by muskrats or geese is responsible for marsh "eat-outs", occurring regularly in the Louisiana marshes (Lynch, O'Neil, and Lay, 1947). The rhizomes and shoots of the cat-tail or other plants are eaten or destroyed and the marsh floor dug up--to a depth of eight inches by geese, and a depth of twenty inches by muskrats. Similar eat-outs by muskrats are mentioned as occurring in marshes in Maryland and New Jersey (Dozier, Markeley, and Llewellyn, 1948; Pancoast, 1937).

Extensive disappearance of cat-tail and reed in Iowa is described by Hayden (1939, 1947, 1948). The die-off accompanied a period of high water in the marshes and lakes and resulted in areas of emergent vegetation being reduced to open water. This condition in cat-tail was ascribed to a microorganism, referred to as root-rot, which destroyed the rhizomes. Apparently the die-off continued in lakes which had dried up and left the cat-tail colonies exposed on mud flats (Hayden, 1947). The die-off occurred in 1937 and again in 1947 and 1948. Young shoots grew up around the edges of affected colonies and in turn rotted at the base. The rhizomes are described as soft and somewhat deliquescent, and the leaves as somewhat less elastic (Hayden, 1947). Cultures were taken but no report is available as to the results.

Progress of Die-off in Michigan

The die-off in Michigan was catastrophic, killing off all the plants simultaneously. The plants were flourishing, with sturdy, dense growth one summer, then the next spring no shoots whatsoever came up. The area was covered with the mass of old dead stalks which gradually fell over and broke off, mostly the second winter after growth. During the second summer after the die-off scattered single stems grew up in the shallower areas. Whether these appeared the first summer or not is not known, but they probably did.

The great bulk of the die-off occurred after the 1945 growing season. It became apparent in the late summer of 1946, when the abundant muskrats nearly stripped the marsh of the dead material to use in their houses. The death after the 1946 growing season of several small stands was apparent in July of 1947. No further deaths occurred.

The die-offs in Iowa are the only cases described which seem at all comparable to the occurrence under present consideration. Grossly at least, conditions were very similar; in both places the die-off accompanied or followed a period of extreme high water, and several species were involved--reed, two species of cat-tail, and three species of round-stem bulrush in Iowa; reed, two species of cat-tail, two species of round-stem bulrush, river bulrush, and tussock sedge in Michigan. Following the die-off the areas were all covered with open water, and with falling water levels at least a portion was recovered by emergents. In Iowa, studies were carried on during the die-off; in Michigan, studies were not

started until afterwards. The die-offs of different species of plants were tentatively ascribed to different causes in Iowa.

Rejected Causes

No evidence of important insect action was found in this study. Although, as described earlier, several insects were found attacking cat-tail, none of these seemed to do more than affect individual stems, and the stand was left virtually unchanged. Even where large numbers of stems were attacked, as in some stands near Ann Arbor, the health of the rhizomes was rarely affected. It is only in aerated soil or in shallow water that insect pests can become at all numerous. In deep water it is impossible for stem or rhizome borers to become abundant. Hundreds of dead stalks in the die-off areas were examined and no evidence found of boring insects. The inability of boring insects to attack stems in deep water is also shown by the experiences described by Pancoast (1942), in which a foot of water was found to control a borer. The insects infesting the head, although very abundant, have no effect on the general well-being of the plant.

Studies in regard to microorganisms were inconclusive. Since the die-off stopped before this study got underway, there was no opportunity to examine plants in the process of death. Injuries to cat-tail by various agencies, particularly muskrats, were studied, but in no case did they enable an organism to attack the healthy tissue of the plant. The scant lingering shoots present in a few areas in 1947 showed no

evidence of a pathological condition in their rhizomes, although in several cases these plants were completely dead the next year. One widespread fungus was found present on submerged outer sheaths, but it appeared to be only semiparasitic. The possibility of a disease organism whose attacks were made more effective in some way by the high water still exists, but such a mechanism is not known. Such an organism would have to be able to attack a variety of plants, or else multiple explanations for the die-offs are necessary.

Altogether 44 species of fungi have been reported from cat-tail in North America (Seymour, 1929); 3 from Typha angustifolia, 35 from Typha latifolia, and 6 from undetermined forms. However, many of these grew on dead material. Few of the parasitic forms listed seem to be virulent, and none has been described as causing any condition such as led to the present study.

Other causes--silting, pollution, death from old age, and smothering by dense growth--have been suggested for the die-off. Heavy silting or deposits of sand over the beds of emergent plants simply did not occur. Except in the vicinity of the big washout, sand washed in from the lake after the die-off and not before. Some stands of cat-tail survived the passage of the beach right across the stand the past two years, a few stems coming up even in the center of the beach ridge. Pollution also is ruled out; the die-off was scattered over too large an area. Although some pollution does occur in the Pointe Mouillée area there is no evidence for the occurrence of harmful types at just one period, nor is there any for the

distribution of the same harmful type of pollution along several hundred miles of coast-line in three lakes, Lake Huron, Lake St. Clair, and Lake Erie.

The explanation of old age or senescence likewise does not seem to fit, for several reasons. Cat-tail grows by continuous renewal of the rhizomes, and any specific rhizome is never more than two years old. The center of the stand is kept filled up by new growth of rhizomes or shoots. Eventually the course of ecological succession results in replacement of the cat-tail stand by a different community, but this replacement is gradual in response to gradual building up of the soil. Where the building up of the soil is offset by sinking of the shoreline, as on Lake Erie, the cat-tail should hold the marsh indefinitely. At Pointe Mouillée, according to local information, certain areas have been covered by cat-tail for forty years. These areas are still covered by cat-tail, while the cat-tail died out in areas which it had invaded much more recently.

Too great a density of growth does not seem to be an explanation which can be accepted. Building up of the soil by dense growth should simply speed up succession, not kill off the community. In a few places large masses of drifting stalks deposited on a stand of cat-tail delayed the growth of new shoots in the early summer, but in every case the area was filled with abundant growth by August of the same year. A similar condition described by Johnson (1925) had been attributed by the owner to destruction of shoots and rhizomes by muskrats. There is no indication that either decayed or

undecayed materials can pile up in the soil and cause the death of the cat-tail. Much of the soil in which the cat-tail is growing is fibrous peat, formed from the broken parts of the plants.

The most apparent explanation, one which might affect all species concerned in the die-off, is a drowning or suffocation by too high water. The die-off occurred during a period of high water in the growing season, it progressed up channels and deeper areas, and it affected all species growing in the area. The objections to this explanation are that not all plants growing at the same level died, that the main die-off came three years after the water level rose, that no further die-off occurred although water levels subsequently rose another nine inches, and that recovery began at a high level. Some plants or some species may have been killed in this way.

Although high water levels over several years might have progressively weakened the plants, there is little evidence for a lingering death such as would be expected with such a condition. Instead the plants died abruptly, after vigorous growth. The lack of additional deaths during two more years of high water, with rapid spread occurring the second year, seems particularly strong evidence against this theory. The possibility remains that the surviving plants belonged to strains particularly capable of resisting the conditions produced by high water levels. If true, such strains were limited in distribution to the more shallow areas, and the capability of resistance often resided in only a few small pieces of rhizomes from large clones.

Suggested Cause--Drowning by High Water Level in Winter

As shown earlier, the lake level regularly hits a peak in June and a low point in January or February. The fact that the water is low in winter gives the dormant shoots access to air during the winter. Laing (1941) regards the emergence of green shoots through the ice as important in providing for respiration of the plants even though the rhizomes can survive at least a short period by anaerobic respiration. During the summer the rhizomes apparently must endure anaerobic conditions largely regardless of the depth of the water, but growth of shoots cannot occur unless relatively large amounts of oxygen are present.

Examination of Figure 3, B, Monthly Mean Water Level of Lake Erie, shows that in the winter of 1945-1946 the lowest level was seven inches higher than that reached the previous winters. It seems possible that this depth submerged all shoots over a large area, killing them and the rhizomes by cutting off the oxygen supply, so that no shoots emerged in the spring. Two winters later, the winter of 1947-1948, the water level again stayed at this height but no plants were left whose dormant shoots would be submerged by this level so no further deaths occurred.

In a Louisiana eat-out, the rhizomes were no longer able to grow after five months of submergence (Lynch, O'Neil, and Lay, 1947). Perhaps this is too long a period for survival of the rhizomes by anaerobic respiration alone. A winter period of submergence might have the same result. Gluck (1911) found that rhizomes of Typha angustifolia submerged in six to

nine feet of water were dead or dying after 3.5 months of submergence. In this case, however, food materials and energy were being used in growth of shoots, which failed to reach the surface.

Although Typha angustifolia survived in deeper water than T. glauca, neither species survived in any area deeper than one in which it died. The scattered stems and clumps which survived probably were either on slightly higher projections and knolls, or had shoots which were slightly longer and so projected into the air. In this way very small differences would be of value and account for the extreme irregularity of the margin of the die-off, with many isolated spots dying in the interior of the cat-tail stands. This explanation, combined with a drowning action of deep summer levels on some species of plants, may account for the death of all the different species involved.

The major flaw in this explanation is the fact that a small amount of die-off occurred after the 1946 growing season. During the winter of 1946-1947 the mean monthly level for three months was seven inches below the minimum of the winter before. This should have been low enough to permit all shoots to have access to air, yet some stands died out on relatively high ground. It seems possible that ice conditions may have an influence; however, nothing is known by the author concerning the ice cover during the two periods.

CHAPTER VIII

SUGGESTIONS FOR MARSH MANAGEMENT PRACTICES

The primary point developing from this study is one already firmly established: that control of water level is necessary for management of aquatic plants. Such control could be developed in the Pointe Mouillée marsh only by a system of dykes, very expensive to build and maintain. At the present time the stages of plant succession in this marsh depend on the current position of the climatic cycle of the water level. This marsh cannot be held at a desirable stage in the succession under such conditions.

With controlled water levels the die-off could probably have been prevented and the marsh maintained in a dense condition, or the more open condition might already have been produced and maintained. Which condition is desirable in a marsh depends upon the major product--waterfowl or muskrats--and the practices necessary to secure that production.

The species of cat-tail used is important in maintaining different conditions. Stands of Typha angustifolia will survive indefinitely in water one to three feet deep, stands of T. glauca in water a few inches to one and one-half feet deep, and those of T. latifolia probably only in water not over six inches deep. All three may survive periods of at least several weeks in deeper water. Typha angustifolia

is more desirable for a waterfowl marsh; growing in deeper water, it provides cover which can be reached by the hunter by boat, and many open pools and channels occur within the stands. Typha glauca and T. latifolia are probably best suited for muskrats. Besides growing in more shallow water, they form a continuous, dense cover.

If, as suggested by Dozier (1945), there is really a preference by muskrats for Typha latifolia or T. glauca instead of T. angustifolia, it may be due to differences in rhizome formation and stem structure. Formation of rhizomes is much greater in the first two species, and the volume of the edible, soft inner core of the stems is also much larger. The amount of food produced by these two species is probably greater than that produced by T. angustifolia. In this marsh these advantages of T. glauca are offset by the more favorable water depths present in the T. angustifolia stands. It is possible, however, that the latter species cannot support as high a population of muskrats as can T. glauca or T. latifolia.

Winter water levels are extremely important if the conclusions in this paper concerning the die-off are correct. These conclusions imply that a depth of water of six inches or more during the winter, which is sufficient to submerge all dormant shoots, will destroy a stand of cat-tail. In view of the recommendations for management of muskrat marshes by Hewitt (1942)--depths of three feet in winter, this seems doubtful and needs checking by experimentation. Perhaps certain combinations of ice cover and fluctuations of water level are also involved.

This study showed that exposed mud banks will be colonized by plants important as waterfowl foods. Wild millet, smartweed, rice cutgrass, spike rush, and nutgrass were annual waterfowl food plants which appeared on such banks during this study. Bulrush and duck potato are desirable perennials which also colonized these areas. Round-stem bulrush and cat-tail seemed to be the two reed-marsh dominants to be ultimately expected on these banks. Control of water levels would permit deliberate exposure of this soil for natural or artificial plantings.

Removal of cat-tail may be accomplished by increasing water levels or by cutting or poisoning (Uhler, 1944). Probably real control of this operation can be secured only by cutting or poisoning. Individual stands or portions of stands could be destroyed by those methods without affecting the rest of the plants, whereas control by water level affects all plants in the stand. Removal of stands in shallow areas, combined with lowering of water levels, would provide mud flats for colonization by other plants. If round-stem bulrush succeeded the annuals, then the improvement in production of waterfowl foods would be relatively permanent; if cat-tail closed in the area, the removal might have to be repeated in three or four years. The exposed flats should be reflooded during the autumn to make them more available to waterfowl. In Lake Erie marshes such flooding could occasionally be achieved by taking advantage of a seiche.

With such a system in operation some of the shallow areas in a marsh might be maintained in round-stem bulrush,

some in cat-tail (Typha glauca or latifolia), and others in early stages of the mud bank succession. The deeper areas could contain stands of Typha angustifolia. This latter plant shows very little spread when growing in deep water, but Typha glauca and latifolia spread rapidly on mud or in very shallow water and would require continuous control. Typha is regarded as superior to bulrush for muskrat production (Errington, 1948), so the relative amounts maintained of the two forms might be determined by the importance given to muskrat production.

The value of wild rice seems overstressed in this region. The concentrations of blackbirds and bobolinks which feed in the rice beds must take a large proportion of the crop. In view of the attention concentrated on rice it would seem desirable to determine just how much of the crop escapes these birds. Large stands must be developed in order to withstand the destruction by muskrats and perhaps also by carp. Rice does have a place in a marsh in providing another variety of food, and some effort should be made to establish it. The present study showed that cat-tail could be replaced by wild rice under conditions of permanent flooding.

Submerged aquatic plants demonstrated an ability to colonize newly available areas without aid. Wild celery, coontail, sago pondweed, bushy pondweed, and several other species of submerged and floating-leaf pondweeds were included in the group. These forms were abundant in the new water areas the third summer after the die-off, and completely dominant the fourth summer. Establishment probably proceeded as fast as conditions would permit, and could not have been speeded

up artifically.

Any enclosure of water areas will result in impoundment of fish, and such fish could provide recreation and food. Poisoning and stocking procedures could be utilized to control populations and species present. Survival of these fish would depend upon the presence of water of sufficient depth to remain cool in the summer and not freeze to the bottom in the winter. However, any marsh area in the north would be liable to occasional winter-kills of fish due to oxygen depletion under the ice. Rough fish are likely to become overabundant in an enclosure and destroy aquatic vegetation, either directly by feeding on it and rooting it up, or indirectly by making the water turbid. Control of these fish would be especially necessary.

Most of the management suggestions made above are not particularly new (see Errington, 1948; Bellrose, 1941). The new point brought out is the difference in the response of species of cat-tail to the habitat, and the importance of using the correct species to fit the conditions desired. This study showed that in the Lake Erie marshes desirable waterfowl food plants would spread quickly without aid when the proper habitat developed.

SUMMARY

This study was undertaken to determine the cause of a widespread disappearance of emergent aquatic vegetation in Lake Erie and Lake Huron. Intensive observations were made for three years on the Pointe Mouillée State Game Area, Michigan, located on Lake Erie. Recorded information includes:

a) Conditions in area during period of die-off.

b) Impact of die-off on marsh habitat and changes in the marsh following the die-off.

c) Physical habitat and make-up of marsh communities.

d) Activities of vertebrates as members of marsh communities.

e) Biology and ecology of cat-tail (Typha angustifolia, T. glauca, T. latifolia).

The water level of the marsh is the same as that of Lake Erie. Changes include a long term fluctuation of five feet, an annual fluctuation averaging 1.55 feet, and seiches with amplitudes from one-half inch to several feet. The lake is rising about one foot per century due to a tilting of the basin. This has resulted in abandonment of flooded farmland, and extensive wave erosion on the shores.

Between 1910 and 1944 the predominant emergent cover changed from wild rice (Zizania aquatica) to cat-tail (Typha). In 1945 reed-marsh vegetation died abruptly over 1205 acres.

Seven different species (Typha angustifolia, Typha glauca, Phragmites communis var. Berlandieri, Scirpus validus var. creber, S. acutus, S. fluviatilis, and Carex stricta) were involved. Sixty-two acres of Cephalanthus occidentalis died at about this same time. The die-off occurred during a period of high water.

The reed-marsh was replaced by submerged aquatics. Relict stands of Utricularia vulgaris were replaced by Vallisneria americana, Ceratophyllum demersum, Najas minor, and Potamogeton spp. Sheltered pools and openings were covered by Nymphaea odorata. Wild rice, Zizania aquatica, invaded some of the area.

In 1949 the emergent vegetation had regained 18.5 per cent of the area lost. Mud banks and floating masses of muck were colonized by annual plants, Sagittaria latifolia, Scirpus spp., and cat-tail. Relict fragments of Typha glauca spread extensively.

The die-off shifted a large area from production of cover and muskrat food to production of waterfowl foods. Solid cat-tail stands were broken up and made available for coot and gallinule nesting. With the return of emergent vegetation some former cat-tail stands were replaced by Scirpus, useful for waterfowl.

The differences in habitat tolerances and requirements of the species of cat-tail were recorded. The optimum water depth for Typha angustifolia, one to two feet, is six to eighteen inches deeper than that for T. glauca and T. latifolia, and the maximum depth for successful growth, three feet, is

eighteen inches deeper. Growth starts when the mean temperature is about 45°F. (7°C.) and the rate of growth varies directly with the temperature.

On exposed mud banks stands of Typha glauca and Typha latifolia spread an average of seventeen feet a year by vegetative growth, and T. angustifolia spreads similarly but more slowly. When growing in its usual station in the water, Typha angustifolia forms tussocks by upward growth of short rhizomes. Lack of oxygen in the submerged mud probably contributes to this reduced growth. The formation of tussocks results in open, pool-dotted stands of T. angustifolia in contrast to closed, solid stands of T. glauca.

The die-off of emergent vegetation is believed to be due to an unusually high winter water level, which submerged the dormant shoots and killed the plants. High summer levels may have been responsible for part of the damage. Insects were not involved, and no evidence was found linking any micro-organisms with the die-off.

Management suggestions include the stabilization of water levels, use of Typha angustifolia in waterfowl marshes and T. glauca or T. latifolia in muskrat marshes, removal of cat-tail followed by lowering of water levels for replacement by mud bank annuals and bulrush and arrowhead stands, and removal of cat-tail followed by continuous flooding for establishment of wild rice stands.

LITERATURE CITED

Aldrich, John W. 1943. Biological survey of the bogs and swamps in northeastern Ohio. Amer. Midland Nat., 30: 346-402.

Allen, Arthur A. 1914. The red-winged blackbird: A study in the ecology of a cat-tail marsh. Proc., Linn. Soc. N. Y., Nos. 24-25: 42-128.

Anderson, John M. 1950. Some aquatic vegetation changes following fish removal. Jour. Wildlife Mangt., 14: 206-209.

Barbour, W. T. 1940. A story of Pointe Mouillée. Privately reproduced.

Bay, James W. 1938. Glacial history of the streams of southeastern Michigan. Bul. 12, Cranbrook Inst. Sci., 68 pp.

Beecher, Wm. J. 1942. Nesting birds and the vegetation substrate. Chicago Ornith. Soc., Chicago, Illinois. 69 pp.

Bellrose, Frank C. 1941. Duck food plants of the Illinois River Valley. Bul., Ill. Nat. Hist. Survey, 21: 237-280.

_____, and Louis G. Brown. 1941. The effect of fluctuating water levels on the muskrat population of the Illinois River Valley. Jour. Wildlife Mangt., 5: 206-212.

Bennett, Logan J. 1938. The blue-winged teal, its ecology and management. Collegiate Press, Ames, Iowa. xiv + 144 pp.

Bent, Arthur C. 1919 to 1929. Life histories of North American birds. Bul. 107, Bul. 113, Bul. 126, Bul. 130, Bul. 135, Bul. 142, Bul. 146, U. S. National Mus.

Billings, Norman. 1949. Is it true what they say about water? Mich. Conserv., 18: 30-32.

Black, John D. 1946. Nature's own weed killer--the German carp. Wis. Conserv. Bul., 11: 3-7.

Bulkley, John M. 1913. History of Monroe County, Michigan, Vol. I. Lewis Publ. Co., Chicago. xxviii + 552 pp.

Burt, Wm. H. 1946. The mammals of Michigan. Univ. of Mich. Press, Ann Arbor, Michigan. 288 pp.

Butler, L. 1940. A quantitative study of muskrat food. Canad. Field-Nat., 54: 37-40.

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

Chamberlain, E. B. 1948. Ecological factors influencing the growth and management of certain waterfowl food plants on Back Bay National Wildlife Refuge. Trans. 13th N. Amer. Wildlife Conf., pp. 347-355.

Chandler, David C. 1940. Limnological studies of western Lake Erie. I. Plankton and certain physical-chemical data of the Bass Island region, from September, 1938, to November, 1939. Ohio Jour. Sci., 40: 291-336.

_____. 1942. Limnological studies of western Lake Erie. III. Phytoplankton and physical-chemical data from November, 1939, to November, 1940. Ohio Jour. Sci., 42: 24-44.

_____. 1944. Limnological studies of western Lake Erie. IV. Relation of limnological and climatic factors to the phytoplankton of 1941. Trans., Amer. Micros. Soc., 63: 203-236.

_____, and Owen B. Weeks. 1945. Limnological studies of western Lake Erie. V. Relation of limnological and meteorological conditions to the production of phytoplankton in 1942. Ecol. Monog., 15: 435-457.

Claassen, P. W. 1919. A possible new source of food supply. Sci. Monthly, 9: 179-185.

_____. 1921. Typha insects; their ecological relationships. Mem., Cornell Univ. Agr. Expt. Sta., 47: 459-531.

Cole, A. C. 1931. Typha insects and their parasites. Ent. News, 42: 6-11, 35-39.

Cole, A. E. 1932. Method for determining the dissolved oxygen content of the mud at the bottom of a pond. Ecology, 13: 51-53.

Cole, Leon J. 1905. The German carp in the United States. App., U. S. Bur. Fisheries Rpt. 1904: 523-641.

Comstock, John A. 1944. Four California moths associated with cat-tails. Bul., South. Calif. Acad. Sci., 43: 81-83.

Comstock, John Henry. 1947. An introduction to entomology. Comstock Publ. Co., Ithaca, N. Y. xix + 1064 pp.

Crocker, Wm. 1907. Germination of seeds of water plants. Bot. Gaz., 44: 375-380.

Davidson, W. M. 1917. The cat-tail rush, Typha latifolia, as a summer host of injurious insects. Monthly Bul., Calif. Comm. Hort., 6: 64-65.

Dean, B. Elizabeth. 1933. Effect of soil type and aeration upon root systems of certain aquatic plants. Plant

Physiol., 8: 203-222.

Detmers, Frederica. 1912. An ecological study of Buckeye Lake, a contribution to the phytogeography of Ohio. Proc., Ohio Acad. Sci., 5 (Pt. 10), Special Paper No. 19, 138 pp.

Dietz, Sándor. 1887. Ueber die Entwickelung der Blüthe und Frucht von Sparganium Tourn, und Typha Tourn. Biblioth. Bot., Heft 5: 1-55.

Dozier, Herbert L. 1945. Sex ratio and weights of muskrats from the Montezuma National Wildlife Refuge. Jour. Wildlife Mangt., 9: 232-237.

_____, M. H. Markeley, and L. M. Llewellyn. 1948. Muskrat investigations on the Blackwater National Wildlife Refuge, Maryland, 1941-1945. Jour. Wildlife Mangt., 12: 177-190.

Emerson, Fred W. 1921. Subterranean organs of bog plants. Bot. Gaz., 72: 359-374.

Enders, Robert K. 1932. Food of the muskrat in summer. Ohio Jour. Sci., 32: 21-30.

Errington, Paul L. 1943. An analysis of mink predation upon muskrats in north-central United States. Iowa Agr. Expt. Sta. Res. Bul., 320: 797-924.

_____. 1948. Environmental control for increasing muskrat production. Trans. 13th. N. Amer. Wildlife Conf., pp. 596-607.

Fernald, M. L. 1950. Gray's Manual of Botany, Eighth Edition. American Book Co., New York. lxiv + 1632 pp.

Freeman, John R. 1926. Regulation of the Great Lakes and effect of diversions by Chicago Sanitary District. Regulation of elevation and discharge of the Great Lakes. Chicago Sanitary District, Chicago. xxiii + 548 pp.

Freudenthal, L. E. 1922. Cat-tail (Typha latifolia) as a feed. Science, 55: 456-457.

Frohne, W. Carrington. 1938. Contribution to knowledge of the limnological role of the higher aquatic plants. Trans., Amer. Micros. Soc., 57: 256-268.

Gates, Frank C. 1912. The vegetation of the Beach area in northeastern Illinois and southeastern Wisconsin. Bul., Ill. Nat. Hist. Surv., 9: 255-372.

Gèze, J. B. 1912. Études botaniques et agronomiques sur les Typha et quelques autres plantes palustres. Société Anonyme d'Imprimerie de Villefranche-de-Rouergue. 174 pp.

Gluck, Hugo. 1911. Biologische und morphologische Untersuchungen über Wasser- und Sumpfgewächse. Dritter Teil: Die Uferflora. Jena. pp. 7-9.

Graebner, Paul. 1900 Typhaceae. Das Pflanzenreich, IV, 8. Leipzig. 18 pp.

Greeley, Aaron. 1810. Plan of private claims in Michigan Territory as surveyed by Aaron Greeley, D. Surveyor, in 1810. To accompany Rpt. of the Secretary of the Treasury, Sen. Doc., 29th Cong., 2nd Session.

Hall, Thomas F., and William T. Penfound. 1944. The biology of the American lotus, Nelumbo lutea (Willd.) Pers. Amer. Midland Nat., 31: 744-758.

Hankinson, Thomas L. 1933. Distribution of the fishes in the inland lakes of Michigan. Papers, Mich. Acad. Sci., Arts, Letters, 17 (1932): 553-574.

Härdtl, Heinrich. 1938. Die Wirkung eines Schilfeulenbefalls an Typha-Beständen. Ztschr. f. Pflanzenkrank., 48: 59-63.

_____. 1938a. Die Pollen- und Samenerzeugung unserer Rohrkolben. Beih. Bot. Centralbl., Bnd. 58, Abt A: 291-307.

Harper, Horace J., and Harley A. Daniel. 1934. Chemical composition of certain aquatic plants. Bot. Gaz., 96: 186-189.

Hayden, Ada. 1919. The ecologic subterranean anatomy of some plants of a prairie province in central Iowa. Amer. Jour. Bot., 6: 87-105.

_____. 1939. Notes on Typha angustifolia L. in Iowa. Iowa State Col. Jour. Sci., 13: 341-351.

_____. 1947. Notes on destructive factors operating among the emergent plants of the Ruthven area in the summer of 1947. Quart. Rpt., Iowa Coop. Wildlife Res. Unit (mimeographed), July-Sept.: 4-15.

_____. 1948. Notes on the repopulation of the aquatic flora of the Ruthven area. Quart. Rpt., Iowa Coop. Wildlife Res. Unit (mimeographed), July-Sept.: 4-7.

Hayford, John F. 1922. Effects of winds and of barometric pressures on the Great Lakes. Publ. 317, Carnegie Inst., v + 133 pp.

Hefley, Harold M. 1937. Ecological studies on the Canadian River floodplain in Cleveland County, Oklahoma. Ecol. Monog., 7: 345-402.

Hewitt, Oliver H. 1942. Management of an artificial marsh in southern Ontario for ducks and muskrats. Trans. 7th N. Amer. Wildlife Conf., pp. 277-282.

Hochbaum, H. Albert. 1944. The canvasback on a prairie marsh. Amer. Wildlife Inst., Washington. xii + 201 pp.

Hoffman, Carl E. 1940. Limnological relationships of some northern Michigan Donaciini (Chrysomelidae; Coleoptera). Trans., Amer. Micros. Soc., 59: 259-274.

Hotchkiss, Neil, and Herbert L. Dozier. 1949. Taxonomy and distribution of N. American cat-tails. Amer. Midland Nat., 41: 237-254.

Hottes, Frederick C., and Theodore H. Frison. 1931. The plant lice or Aphilidae, of Illinois. Bul., Ill. Nat. Hist. Surv., 19: 121-447.

Hubbard, Bela. 1818. Manuscript map of the counties and townships of Michigan. Wayne County - Brownstown and part of Ash. Monroe County - part of Ash. In Burton Historical Library, Detroit.

Hubbs, Carl L., and Karl F. Lagler. 1947. Fishes of the Great Lakes region. Bul. 26, Cranbrook Inst. Sci., xi + 186 pp.

Johnson, Charles E. 1925. The muskrat in New York, its natural history and economics. Roosevelt Wild Life Bul., 3: 199-320.

Karpinsky, Louis C. 1931. Bibliography of the printed maps of Michigan, 1804-1880. Mich. Hist. Comm., Lansing. 539 pp.

Koelz, W. 1926. Fishing industries of the Great Lakes. App. 11, U. S. Comm. Fisheries Rpt. for 1925, pp. 553-617.

Krecker, F. H. 1928. Periodic oscillations in Lake Erie. Contr. 1, Ohio State Univ. Franz Theodore Stone Lab., 22 pp.

Kronfeld, M. 1889. Monographie der Gattung Typha Tourn. Zool.-Bot. Gesell. Wien, Verhandl., 39: 89-192.

Laing, H. E. 1940. Respiration of the rhizomes of Nuphar advenum and other water plants. Amer. Jour. Bot., 27: 574-581.

_____. 1940a. Respiration of the leaves of Nuphar advenum and Typha latifolia. Amer. Jour. Bot., 27: 583-585.

_____. 1940b. The composition of the internal atmosphere of Nuphar advenum and other water plants. Amer. Jour. Bot., 27: 861-868.

_____. 1941. Effect of concentration of oxygen and pressure of water upon growth of rhizomes of semi-submerged water plants. Bot. Gaz., 102: 712-724.

Leverett, Frank, and Frank B. Taylor. 1915. Pleistocene of Indiana and Michigan and the history of the Great Lakes. Monog. 53, U. S. Geol. Survey, 529 pp.

Loew, E. 1908. Gattung Typha Tourn. Rohrkolben. In: von Kirchner, O., E. Loew, and C. Schroter. 1908. Lebensgeschichte der Blütenpflanzen Mitteleuropas, Band 1, Abt. 1: 345-374.

Low, Jessop B. 1940. Production of the redhead (Nyroca americana) in Iowa. Wilson Bul., 52: 153-164.

_____, and Frank C. Bellrose. 1944. The seed and vegetative yield of waterfowl food plants in the Illinois River valley. Jour. Wildlife Mangt., 8: 7-22.

Lynch, John J., Ted O'Neil, and Daniel W. Lay. 1947. Management significance of damage by geese and muskrats to Gulf Coast marshes. Jour. Wildlife Mangt., 11: 50-76.

McAtee, W. L. 1939. Wildfowl food plants, their value, propagation, and management. Collegiate Press, Ames, Iowa. ix + 141 pp.

Martin, A. C., and F. M. Uhler. 1939. Food of game ducks in the United States and Canada. U. S. D. A. Tech. Bul. 634, 156 pp.

Meyer, Bernard S., and Albert C. Heritage. 1941. Effect of turbidity and depth of immersion on apparent photosynthesis in Ceratophyllum demersum. Ecology, 22: 17-22.

Misra, R. D. 1938. Edaphic factors in the distribution of aquatic plants in the English lakes. Jour. Ecol., 26: 411-451.

Morinaga, T. 1926. Effect of alternating temperatures upon the germination of seeds. Amer. Jour. Bot., 13: 141-158.

_____. 1926a. The favorable effect of reduced oxygen supply upon the germination of certain seeds. Amer. Jour. Bot., 13: 159-166.

Moseley, E. L. 1904. Formation of Sandusky Bay and Cedar Point. Proc., Ohio Acad. Sci., 4 (Pt. 5): 178-238.

Moyle, John B. 1945. Some chemical factors influencing the distribution of aquatic plants in Minnesota. Amer. Midland Nat., 34: 402-420.

_____, and Neil Hotchkiss. 1945. The aquatic and marsh vegetation of Minnesota and its value to waterfowl. Tech. Bul. 3, Minn. Dept. Conserv., 122 pp.

Muenscher, W. C. 1936. Storage and germination of seeds of aquatic plants. Bul. 652, Cornell Univ. Agr. Expt. Sta., 17 pp.

Musham, H. A. 1943. The practical application of the rhythmic fluctuation of the levels of the Great Lakes. Jour., Western Soc. Engin., 48: 185-196.

Needham, James G., and J. T. Lloyd. 1916. The life of inland waters. Comstock Publ. Co., Ithaca, N. Y. 438 pp.

Newell, J. E. 1910. Sketch Map of P. M. S. C. [Pointe Mouillée Shooting Club]. Manuscript Map. Located at Headquarters, Pointe Mouillée State Game Area.

Oosting, Henry J. 1932. Distribution of the genus Potamogeton in Michigan. Papers, Mich. Acad. Sci., Arts, Letters, 15 (1931): 141-171.

_____. 1933. Physical-chemical variables in a Minnesota lake. Ecol. Monog., 3: 493-533.

Pancoast, John M. 1937. Muskrat industry in southern New Jersey. Trans. 2nd N. Amer. Wildlife Conf., pp. 527-530.

_____. 1942. Remarks. Trans. 7th N. Amer. Wildlife Conf., pp. 482-484.

Pearsall, W. H. 1920. The aquatic vegetation of the English lakes. Jour. Ecol., 8: 163-201.

Penfound, W. T., T. F. Hall, and A. D. Hess. 1945. The spring phenology in and around the reservoirs in north Alabama with particular reference to malaria control. Ecology, 26: 332-352.

Penfound, W. T., and Edward S. Hathaway. 1938. Plant communities in the marshlands of southeastern Louisiana. Ecol. Monog., 8: 1-56.

Peterson, Roger Tory. 1947. A field guide to the birds. Houghton Mifflin Co., Boston. xxiv + 290 pp.

Provost, Maurice W. 1947. Nesting of birds in the marshes of northwest Iowa. Amer. Midland Nat., 38: 485-503.

Ricker, W. E., and John Gottschalk. 1941. An experiment in removing coarse fish from a lake. Trans., Amer. Fisheries Soc., 70: 382-390.

Rickett, H. W. 1922. A quantitative study of the larger aquatic plants of Lake Mendota. Trans., Wis. Acad. Sci., Arts, Letters, 20: 501-527.

_____. 1924. A quantitative study of the larger aquatic plants of Green Lake, Wisconsin. Trans., Wis. Acad. Sci., Arts, Letters, 21: 381-414.

Roscoe, Muriel V. 1927. Cytological studies in the genus

Typha. Bot. Gaz., 84: 392-406.

Sakharov, N. 1927. Some edible plants of the Volga delta. Bul. App. Bot. Gen. and Plant Breed. [Russia], 18: 365-370. From auth. summary in Biol. Abs., 3: 246, 1929.

Sampson, Homer C. 1921. An ecological survey of the prairie vegetation of Illinois. Bul., Ill. Nat. Hist. Surv., 13: 523-577.

Sanborn, Charles E. 1906. Kansas Aphididae, with catalogue of North American Aphididae and with host-plant and plant-host list, Part II. Kan. Univ. Sci. Bul., 3: 225-274.

Satterthwait, A. F. 1920. Notes on the habits of Calendra pertinax Olivier. Jour. Econ. Ent., 13: 280-295.

Saunders, Aretas A. 1926. The summer birds of central New York marshes. Roosevelt Wild Life Bul., 3: 335-476.

Seymour, Arthur Bliss. 1929. Host index of the fungi of North America. Harvard Univ. Press, Cambridge, Mass. xiii + 732 pp.

Shelford, V. E., and M. W. Boesel. 1942. Bottom animal communities of the island area of western Lake Erie in the summer of 1937. Ohio Jour. Sci., 42: 179-190.

Sherff, Earl E. 1912. The vegetation of Skokie Marsh, with special reference to subterranean organs and their interrelationships. Bot. Gaz., 53: 415-435.

_____. 1913. Evaporation conditions in Skokie Marsh. Plant World, 16: 154-160.

Sherzer, W. H. 1900. Geological report on Monroe County, Michigan. Geol. Survey of Michigan, Vol. 7, Part I. x + 240 pp.

_____. 1917. Description of the Detroit District. Detroit Folio, Michigan. No. 205, Geologic Atlas of the U. S., U. S. Geol. Survey, 22 pp.

Sigler, Wm F. 1948. Aquatic and shore vegetation of Spirit Lake, Dickinson County, Iowa. Iowa State Col. Jour. Sci., 23: 103-124.

Sooter, Clarence A. 1941. Ecology and management of the American coot Fulica americana americana Gmelin. Abs. of Doctoral Thesis, Iowa State Col. Jour. Sci., 17: 126-128.

Stallard, H. 1929. Secondary succession in the climax forest formations of northern Minnesota. Ecology, 10: 476-547.

Steenis, John H., and Clarence Cottam. 1945. A progress

report on the marsh and aquatic plant problem: Reelfoot Lake. Jour., Tenn. Acad. Sci., 20: 6-19.

Struthers, P. H. 1930. Carp control studies in the Cayuga and Owasco Lake basins. A Biol. Survey of the Champlain Watershed, Suppl. to 19th Ann. Rpt., N. Y. State Conserv. Dept., pp. 261-280.

Taylor, Frank B. 1927. The present and recent rate of land-tilting in the region of the Great Lakes. Papers, Mich. Acad. Sci., Arts, Letters, 7 (1926): 145-157.

Titcomb, J. W. 1923. Aquatic plants in pond culture, 2nd. Ed. App. 2, U. S. Comm. Fisheries Rpt. for 1923, 24 pp.

Uhler, Francis M. 1944. Control of undesirable plants in waterfowl habitats. Trans. 9th N. Amer. Wildlife Conf., pp. 295-303.

_____. 1945. Remarks on problems of wet land management. Minutes of Conference on Wet Land Uses and Management, Conserv. Inst., Mich. State Col. (Mimeo.)

U. S. Geological Survey. 1940. Rockwood Quadrangle, Estral Beach Quadrangle; Michigan.

U. S. Lake Survey. 1902. Lake Erie Coast Chart No. 7, Port Clinton to Toledo and Detroit River. Survey of the Northern and Northwestern Lakes.

_____. 1918. Lake Erie Coast Chart No. 7, Port Clinton to Toledo and Detroit River. Survey of the Northern and Northwestern Lakes.

_____. 1950. Chart of monthly mean water levels, 1860 to date.

U. S. Land Office. 1817. Township plats and transcript of field notes, T. 6 S. and T. 5 S., R. 10 E. of Michigan Meridian.

U. S. War Department. 1849. West end of Lake Erie and Detroit River. Survey of the Northern and Northwestern Lakes, Topog. Bur.

U. S. Weather Bureau. 1930-1950. Climatological data, Michigan section. Vol. 45 - 65.

_____. 1936. Climatic summary of the United States. Section 65, Eastern Lower Michigan. 29 pp.

Veatch, J. O. 1933. Some relationships between water plants and water soils in Michigan. Papers, Mich. Acad. Sci., Arts, Letters, 17 (1932): 409-413.

Veatch, J. O. 1933a. Agricultural land classification and land types of Michigan. Spec. Bul. 231, Mich. Agr. Expt. Sta., 51 pp.

Walton, W. R. 1908. Notes on the life history of Nonagria oblonga Gr. Ent. News, 19: 295-299.

Ward, Edward. 1942. Phragmites management. Trans. 7th N. Amer. Wildlife Conf., pp. 294-298.

Weaver, J. E., and F. E. Clements. 1938. Plant ecology. McGraw-Hill, N. Y. xxii + 601 pp.

Weaver, J. E., and W. J. Himmel. 1930. The relation of increased water content and decreased aeration to root development in hydrophytes. Plant Physiol., 5: 69-92.

White, G. W. 1944. Lake Erie shore erosion in Ohio. Shore and Beach, 12: 8-10.

Williams, Cecil S., and W. H. Marshall. 1938. Evaluation of nesting cover for waterfowl on Bear River Refuge. Trans. 3rd N. Amer. Wildlife Conf., pp. 640-646.

Wilson, L. R. 1937. A quantitative and ecological study of the larger aquatic plants of Sweeney Lake, Oneida County, Wisconsin. Bul., Torrey Bot. Club., 64: 199-208.

Wilson, H. F., and R. A. Vickery. 1918. A species list of the Aphididae of the world and their recorded food plants. Trans., Wis. Acad. Sci., Arts, Letters, 19: 22-355.

Wright, A. H., and A. A. Wright. 1949. Handbook of frogs and toads of United States and Canada. Comstock Pub. Co., Ithaca, N. Y. xii + 640 pp.

Yanovsky, Elias. 1936. Food plants of the North American Indians. U. S. D. A. Misc. Pub. 237, 83 pp.

Yapp, R. H. 1909. On stratification in the vegetation of a marsh and its relation to evaporation and temperature. Ann. Bot., 23: 275-320.

Yeager, Lee E. 1945. Capacity of Illinois land types to produce furs. Trans. 10th N. Amer. Wildlife Conf., pp. 76-86.

_____. 1949. Effect of permanent flooding in a river-bottom timber area. Bul., Ill. Nat. Hist. Surv., 25: 33-65.

APPENDIX

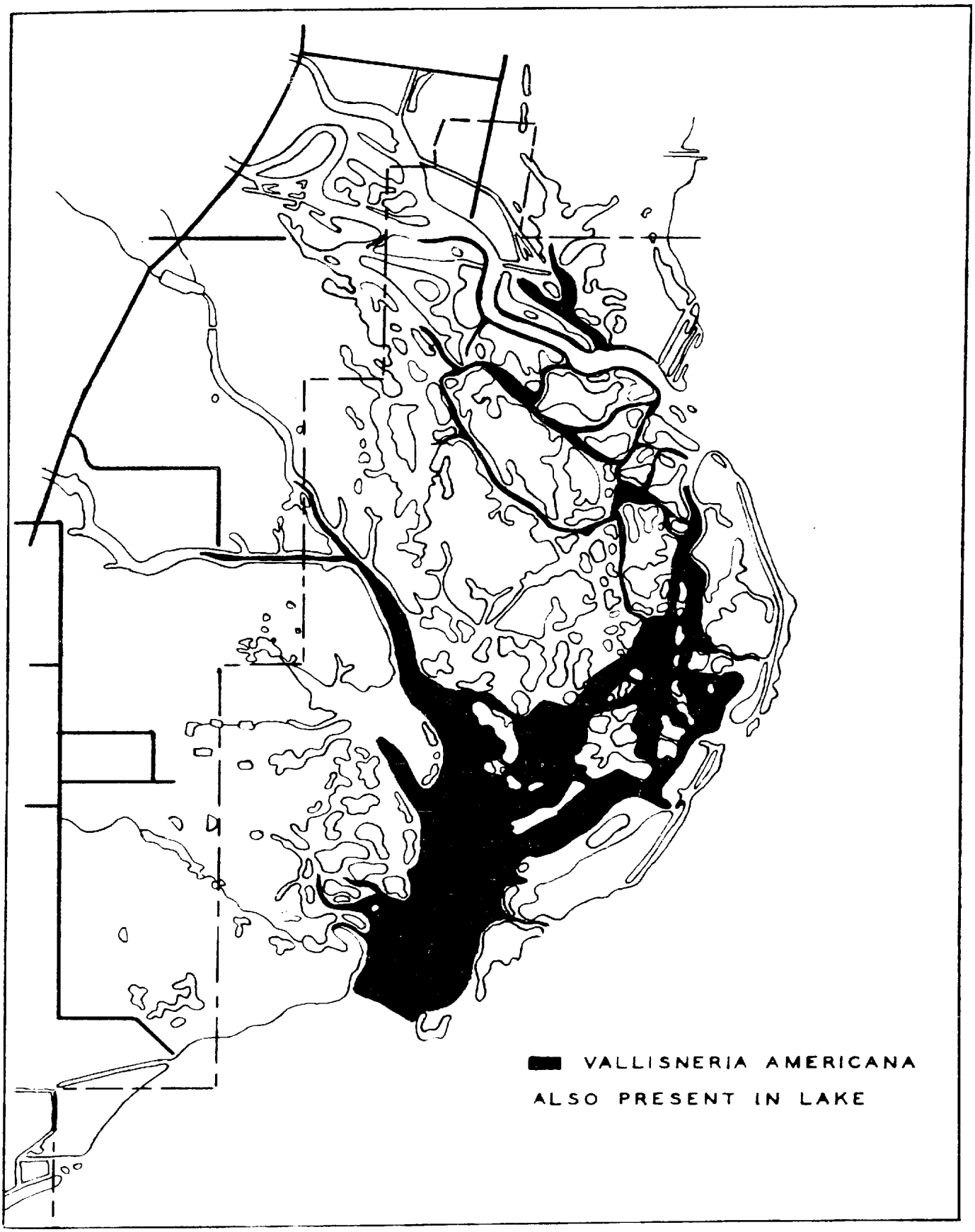


FIG. 18 DISTRIBUTION OF VALLISNERIA AMERICANA MOUILLÉE DISTRICT, 1949

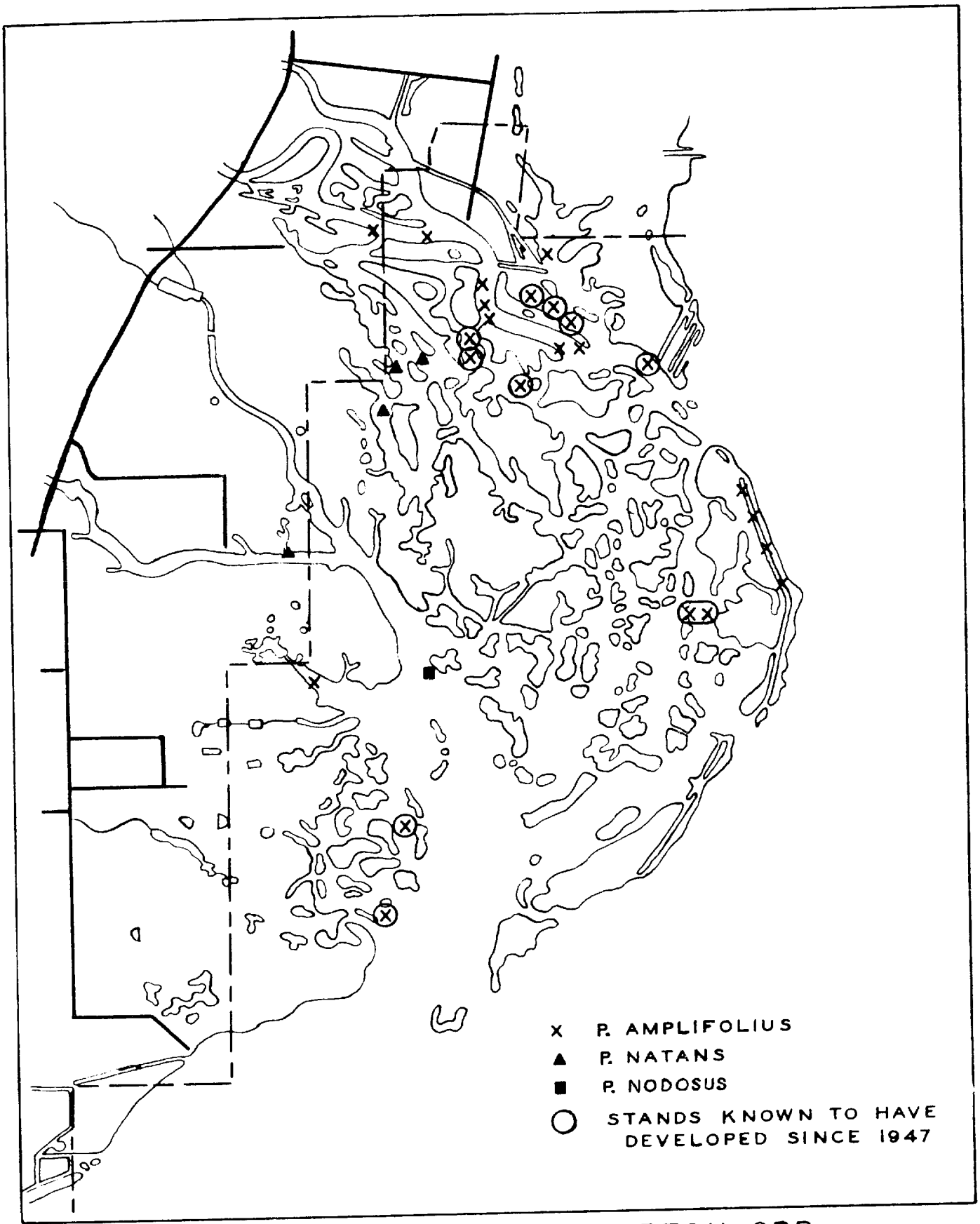


FIG. 19 DISTRIBUTION OF POTAMOGETON SPP.
MOUILLÉE DISTRICT, 1949

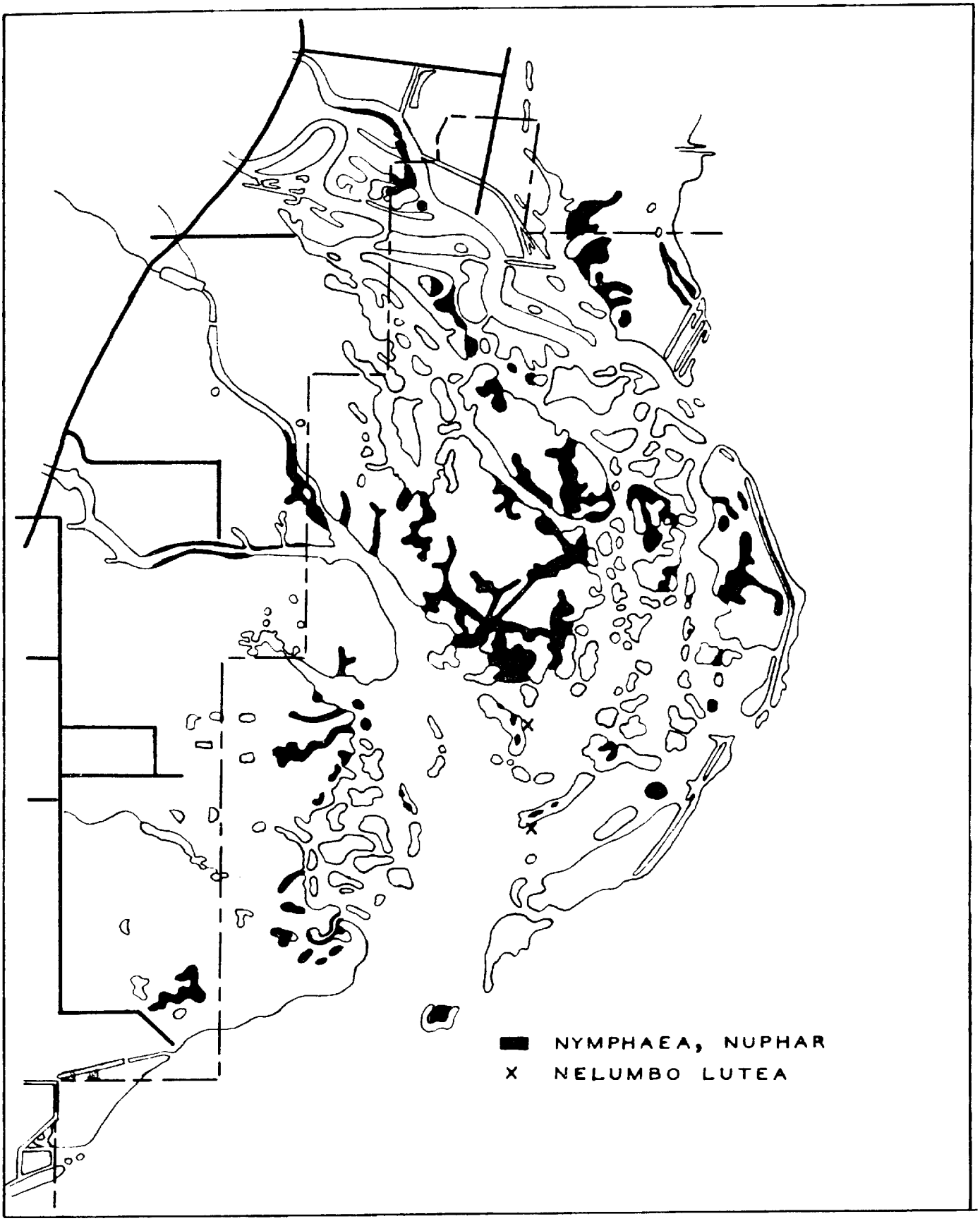


FIG. 20 DISTRIBUTION OF NYMPHAEACEAE
MOUILLÉE DISTRICT, 1949

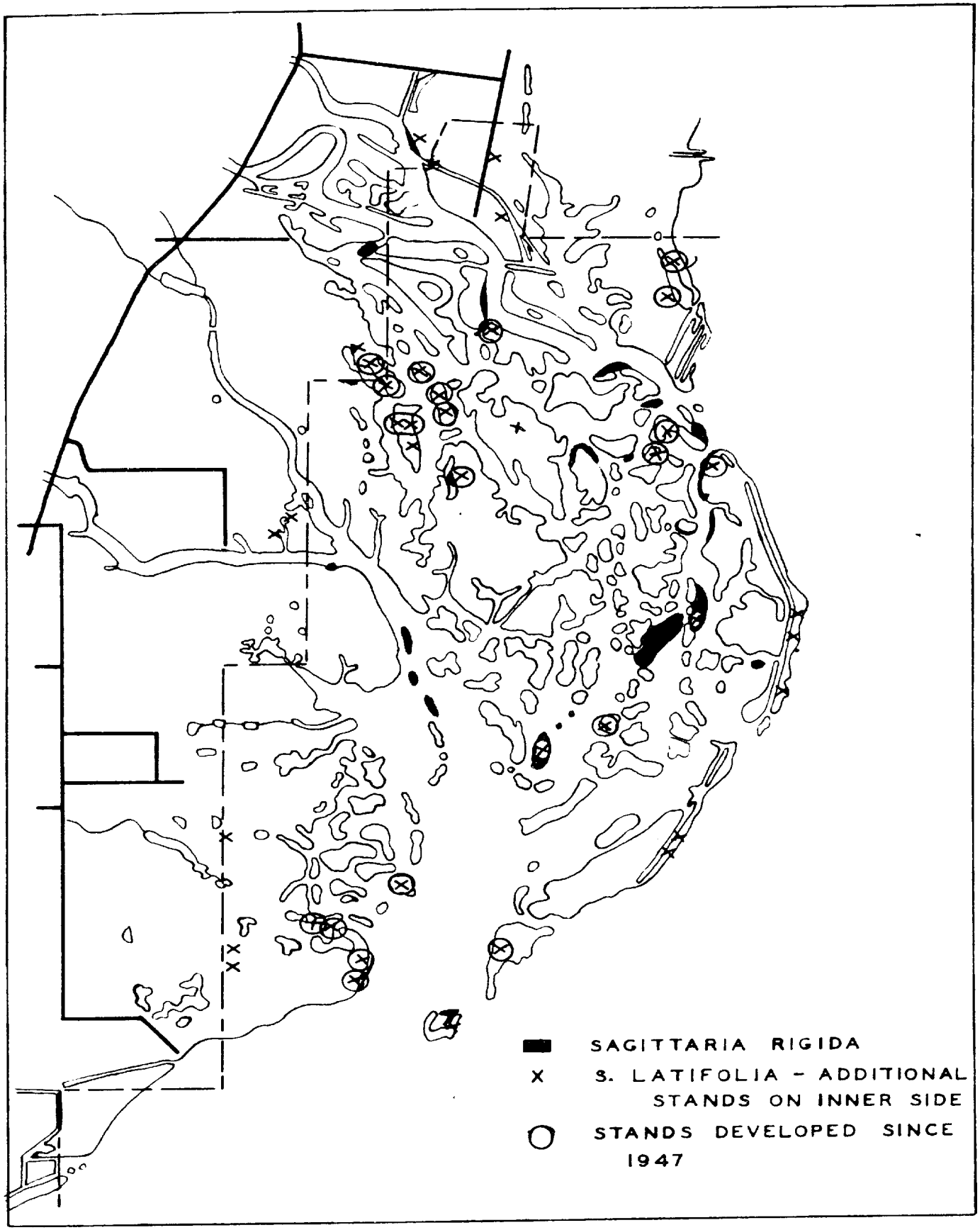


FIG. 21 DISTRIBUTION OF SAGITTARIA MOUILLÉE DISTRICT, 1949

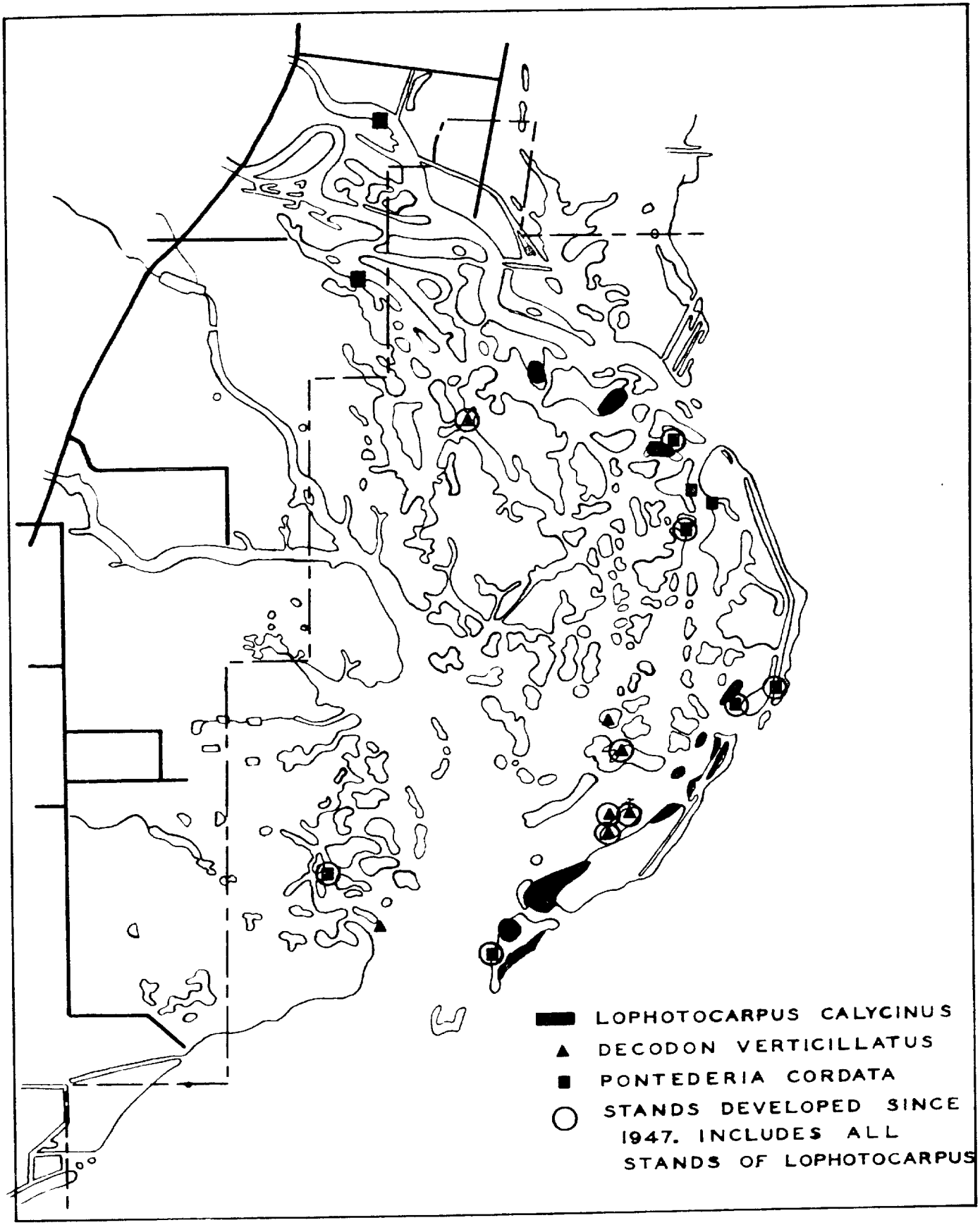


FIG. 22 DISTRIBUTION OF AQUATIC PLANTS MOUILLÉE DISTRICT, 1949

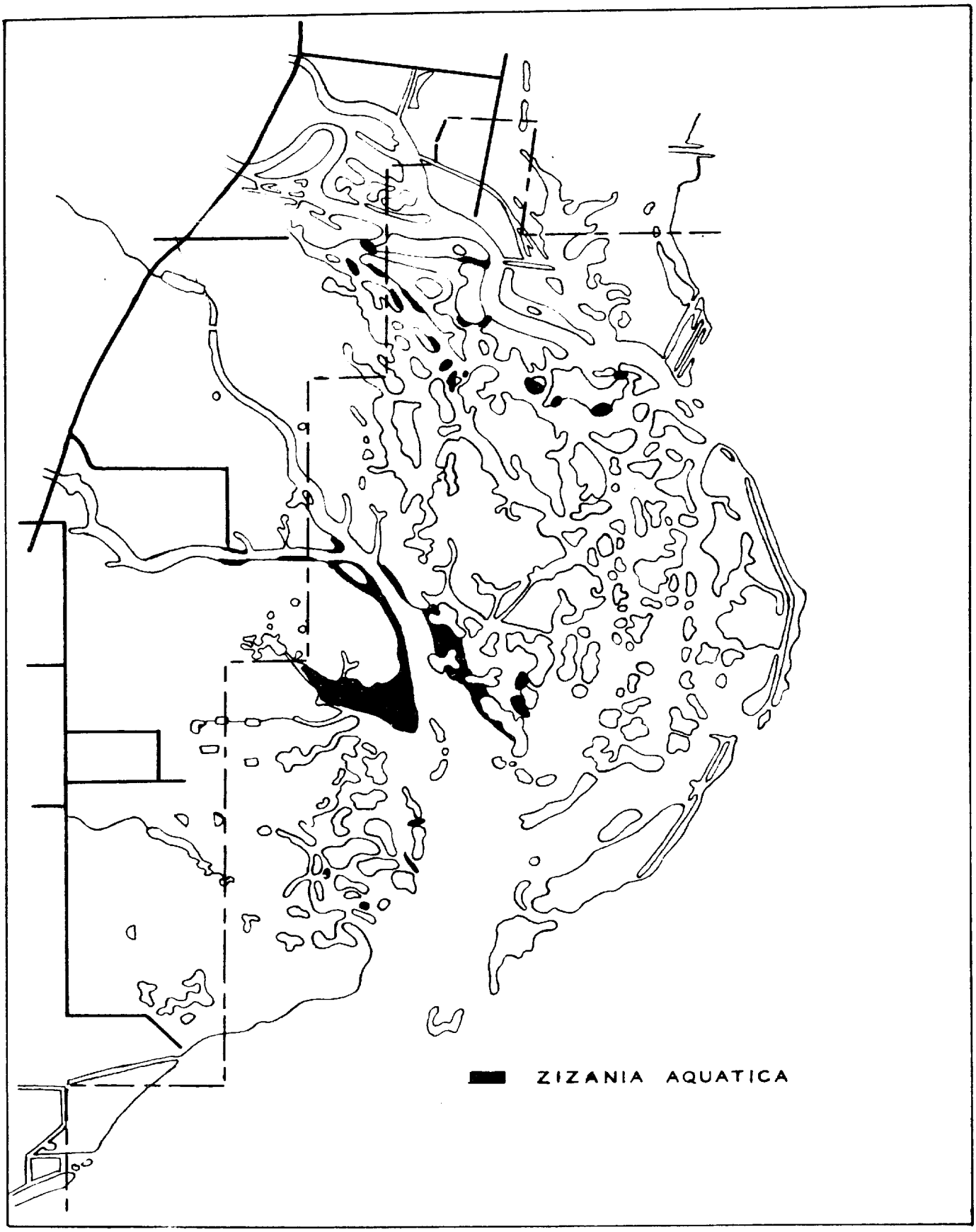


FIG. 23 DISTRIBUTION OF ZIZANIA MOUILLÉE DISTRICT, 1949

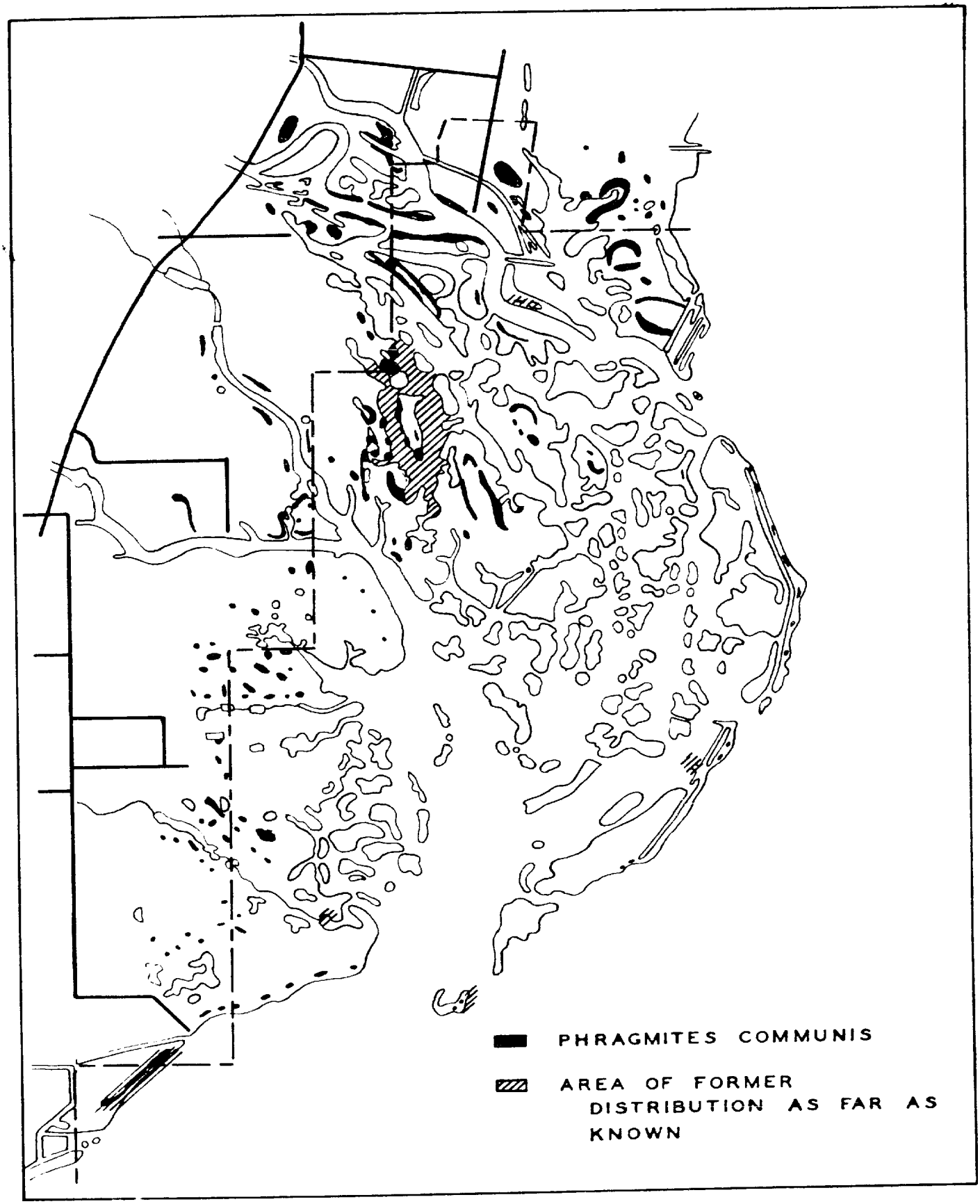


FIG. 24 DISTRIBUTION OF PHRAGMITES
MOUILLÉE DISTRICT, 1949

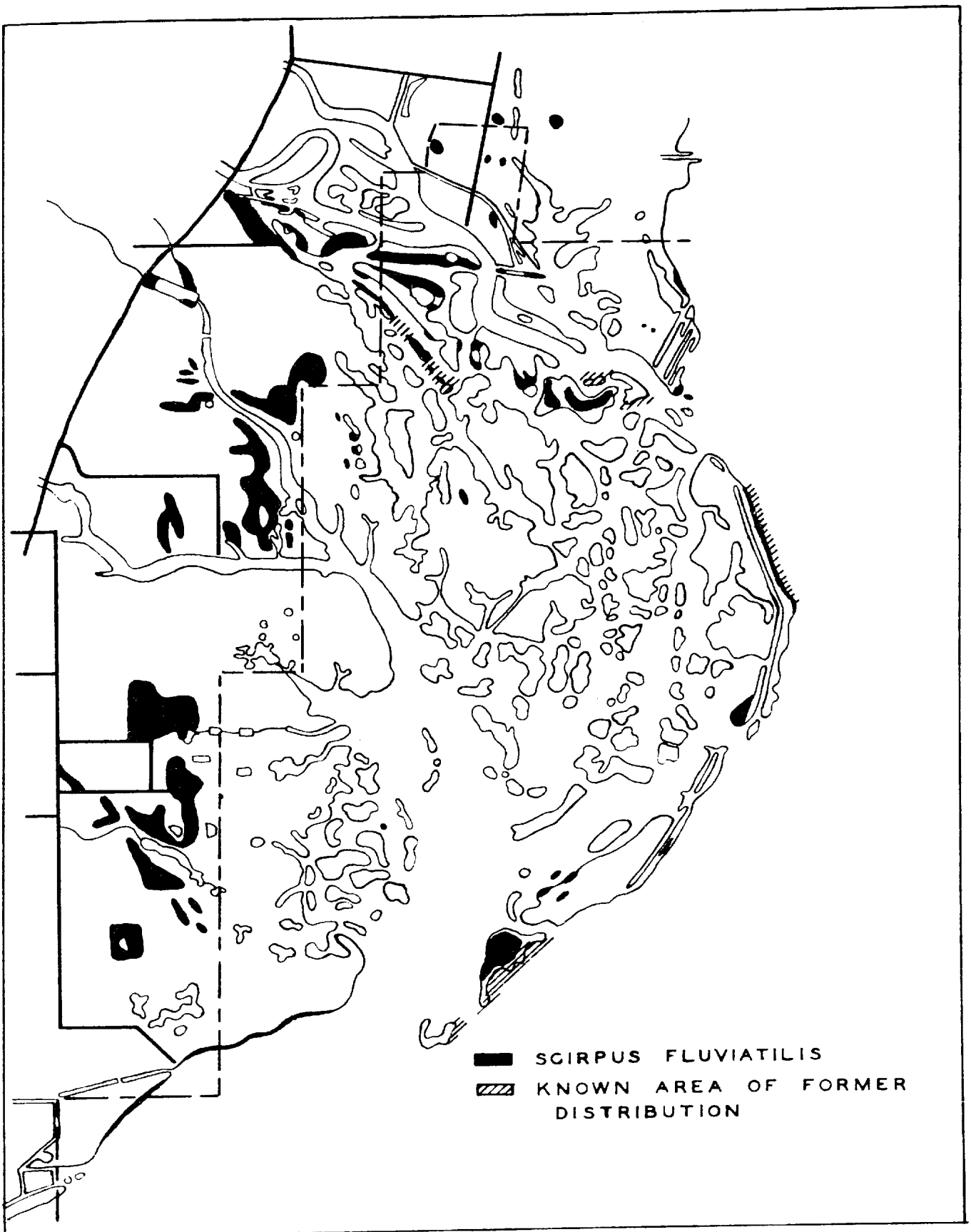


FIG. 25 DISTRIBUTION OF SCIRPUS FLUVIATILIS MOUILLÉE DISTRICT, 1949

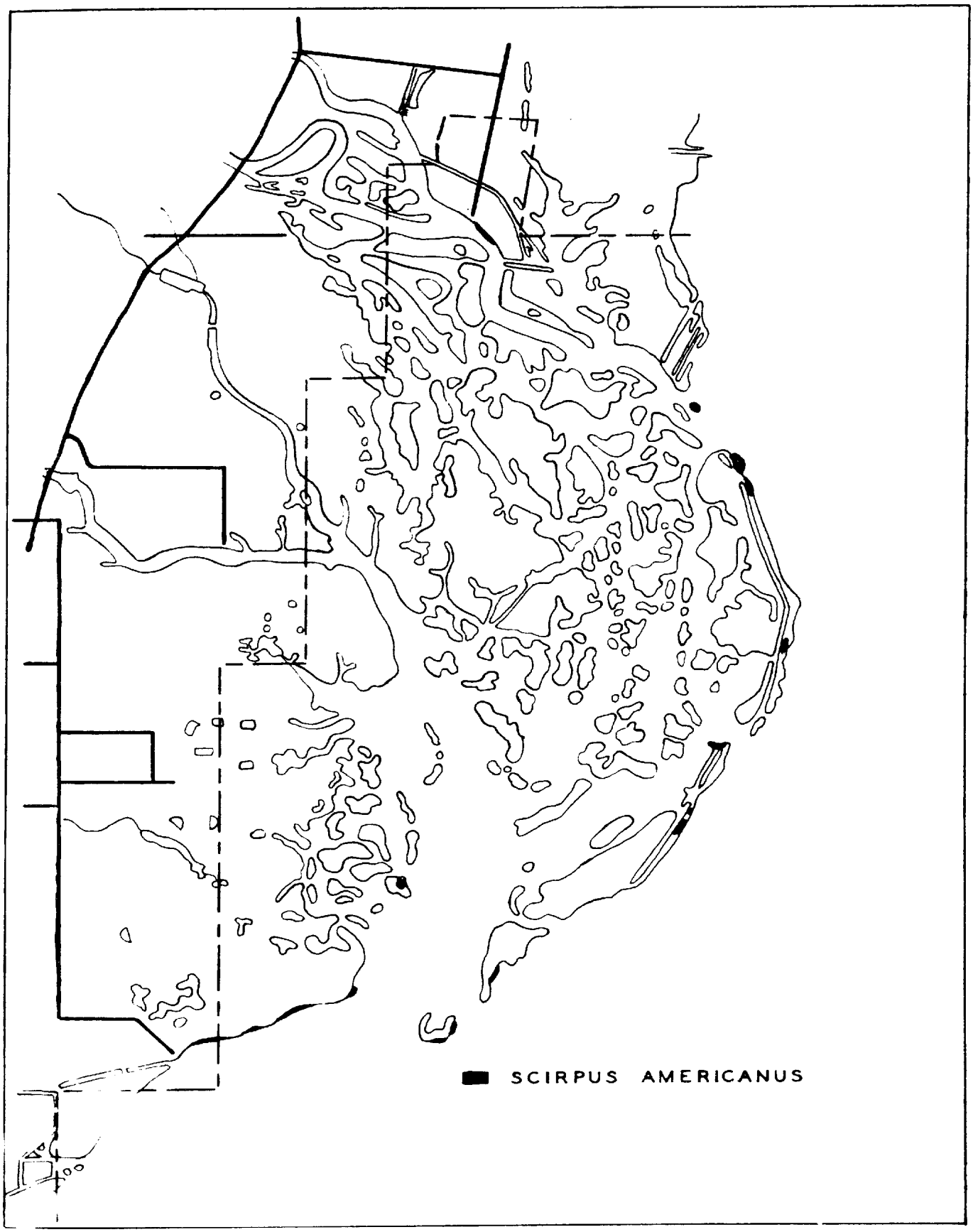


FIG. 26 DISTRIBUTION OF SCIRPUS AMERICANUS
MOUILLÉE DISTRICT, 1949

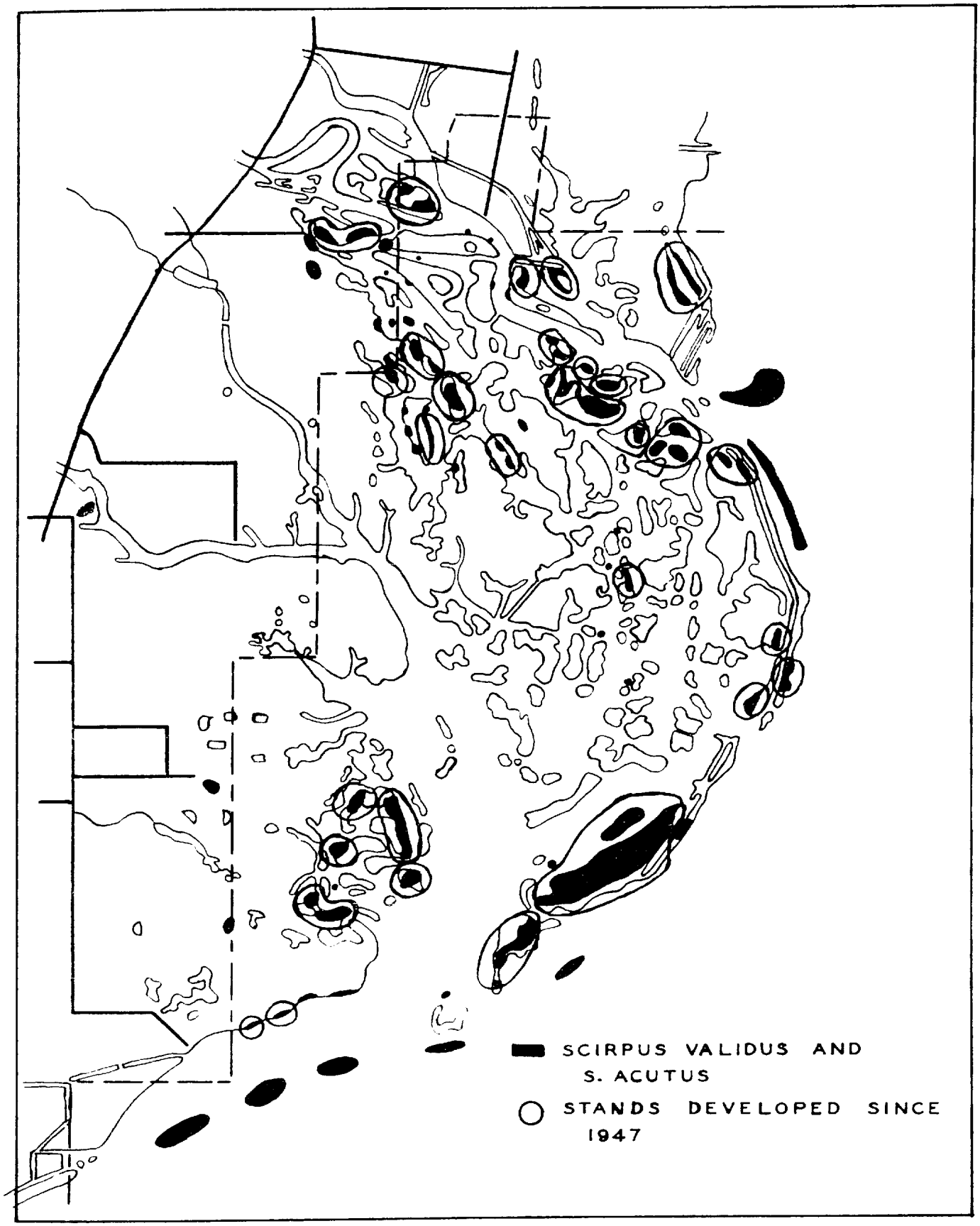


FIG. 27 DISTRIBUTION OF SCIRPUS SPP.
MOUILLÉE DISTRICT, 1949

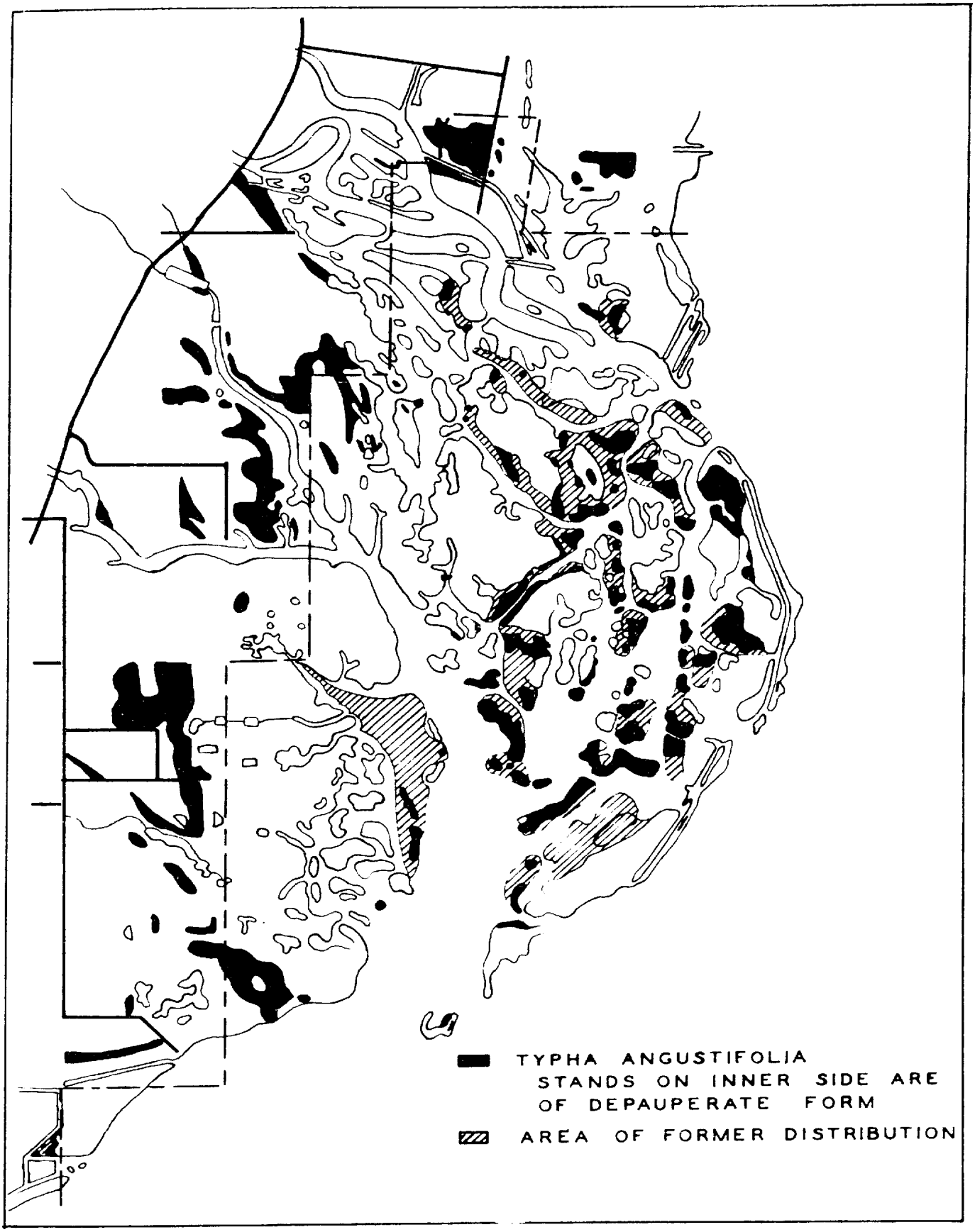


FIG. 28 DISTRIBUTION OF TYPHA ANGUSTIFOLIA
MOUILLÉE DISTRICT, 1949

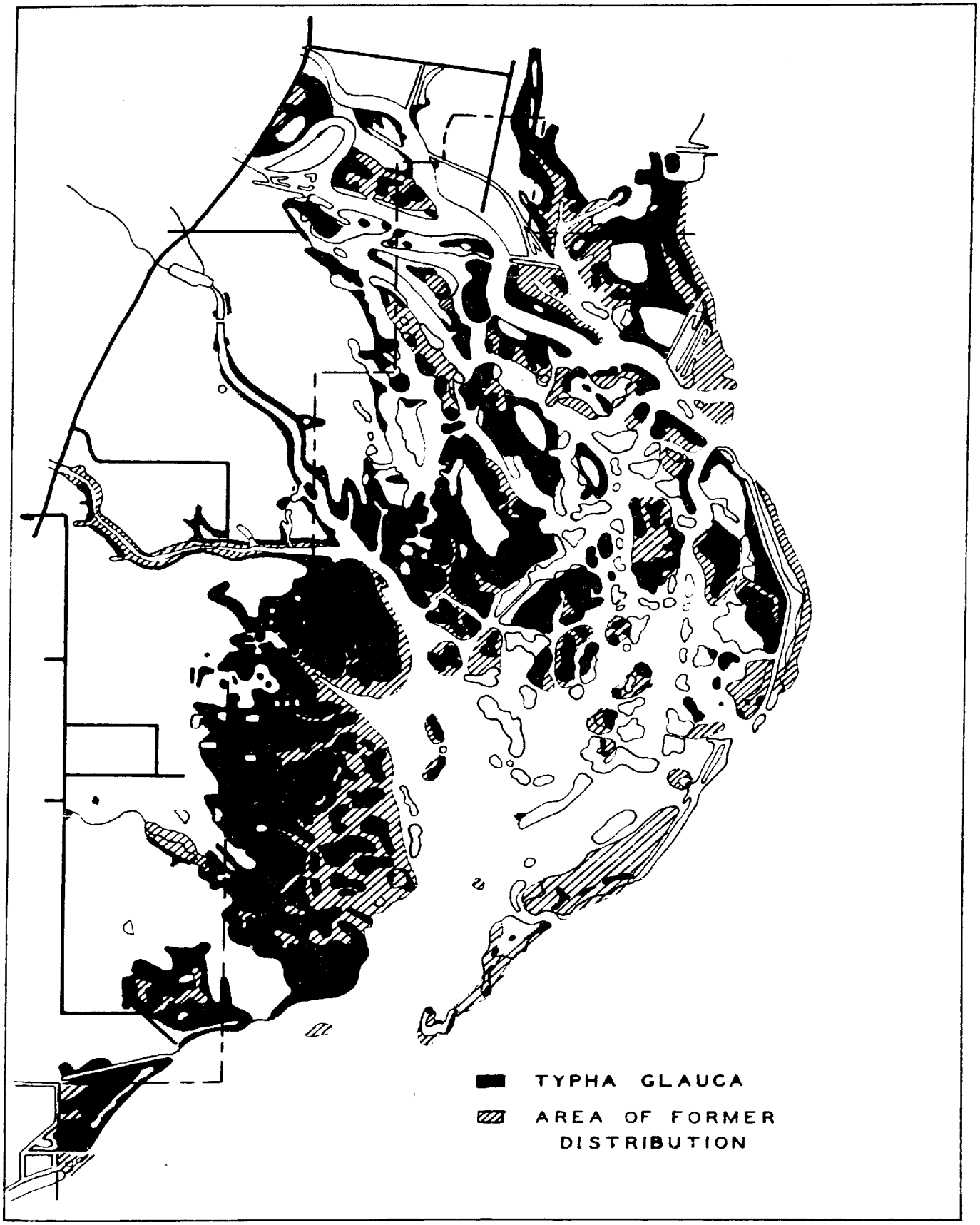


FIG. 29 DISTRIBUTION OF TYPHA GLAUCA MOUILLÉE DISTRICT, 1949

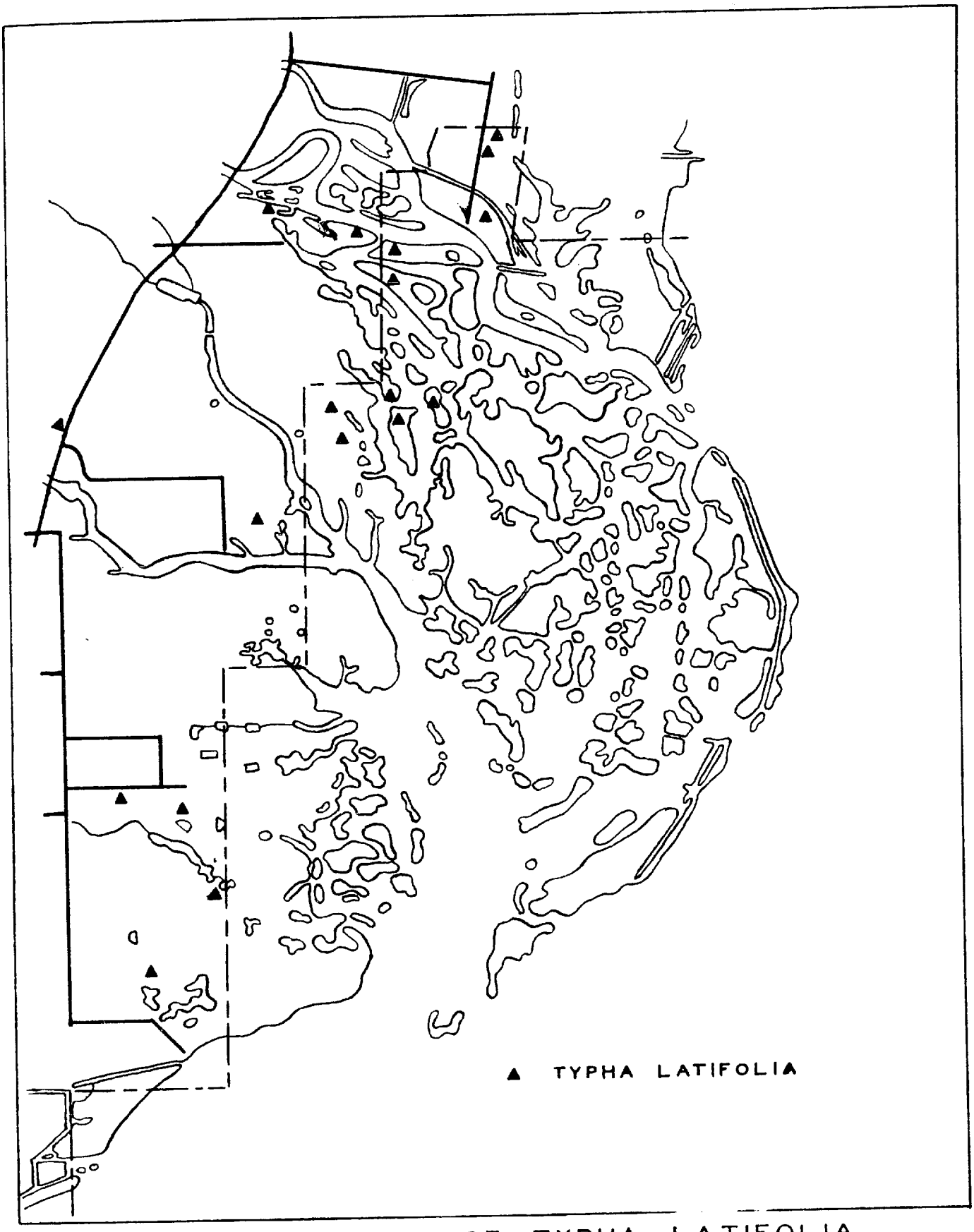


FIG. 30 DISTRIBUTION OF TYPHA LATIFOLIA
MOUILLÉE DISTRICT, 1949

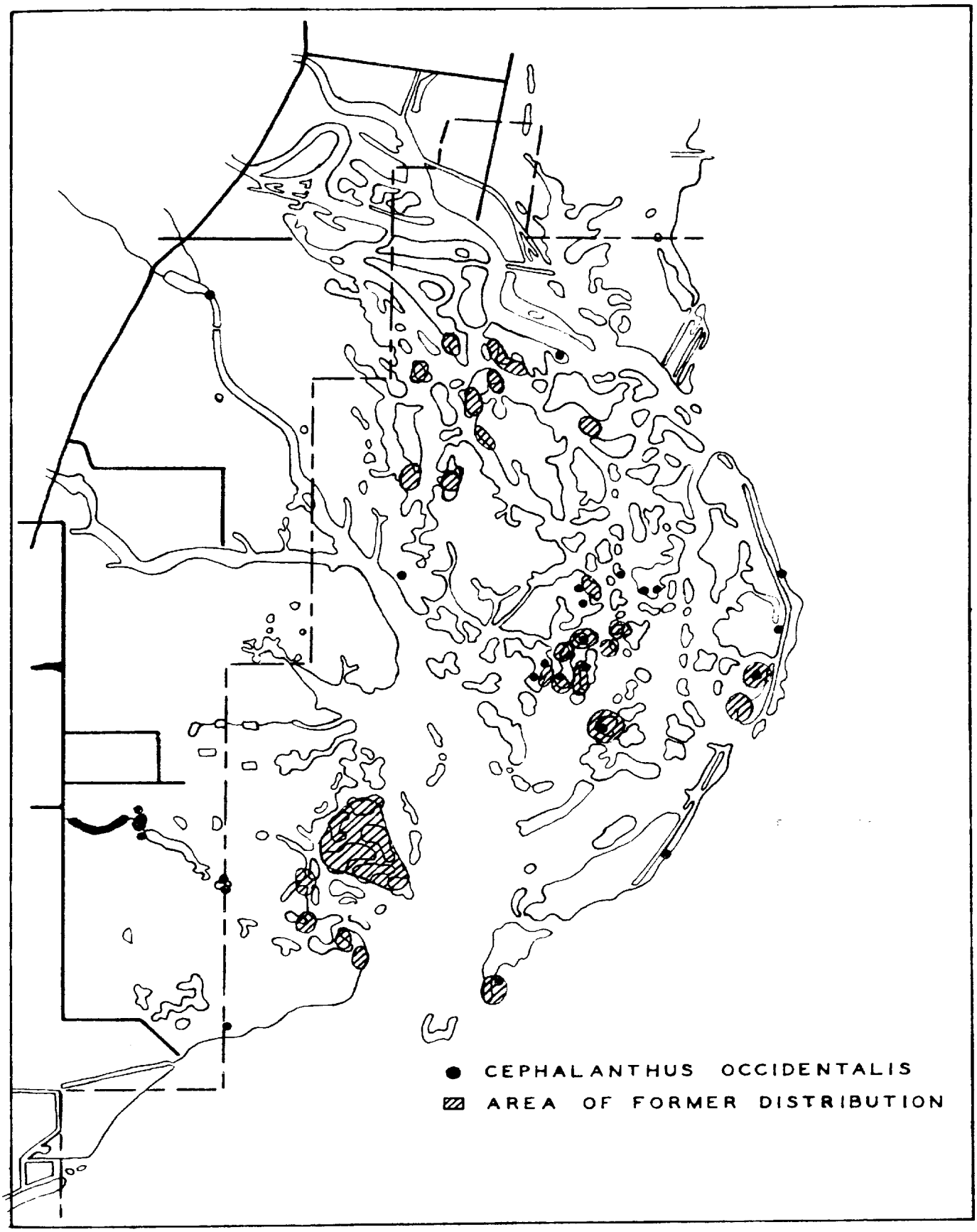


FIG. 31 DISTRIBUTION OF CEPHALANTHUS MOUILLÉE DISTRICT, 1949

TABLE 12

SPECIES OF PLANTS AND THEIR ECOLOGICAL DISTRIBUTION
PTE. MOUILLÉE STATE GAME AREA MARSH

The order of families and the nomenclature is that of Gray's Manual of Botany, Eighth Edition (Fernald, 1950). The family name is given for the first family starting on each page and for a few important families; the remaining families are separated by an extra space. Species are listed alphabetically within each family and genus. Frequency of occurrence within each community is indicated by a number. This frequency is not based on quadrat counts or studies, but on general observations over the entire marsh.

LEGEND

a Submerged Plant Community	k Sand Meadow	Community Groups
b Floating-leaf Community	l Beach Thicket	Marsh - a, b, c, d, e, h, i
c Aestival Reed-marsh	m Willow-Cottonwood Grove	Beach - j, k, l, m
d Reed-marsh		Islands - f, g
e Sedge-meadow	1 Very rare	
f Wet Meadow	2 Rare	
g Meadow Thicket	3 Common	
h Swamp Thicket	4 Abundant	
i Flotage and Mud Bank Communities	5 Very abundant	
j Sand Bar Community	* Specimen collected	

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Characeae													
*Chara sp.	2												
*Riccia fluitans				5									
Ricciocarpus natans				3									
*Equisetum arvense												2	
*Equisetum fluviatile					2								
*Dryopteris Thelypteris var. pubescens						2							
*Oncolea sensibilis						3							
*Juniperus communis							1						
*Typha angustifolia				5	3						2		
*Typha glauca				5						2			
*Typha latifolia				2	1								
*Sparganium eurycarpum				4						4			

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Zosteraceae													
*Potamogeton amplifolius	2	3											
*Potamogeton crispus	4	3	2										
*Potamogeton foliosus	3	2											
*Potamogeton natans		1											
*Potamogeton nodosus	1												
*Potamogeton pectinatus	4	3	2										
*Potamogeton Richardsonii	2												
*Potamogeton zosteriformis	2												
*Zannichellia palustris	2												
*Naias flexilis	3												
*Naias minor	5	3	3										
*Alisma subcordatum									4				
*Lophotocarpus calycinus									3				
*Sagittaria latifolia	1		2						5				
*Sagitteria rigida			4						2				

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Butomaceae													
*Butomus umbellatus									3				
*Elodea canadensis	3												
*Vallisneria americana	5												
Gramineae													
*Agropyron repens											3		
*Agrostis alba						3					3		
*Bromus inermis											2		
Bromus mollis											2		
Bromus tectorum											2		
*Calamagrostis canadensis					5	4							
*Cenchrus longispinus											1		
*Dactylis glomerata											1		
*Digitaria sanguinalis										2	3		
*Echinochloa crusgalli									2				
*Echinochloa Walteri									5				
*Elymus canadensis												2	

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
*Elymus virginicus						2							
Eragrostis Frankii										1			
*Eragrostis hypnoides									3				
*Eragrostis megastachya										1			
*Festuca ovina											1		
*Glyceria striata						2							
*Hordeum jubatum											2		
*Leersia oryzoides									4				
*Muhlenbergia frondosa											2		
*Muhlenbergia mexicana						3					3		
*Panicum capillare										3	4		
*Panicum dichotomiflorum										1			
*Panicum lanuginosum var. implicatum						2							
*Panicum virgatum											2		
*Phalaris arundinacea					2								
*Phleum pratense										2	3		

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
*Phragmites communis var. Berlandieri				5	2								
*Poa compressa						3					2		
*Poa pratensis						4					2		
*Poa trivialis						2							
*Setaria glauca											3	3	2
*Setaria viridis											1		
*Spartina pectinata						4							
*Sphenopholis obtusata											2		
*Zizania aquatica			4						1				
Cyperaceae													
*Carex conjuncta					2								
*Carex gracilescens						2							
*Carex granularis						2							
Carex lacustris					3								
*Carex lanuginosa					3	3							
*Carex normalis					2								
*Carex Sartwellii					2								

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
*Carex stipata					2								
*Carex stricta					4	3							
*Carex tribuloides					3	3							
*Carex vulpinoidea					4	4							
*Cyperus diandrus									2				
*Cyperus erythrorhizos									5	4			
*Cyperus ferruginescens										3			
*Cyperus inflexus										2			
Cyperus rivularis											1		
*Cyperus strigosus									5	4			
*Eleocharis acicularis									3				
*Eleocharis Engelmanni									2				
*Eleocharis intermedia					1								
*Eleocharis macrostachya					4				2				
*Eleocharis obtusa					2								
*Eleocharis palustris					3								

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
*Eleocharis palustris var. major									1				
*Scirpus acutus				2					4				
*Scirpus americanus				1						4			
*Scirpus atrovirens					3	3							
*Scirpus cyperinus					2								
*Scirpus fluviatilis				4	3	3							
*Scirpus lineatus					3								
*Scirpus validus var. creber				3					5				
Araceae													
*Acorus Calamus					2								
*Lemna minor	5	5	5	5									
*Lemna trisulca				3									
*Spirodela polyrhiza	5	4	4	4									
*Wolffia columbiana	3	5											
*Tradescantia ohiensis						3							

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Pontederiaceae													
*Heteranthera dubia	5								5				
*Pontederia cordata				2					2				
*Juncus bufonius											2		
*Juncus Dudleyi						5					3		
*Juncus effusus					3								
*Juncus nodosus						3					3		
*Juncus Torreyi					3								
*Allium canadense						3						2	
*Asparagus officinalis													2
*Hemerocallis fulva											2		
*Lilium michiganense						2							
*Smilacina stellata						4						2	
*Smilax cirrhata							1						
*Smilax lasioneura							1						
*Dioscorea villosa							3						

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Amaryllidaceae													
*Hypoxis hirsuta						2							
*Iris virginica var. Shrevei					2	3							
*Sisyrinchium albidum						2							
*Habenaria leucophaea						3							
*Habenaria psycodes						1							
Salicaceae													
*Populus alba													1
*Populus deltoides					1	1						3	5
*Salix alba													3
*Salix amygdaloides												4	
*Salix discolor						3							
*Salix gracilis var. textoris						2							
*Salix interior					1							2	
*Corylus americana							1						

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Fagaceae													
*Quercus macrocarpa							1						
*Celtis occidentalis							2						
*Ulmus americana												1	
*Ulmus rubra					1		3					2	
*Morus rubra												1	
*Humulus Lupulus												1	
*Boehmeria cylindrica												2	
*Parietaria pensylvanica													2
*Pilea pumila						2					3		
*Urtica procera											3	4	
Polygonaceae													
*Polygonum amphibium var. stipuleceum		1		2	3								
Polygonum sviculare							1				1		
*Polygonum coccineum				2	3								

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
*Polygonum Hydropiper						2			2				
*Polygonum hydropiperoides										3			
*Polygonum lapathifolium									4	3			
*Polygonum lapathifolium var. prostratum									1	3			
*Polygonum pensylvanicum						3				3			
*Polygonum Persicaria										2			
*Polygonum punctatum						3			4	4			
*Polygonum scandens											2	3	
*Rumex crispus											3		
*Rumex orbiculatus					3								
*Rumex verticillatus										1			
Chenopodiaceae													
Atriplex patula var. hastata											1		
*Chenopodium album											2		
*Chenopodium ambrosioides											2		
Chenopodium hybridum var. gigantospermum											1		
*Chenopodium leptophyllum										1			

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Kochia Scoparia											1		
*Salsola Kali var. tenuifolia										1			
Amaranthaceae													
*Acnida altissima									5	5	4		
*Acnida altissima var. subnuda										3			
*Amaranthus albus										2			
*Amaranthus cruentus										1			
*Amaranthus graecizans										2			
*Amaranthus retroflexus										2			
Mirabilis nyctaginea											1		
*Mollugo verticillata										2			
*Claytonia virginica						2							
Portulaca oleracea										1			
Caryophyllaceae													
*Agrostemma Githago											1		
*Cerastium vulgatum											2		

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
*Saponaria officinalis												3	
*Silene Armeria											1		
*Stellaria graminea											2		
*Stellaria longifolia							2						
*Stellaria media											1		
Ceratophyllaceae													
*Ceratophyllum demersum	5	4	4										
*Nelumbo lutea		2											
*Nuphar advena		4											
*Nuphar variegatum		4											
*Nymphaea odorata		5		3					2				
Ranunculaceae													
*Anemone canadensis						4							
*Anemone virginiana						2	2						
*Clematis virginiana												1	
*Ranunculus abortivus							1						
*Ranunculus pensylvanicus					1								

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
*Ranunculus sceleratus									5	2			
*Ranunculus septentrionalis						2							
*Ranunculus trichophyllus									2				
*Thalictrum dasycarpum												3	
*Thalictrum revolutum						3	2						
Capparidaceae													
*Polanisia graveolens											3		
Cruciferae													
*Barbarea vulgaris											2		
*Berteroa incana										1			
Brassica juncea										2	2		
*Brassica Kaber var. pinnatifida											3		
*Brassica Rapa											1		
*Capsella Bursa-pastoris										3	3		
*Cardamine bulbosa													2
*Cardamine pensylvanica									2	2			
*Erysimum cheiranthoides											3		

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
*Lepidium virginicum										3			
*Rorippa islandica									2				
*Rorippa islandica var. hispida									4				
*Sisymbrium altissimum											1		
Thlaspi arvense											1		
Saxifragaceae													
*Penthorum sedoides									3				
*Ribes americanum												2	
*Platanus occidentalis													1
Rosaceae													
*Agrimonia parviflora						3	4						
*Crataegus crus-galli							1						
*Crataegus mollis							4						
*Fragaria virginiana							3						
*Geum aleppicum var. strictum						3							
*Geum laciniatum							2						
*Potentilla anserina						3							

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
*Potentilla norvegica										2	2		
*Potentilla paradoxa										2			
*Potentilla simplex						1							
*Prunus americana							1						
*Prunus serotina							1						
*Pyrus communis						1							
*Pyrus Malus						1							
*Rosa carolina							2						
*Rosa palustris						1							
*Rubus flagellaris							3						
*Rubus occidentalis											2		
*Spiraea alba						1							
Leguminosae													
*Amphicarpa bracteata var. comosa							1						
*Apios americana							2					2	
*Astragalus canadensis						1					3		
*Desmodium canadense						3							

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
*Gleditsia triacanthos												2	
*Lathyrus palustris						2							
*Lespedeza capitata						2							
*Medicago lupulina						2					2		
*Medicago sativa											1		
*Melilotus alba						2				4	4		
Melilotus officinalis											2		
*Strophostyles helvola							2				3		
Trifolium hybridum											1		
*Trifolium pratense						1					1		
*Trifolium repens						2							
Oxalidaceae													
*Oxalis europaea							3				2	3	
*Oxalis stricta											1		
*Xanthoxylum americanum							2						
*Ailanthus altissima												3	2

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Euphorbiaceae													
*Acalypha rhomboidea							3				3		
*Euphorbia supina											2		
*Euphorbia polygonifolia										1			
*Rhus glabra							2						
*Rhus radicans							2						
*Rhus typhina							3				3		
*Celastrus scandens							2						
*Acer Negundo												3	2
*Acer rubrum										3		2	
*Impatiens capensis					2				3		3		
*Rhamnus Frangula												1	
*Parthenocissus inserta							3					3	3
*Vitis riparia							4					4	4

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Tiliaceae													
*Tilia americana												1	
*Abutilon Theophrasti										1			
*Hibiscus palustris				2				3					
*Hypericum mutilum						2							
*Hypericum punctatum						3							
*Viola affinis						3							2
*Decodon verticillatus								2					
*Lythrum alatum						2							
*Epilobium glandulosum var. adenocaulon						2			3				
*Gaura biennis						3					3		
*Oenothera biennis										3	4		
Oenothera pilosella						1							
*Ludwigia palustris var. americana									1				

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Haloragaceae													
*Myriophyllum verticillatum var. pectinatum	3												
*Cicuta bulbifera					2								
Daucus Carota						1					1		
*Pastinaca sativa						2							
*Sanicula canadensis												1	
*Sium suave					3				2				
*Zizia aurea						1							
*Cornus Drummondi												1	
*Cornus obliqua						2		2				2	
*Cornus racemosa							2						
*Lysimachia ciliata						3					2		
*Lysimachia Nummularia						2							
*Lysimachia thyrsiflora					2								
*Fraxinus pennsylvanica								2				2	

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Gentianaceae													
*Gentiana Andrewsii						3							
*Apocynum cannabinum						4					2		
*Apocynum sibiricum						3							
*Asclepias incarnata						3							
*Asclepias syriaca						2					2	2	
*Convolvulus sepium						4	5				2	4	
*Cuscuta compacta						2					3		
*Cuscuta Coryli						2							
*Hydrophyllum virginianum							3						
*Hackelia virginiana											2		
*Lippia lanceolata var. recognita									1	1			
*Verbena hastata						3			2	2	4		
*Verbena urticifolia						1							

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Labiatae													
*Glecoma hederacea										1			
*Leonurus Cardiaca											2		
*Lycopus americanus					3	3					3		
*Lycopus asper											2		
*Lycopus uniflorus						3					2		
*Lycopus virginicus					3	3					3		
*Mentha arvensis											2		
*Mentha arvensis var. villosus					3	3					4		
*Mentha piperita											2		
*Monarda fistulosa						5							
*Nepeta Cataria											2		
*Prunella vulgaris var. lanceolata						2					1		
*Pycnanthemum virginianum						4							
*Scutellaria epilobiifolia						3			3		3		
*Scutellaria lateriflora									2		2		
*Stachys palustris var. homotricha						3			2				

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
*Stachys palustris var. nipigonensis											2		
*Teucrium canadense var. virginicum						3					3		
Solanaceae													
*Datura Stramonium										2			
*Physalis heterophylla											2		
*Solanum americanum										2	2		
*Solanum Dulcamara								1	1		2	3	
*Lindernia dubia									4	3			
*Mimulus ringens									3		3		
*Penstemon Digitalis						1							
*Verbascum Thapsus										1	2		
*Veronica peregrina									2	2			
*Veronicastrum virginicum						2							
*Orobanche uniflora							1						
*Utricularia vulgaris	1	3	2	5	2								

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Plantaginaceae													
*Plantago major						2					3		
*Cephalanthus occidentalis								5					
*Galium Aparine							2					2	
*Galium palustre						3			1				
*Galium tinctorium						1							
*Sambucus canadensis							4	2					
*Triosteum perfoliatum						4							
*Viburnum cassinoides												1	
*Echinocystis lobata												3	
*Sicyos angulatus						2					2	3	
*Campanula aparinoides						2							
*Lobelia siphilitica						2					2		
*Lobelia spicata						1							

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
Compositae													
*Achillea lanulosa						2							
*Ambrosia artemisiifolia var. elatior						2				2			
*Ambrosia trifida						2				1			
*Antemaria neglecta						2							
*Arctium minus							1		1		2		
*Artemisia biennis											2		
Aster ericoides						2							
*Aster novae-angliae						4					3		
*Aster pilosus						4					2		
*Aster simplex var. interior											3		
*Bidens cernua						4			5	4	3		
*Bidens connata						2			2	3	2		
*Bidens coronata						2							
*Bidens frondosa						4			5	4	3		
*Boltonia asteroides									1		2		
*Cirsium arvense						2				2	4		

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
*Cirsium discolor						3					3		
*Cirsium vulgare						2					3		
*Eclipta alba									5	2			
*Erechtites hieracifolia											2		
*Erigeron annuus										1			
*Erigeron canadensis										3	3		
*Erigeron philadelphicus						3				2	3		
*Erigeron strigosus						2					2		
*Eupatorium maculatum						3					2		
*Eupatorium perfoliatum						4					3		
*Gnaphalium obtusifolium						1							
*Helenium autumnale						3							
*Helianthus giganteus							3						
*Helianthus petiolaris											1		
*Helianthus tuberosus											3		
*Heliopsis helianthoides											2		

TABLE 12--Continued

Species	Community												
	a	b	c	d	e	f	g	h	i	j	k	l	m
*Lactuca canadensis						2							
*Lactuca virosa										1			
*Ratibida pinnata						2	3						
*Rudbeckia laciniata												3	
*Rudbeckia serotina						3					2		
*Silphium perfoliatum												2	
*Silphium terebinthinaceum						2							
*Solidago altissima						5					3		
*Solidago canadensis						5							
*Solidago gigantea var. leiophylla											3		
*Solidago graminifolia var. Nuttallii						4					3		
*Sonchus asper									2				
*Sonchus uliginosus										3	2		
*Taraxacum officinale										2	3		
*Vernonia Baldwini						3							
*Vernonia missurica											3		
*Xanthium italicum										4			

TABLE 13

VERTEBRATES OBSERVED ON PTE. MOUILLÉE STATE GAME AREA, 1947 - 1949

Common Name	Scientific Name	Status[a]	Community Group[b]	Notes
	MAMMALS			
Opossum	Didelphis v. virginiana	Vi	B,M	
Short-tailed Shrew	Blarina brevicauda kirtlandi	Res	B	
Raccoon	Procyon l. lotor	Res	B,M,I	
Mink	Mustela vison mink	Res	M	
Red Fox	Vulpes fulva	W.Vi	M	
Woodchuck	Marmota m. monax	Res	B	
White-footed Mouse	Peromyscus leu. noveboracensis	Res	B,I	
Meadow Vole	Microtus p. pennsylvanicus	Res	B,M,I	
Muskrat	Ondatra z. zibethica	Res	B,M	
Cottontail	Sylvilagus floridanus mearnsi	Res	B,I	
House Rat	Rattus norvegicus	Res	B,M	

[a]Applies only to the State Game Area. Vi - Visitor from surrounding area, Res - Resident, S. - Summer, W. - Winter, Tr - Transient.

[b]B - Beach, sand-bar to willow-cottonwood grove; M - Marsh, open water to sedge-meadow; I - Permanent Islands, wet meadow to meadow thicket.

TABLE 13--Continued

Common Name	Scientific Name	Status	Community Group	Notes
	BIRDS			
Common Loon	Gavia immer	Tr	M	1, Nov. 14, 1948
Horned Grebe	Colymbus auritus	Tr	M	1, Nov. 23, 1947
Pied-billed Grebe	Podilymbus podiceps	Res	M	Nesting
White Pelican	Pelicanus erythrorhynchos	Tr	M	3, Aug. 13 to Sep. 11, 1948
Double-crested Cormorant	Phalacrocorax auritus	Tr	M	1, May 9, 1948
Great Blue Heron	Ardea herodias	S.Res	B,M	
American Egret	Casmerodius albus	S.Vi	B,M	
Little Blue Heron	Florida caerulea	S.Vi	M	1, July 20, 1949; 5, Aug. 23, 1949
Green Heron	Butorides virescens	S.Res	B,M	Probably nesting
Black-crowned Night Heron	Nycticorax nycticorax	S.Res	B,M,I	
American Bittern	Botaurus lentiginosus	S.Res	M	Probably nesting
Least Bittern	Ixobrychus exilis	S.Res	M	Nesting
Mute Swan	Cygnus olor	Vi	M	2, July 3 to July 19, 1949
Whistling Swan	Cygnus columbianus	W.Res	M	
Canada Goose	Branta canadensis	Tr	M	

TABLE 13--Continued

Common Name	Scientific Name	Status	Community Group	Notes
Blue Goose	Chen caerulescens	Tr	M	
Mallard	Anas platyrhynchos	Res	M,I	Probably nesting on islands
Black Duck	Anas rubripes	Res	M,I	Prpbably nesting on islands, Brood of 7, July 13, 1949
Gadwall	Anas strepera	Tr	M	
Pintail	Anas acuta	Tr	M	
Green-winged Teal	Anas carolinensis	Tr	M	
Blue-winged Teal	Anas discors	S.Res	M	Probably nesting on islands
Baldpate	Mareca americana	Tr	M	
Shoveller	Spatula clypeata	Tr	M	
Wood Duck	Aix sponsa	S.Res	B,M	Perhaps nesting along beach, Brood of 11, Aug. 6, 1949
Redhead	Aythya americana	Tr	M	
Ring-necked Duck	Aythya collaris	Tr	M	
Canvas-back	Aythya valisineria	W.Res	M	
Greater Scaup Duck	Aythya marila	W.Res	M	
Lesser Scaup Duck	Aythya affinis	Tr	M	
American Golden-eye	Glaucionetta clangula	W.Res	M	
Buffle-head	Glaucionetta albeola	W.Res	M	

TABLE 13--Continued

Common Name	Scientific Name	Status	Community Group	Notes
Ruddy Duck	Erismatura jamaicensis	W.Res	M	
Hooded Merganser	Lophodytes cucullatus	Tr	M	
American Merganser	Mergus merganser	W.Res	M	
Red-breasted Merganser	Mergus serrator	Tr	M	
Cooper's Hawk	Accipiter cooperii	Tr	B	
Red-tailed Hawk	Buteo jamaicensis	Vi	B	
Red-shouldered Hawk	Buteo lineatus	S.Vi	...	Seen in flight
American Rough-legged Hawk	Buteo lagopus	W.Vi	B	
Bald Eagle	Haliaeetus leucocephalus	Vi	B,M	
Marsh Hawk	Circus cyaneus	Res	M	Probably nesting
Osprey	Pandion haliaetus	Tr	B,M	
Duck Hawk	Falco peregrinus	Tr	B,M	
Sparrow Hawk	Falco sparverius	Tr	...	Seen in flight
Ring-necked Pheasant	Phasianus colchicus	Res	B,M,I	Probably nesting on islands
King Rail	Rallus elegans	S.Res	M	Nesting
Virginia Rail	Rallus limicola	S.Res	M	Probably nesting
Sora	Porzana carolina	S.Res	M	Probably nesting

TABLE 13--Continued

Common Name	Scientific Name	Status	Community Group	Notes
Yellow Rail	Coturnicops noveboracensis	Tr	M	1, May 9, 1948
Florida Gallinule	Gallinula chloropus	S.Res	M	Nesting
Coot	Fulica americana	S.Res	M	Nesting
Semipalmated Plover	Charadrius hiaticula	Tr	M	
Killdeer	Charadrius vociferus	S.Res	M	Nesting at headquarters
Golden Plover	Pluvialis dominica	Tr	M	Migrating flocks, Apr. 12, 1948. 3, Nov. 11, 1949
Black-bellied Plover	Squatarola squatarola	Tr	M	
Ruddy Turnstone	Arenaria interpres	Tr	M	
Woodcock	Philohela minor	Tr	...	1 by headquarters, Aug. 1, 1949
Wilson's Snipe	Capella gallinago	Tr	M	
Hudsonian Curlew	Numenius phaeopus	Tr	B	500+, May 28, 1949
Upland Plover	Bartramia longicauda	S.Vi	...	1 by headquarters, June 14, 1949
Spotted Sandpiper	Actitis macularia	S.Res	B,M	Probably nesting on beach
Solitary Sandpiper	Tringa solitaria	Tr	M	
Willet	Catoptrophorus semipalmatus	Tr	M	1, Sep. 5, 1949
Greater Yellowlegs	Totanus melanoleucus	Tr	M	
Lesser Yellowlegs	Totanus flavipes	Tr	M	

TABLE 13--Continued

Common Name	Scientific Name	Status	Community Group	Notes
Pectoral Sandpiper	Erolia melanotos	Tr	M	
White-rumped Sandpiper	Erolia fuscicollis	Tr	M	3, Sep. 28, 1947
Least Sandpiper	Erolia minutilla	Tr	M	
Red-backed Sandpiper	Erolia alpina	Tr	M	
Dowitcher	Limnodromus griseus	Tr	M	
Stilt Sandpiper	Micropalama himantopus	Tr	M	1, Sep. 10, 1948
Semipalmated Sandpiper	Ereunetes pusillus	Tr	M	
Northern Phalarope	Lobipes lobatus	Tr	M	1, Oct. 26, 1947; 1, Sep. 3, 1949
Great Black-backed Gull	Larus marinus	W.Vi	M	6, Dec. 10, 1949; 6, Feb. 5, 1950
Herring Gull	Larus argentatus	Res	B,M	
Ring-billed Gull	Larus delawarensis	Res	B,M	
Bonaparte's Gull	Larus philadelphia	Tr	B	
Common Tern	Sterna hirundo	S.Res	B,M	
Caspian Tern	Hydroprogne caspia	Tr	B,M	
Black Tern	Chlidonias nigra	S,Res	B,M	Nesting
Domestic Pigeon	Columba livia	S.Res	B	1, summer of 1947
Mourning Dove	Zenaidura macroura	S.Vi	B,M	

TABLE 13--Continued

Common Name	Scientific Name	Status	Community Group	Notes
Yellow-billed Cuckoo	Coccyzus americanus	S.Res	B	Probably nesting
Barn Owl	Tyto alba	Vi	...	1 by headquarters
Screech Owl	Otus asio	Res	...	In area by headquarters
Snowy Owl	Nyctea scandiaca	W.Res	M	2, Nov. 11, 1949 to Feb. 5, 1950
Short-eared Owl	Asio flammeus	W.Vi	M	
Nighthawk	Chordeiles minor	Tr	...	In flight, Aug. 27, 1949
Chimney Swift	Chaetura pelagica	Tr	...	In flight
Ruby-throated Hummingbird	Archilochus colubris	Tr	B,M	
Belted Kingfisher	Megaceryle alcyon	S.Res	B,M	Nesting
Flicker	Colaptes auratus	S.Res	B,I	Probably nesting
Red-headed Woodpecker	Melanerpes erythrocephalus	S.Res	B	Nesting
Downy Woodpecker	Dendrocopos pubescens	W.Vi	B	
Eastern Kingbird	Tyrannus tyrannus	S.Res	B,I	Nesting
Eastern Phoebe	Sayornis phoebe	S.Res	...	In area by headquarters
Alder Flycatcher	Empidonax traillii	S.Res	B,I	Probably nesting
Least Flycatcher	Empidonax minimus	Tr	B	
Wood Pewee	Contopus virens	S.Res	...	In area by headquarters

TABLE 13--Continued

Common Name	Scientific Name	Status	Community Group	Notes
Horned Lark	Eremophila alpestris	W.Vi	...	In flight
Tree Swallow	Iridoprocne bicolor	S.Res	B,M	Nesting on beach
Bank Swallow	Riparia riparia	S.Res	M	
Rough-winged Swallow	Stelgidopteryx ruficollis	Tr	M	
Barn Swallow	Hirundo rustica	S.Res	M	Nested in shed on beach, 1947
Cliff Swallow	Petrochelidon pyrrhonota	Tr	M	
Purple Martin	Progne subis	S.Res	B,M	
Blue Jay	Cyanocitta cristata	Vi	B	
Crow	Corvus brachyrhynchos	Res	B,M,I	Nesting
Black-capped Chickadee	Parus atricapillus	Vi	B	
Tufted Titmouse	Parus bicolor	Vi	B	
Red-breasted Nuthatch	Sitta canadensis	Tr	B	
Brown Creeper	Certhia familiaris	Tr	B	
House Wren	Troglodytes aedon	S.Res	B	Nesting
Carolina Wren	Thryothorus ludovicianus	Res	B	Probably nesting
Long-billed Marsh Wren	Telmatodytes palustris	S.Res	M	Nesting
Short-billed Marsh Wren	Cistothorus platensis	S.Res	M	Probably nesting

TABLE 13--Continued

Common Name	Scientific Name	Status	Community Group	Notes
Catbird	Dumetella carolinensis	Tr	B,I	
Brown Thrasher	Toxostoma rufum	Tr	B	
Robin	Turdus migratorius	S.Res	B,I	Nesting, on island
Hermit Thrush	Hylocichla guttata	Tr.	B	
Olive-backed Thrush	Hylocichla ustulata	Tr	B	
Blue-gray Gnatcatcher	Polioptila caerulea	Tr	B	
Golden-crowned Kinglet	Regulus satrapa	Tr	B	
Ruby-crowned Kinglet	Regulus calendula	Tr	B	
Cedar Waxwing	Bombycilla cedrorum	W.Vi	B	
Starling	Sturnus vulgaris	Res	B,M	Nesting on beach
Red-eyed Vireo	Vireo olivaceus	S.Res	B	
Warbling Vireo	Vireo gilvus	S.Res	B	
Black and White Warbler	Mniotilta varia	Tr	B	
Prothonotary Warbler	Protonotaria citrea	Tr	B	1, Aug. 7, 1949
Tennessee Warbler	Vermivora peregrina	Tr	B	
Nashville Warbler	Vermivora ruficapilla	Tr	B	
Yellow Warbler	Dendroica petechia	S.Res	B,I	Probably nesting

TABLE 13--Continued

Common Name	Scientific Name	Status	Community Group	Notes
Magnolia Warbler	Dendroica magnolia	Tr	B	
Cape May Warbler	Dendroica tigrina	Tr	B	
Myrtle Warbler	Dendroica coronata	Tr	B	
Black-throated Green Warbler	Dendroica virens	Tr	B	
Blackburnian Warbler	Dendroica fusca	Tr	B	
Bay-breasted Warbler	Dendroica castanea	Tr	B	
Black-poll Warbler	Dendroica striata	Tr	B,I	
Palm Warbler	Dendroica palmarum	Tr	B	
Northern Water-thrush	Seiurus noveboracensis	Tr	B	
Connecticut Warbler	Oporornis agilis	Tr	B	
Yellow-throat	Geothlypis trichas	S.Res	M,I	Probably nesting
American Redstart	Setophaga ruticilla	Tr	B	
House Sparrow	Passer domesticus	Res	B	Nested in shed on beach, 1947
Bobolink	Dolichonyx oryzivorus	S.Res	M,I	
Meadowlark	Sturnella magna	S.Res	...	Near headquarters
Western Meadowlark	Sturnella neglecta	S.Vi	...	Near headquarters
Yellow-headed Blackbird	Xanthocephalus xanthocephalus	Tr	M	1, May 17, 1948

TABLE 13--Continued

Common Name	Scientific Name	Status	Community Group	Notes
Red-wing	Agelaius phoeniceus	S.Res	B,M,I	Nesting
Baltimore Oriole	Icterus galbula	Tr	B	S.Res at headquarters
Rusty Blackbird	Euphagus carolinus	Tr	B,M	
Bronzed Grackle	Quiscalus versicolor	S.Vi	B	
Cowbird	Molothrus ater	S.Vi	B	S.Res at headquarters
Scarlet Tanager	Piranga olivacea	S.Vi	B	1, July 13, 1947
Cardinal	Richmondena cardinalis	Res	B	
Common Goldfinch	Spinus tristis	Res	B	Probably nesting
Towhee	Pipilo erythrophthalmus	Tr	B	
Savannah Sparrow	Passerculus sandwichensis	Tr	M	
Slate-colored Junco	Junco hyemalis	W.Res	B,M	
Tree Sparrow	Spizella arborea	W.Res	B,M	
Chipping Sparrow	Spizella passerina	Tr	B	
White-crowned Sparrow	Zonotrichia leucophrys	Tr	B	
White-throated Sparrow	Zonotrichia albicollis	Tr	B	
Fox Sparrow	Passerella iliaca	Tr	B	

TABLE 13--Continued

Common Name	Scientific Name	Status	Community Group	Notes
Swamp Sparrow	Melospiza georgiana	Res	B,M	Probably nesting in marsh
Song Sparrow	Melospiza melodia	Res	B,M,I	Nesting
Snow Bunting	Plectrophenax nivalis	W,Res	B	
Lapland Longspur	Calcarius lapponicus	W.Vi	...	In flight
	REPTILES			
Fox Snake	Elaphe vulpina	Res	B	
Queen Snake	Natrix septemvittata	Res	B	
DeKay's Snake	Storeria dekayi	Res	B	
Common Garter Snake	Thamnophis sirtalis sirtalis	Res	B,I	
Snapping Turtle	Chelydra serpentina	Res	M	
Painted Turtle	Chrysemys picta	Res	M	
Blanding's Turtle	Emys blandingii	Res	M	
	AMPHIBIANS			
Bullfrog	Rana catesbeiana	Res	M	
Green Frog	Rana clamitans	Res	M	

TABLE 13--Continued

Common Name	Scientific Name	Status	Community Group	Notes
Meadow Frog	Rana pipiens pipiens	Res	M,I	
Cricket Frog	Acris gryllus crepitans	Res	M	
Swamp Cricket Frog	Pseudacris nigrita triseriata	Res	B	
American Toad	Bufo americanus americanus	Res	B	
FISH (List incomplete)				
Sea Lamprey	Petromyzon marinus	-	M	Attached to carp
Longnose Gar	Lepisosteus osseus oxyurus	-	M	
Bowfin	Amia calva	-	M	
Gizzard Shad	Dorosoma cepedianum	-	M	
Carp	Cyprinus carpio	-	M	
Goldfish	Carassius auratus	-	M	
Spottail Shiner	Notropis hudsonius	-	M	
Black Bullhead	Ameiurus melas melas	-	M	
Mud Pickerel	Esox vermiculatus	-	M	
Northern Pike	Esox lucius	-	M	
Yellow Perch	Perca flavescens	-	M	

TABLE 13--Continued

Common Name	Scientific Name	Status	Community Group	Notes
Yellow Pikeperch	Stizostedion vitreum vitreum	-	M	
Largemouth Bass	Micropterus salmoides	-	M	
Pumpkinseed	Lepomis gibbosus	-	M	
Common Bluegill	Lepomis m. macrochirus	-	M	
Rock Bass	Ambloplites r. rupestris	-	M	
Brook Silverside	Labidesthes s. sicculus	-	M	
Sheepshead	Aplodinotus grunniens	-	M	

TABLE 14

COVER TYPES OF MOUILLÉE DISTRICT

Cover Type	1944 Acres	1947 Acres	1949 Acres
Cultivated land	666.4	396.0	559.8
Waste grassland	160.6	205.5	53.6
Meadow thicket	30.0	50.8	56.7
Swamp thicket	2.2	3.1	3.1
Flood plain woodland	57.0	58.5	58.5
Beach woodland	45.0	18.2	17.8
Spoil-bank woodland	25.1	22.0	21.6
Sand beach	1.3	7.8	12.9
Carex-Calamagrostis	353.2	249.5	223.0
Scirpus-Typha	15.6	207.5	203.4
Phragmites	191.9	51.9	59.0
Typha glauca	1178.3	665.6	841.6
Typha angustifolia	366.5	94.1	114.5
Scirpus fluviatilis	54.1	0	45.9
Scirpus spp.---marsh	0	1.9	53.4
Scirpus sp.--lake beds	210.3	42.8	47.0
Sagittaria rigida	16.8	23.6	24.2
Zizania	65.3	78.9	60.0
Inland water	572.3	1629.7	1340.2
Lake Erie area	182.6	387.7	397.7

TABLES 15 AND 16

LEGEND

Symbol	Cover Type	Symbol	Cover Type
Cc	Cultivated land	T	Typha-Scirpus
Cw	Abandoned land and waste grassland	P	Phragmites
Br	Thicket	T.gl	Typha glauca
Sand	Sand beach	T.ang	Typha angustifolia
Wd	Woodland	Sf	Scirpus fluviatilis
Flood pl.	Flood plain woodland	Sv	Scirpus spp.--marsh
Beach	Barrier beach	Ru	Scirpus sp.--lake beds
Spoil b.	Spoil bank	Sg	Sagittaria rigida
Cal	Carex-Calamagrostis	Zi	Zizania

Note: All land shown in each line of table was in the cover type shown at the extreme left, in 1944. Numbers give the acreage.

Table 15

Shifts in Cover, 1944 to 1947, Mouillée District

Cover in 1944	Cover on same areas in 1947															
	Cc	Cw	Br	Sand	Wd	Cal	T	P	T.gl	T.ang	Sf	Sv	Ru	Sg	Zi	Water
Cc	392.5	134.2	6.1			21.9	101.5	0.4	3.3							6.5
Cw	3.5	65.2	13.2		2.0	22.2	40.5	1.9	8.1							4.0
Br			32.2													
Sand				1.3												
Wd-flood pl.					56.5				0.2							0.3
Wd-beach					18.2											26.8
Wd-spoil b.					22.0											3.1
Cal		5.6	2.0			203.4	48.5	5.9	65.9							21.9
T							13.7		1.9							
P			0.6					43.8	48.0							99.5
T.gl		0.4		4.4		1.9	3.1		531.3			1.8		1.1	27.7	606.5
T,ang										94.1				5.0	31.8	235.6
Sf.														1.1		53.0
Sv.												0.1				?
Ru													42.8			167.5
Sg.														9.8		7.0
Zi														0.7	16.9	47.7



Table 16

Shifts in Cover, 1944 to 1949, Mouillée District

Cover in 1944	Cover on same areas in 1949															
	Cc	Cw	Br	Sand	Wd	Cal	T	P	T.gl	T.ang	Sf	Sv	Ru	Sg	Zi	Water
Cc	527.0	23.6	12.0			16.4	73.8	1.2	5.6							6.8
Cw	31.7	24.2	13.2		2.0	25.9	49.4	1.9	8.9							3.4
Br			32.2													
Sand				1.3												
Wd-flood pl.					56.5				0.2							0.3
Wd-beach					17.8											27.2
Wd-spoil b.					21.6											3.5
Cal	0.8	5.6	2.0	0.9		177.6	62.7	9.6	79.5			0.2				14.3
T	0.2					1.6	11.9		1.9							
P			0.6	1.4				46.0	60.3			1.9				81.7
T.gl		0.5		4.5		1.5	5.6	0.2	683.8			43.0		4.4	14.8	419.9
T.ang										114.5		5.6		3.5	23.2	219.7
Sf				0.9					1.2		45.9	2.5			0.5	3.1
Sv												0.1				?
Ru													47.0			163.3
Sg														6.2		10.6
Zi														0.7	10.9	53.7



TABLE 17

INSECTS REPORTED FROM *TYPHA* IN THE UNITED STATES

Species and classification	Bibliogr. Reference[a]	*Typha* species[b]	Part of plant infested
Orthoptera			
Tettigoniidae			
Conocephalus sp.	2	*lat.*	Leaf. Eggs laid in stem.
Conocephalus sp.	2		Eggs laid in stem.
Hemiptera			
Lygaeidae			
Ischnorrhynchus resedae Panz.	1,2	*lat.*, *ang.*	Old head, moist petiole.
Homoptera			
Aphididae			
Aphis avenae Fab.	1,4		Leaf sheath.
Aphis gossypii Glov.	4	*lat.*	Leaf.
Hyalopterus arundinis Fab.	4		Leaf.
Macrosiphum granarium Kirby	4		Leaf.
Rhopalosiphum dianthii Shrank.	8	*lat.*	Leaf.
Rhopalosiphum enigmae Hottes & Frison	7	*lat.*	Leaf.

[a] See list at end of table. [b] *lat.* - *latifolia*, *ang.* - *angustifolia*

TABLE 17--Continued

Species and classification	Bibliogr. Reference	Typha species	Part of plant infested
Rhopalosiphum persicae Sulz.	10	lat., ang.	Leaf.
Siphocoryne nymphaeae Linn.	1,10	lat., ang.	Leaf.
Thripsaphis ballii Gill.	2	lat.	Moist petiole.
Coleoptera			
Chrysomelidae			
Donacia flavipes Kirby	6	lat.	Roots
Donacia subtilis Kunze	6	lat.	Roots
Paria canella var. aterima Oliv.	2	lat.	Leaf sheath.
Curculionidae			
Sphenophorus (Calandra) pertinax Oliv.	1,2	lat.	Rhizome, stem.
Mononychus vulpeculus Fab.	2	lat.	Head.
Notaris puncticollis Lec.	1,2	lat.	Rhizome, stem.
Lepidoptera			
Psychidae			
Thyridopteryx ephemeraeformis Haw.	5		Leaf.
Coleophoridae			
Coleophora sp.	2	lat.	Old stem.

TABLE 17--Continued

Species and classification	Bibliogr. Reference	Typha species	Part of plant infested
Cosmopterygidae			
Lymnaecia phragmitella Staint.	1,2	*lat.*, *ang.*	Head.
Tortricidae			
Archips obsoletana Walk.	1,2	*lat.*	Head.
Bactra maiorina Hein.	2	*lat.*	Head.
Canocecia rosaceana Harr.	2	*lat.*	Stem.
Endotheenia hebesana Wlk.	2	*lat.*	Leaf.
Pyralidae			
Dicymolomia julianalis Walk.	1	*lat.*	Head.
Noctuidae			
Aratela oblinita Abbot & Smith	2		Leaf.
Archanara alameda Smith	3		Stem.
Archanara subcarnea Kell.	2	*lat.*	Stem.
Arsilonche albovenosa Goeze (*Simyra henrici*)	1,2,3	*lat.*, *ang.*	Leaf.
Arzama gargantua Dyar	3	*lat.*	Stem.
Arzama obliqua Walk.	1	*lat.*	Leaf, stem.
Nonagria oblonga Grote	1,2,3,9	*lat.*	Leaf, stem.
Nonagria subflava Grote	2	*lat.*	Leaf.

TABLE 17--Continued

Species and classification	Bibliogr. Reference	Typha species	Part of plant infested
Family unknown			
Species unknown	2		Leaf.
Diptera			
Stratiomyiidae			
Macrosargus clavis Will.	1,2	lat.	Leaf, moist burrow.
Phoridae			
Aphiochaeta chaetonura Mall.	2		Moist burrow.
Syrphidae			
Platychirus quadratus Say	1,2		Old head.
Ortalidae			
Chaetopsis aenea Wied.	1,2,9	lat.	Moist burrow.
Chloropidae			
Elachiptera nigriceps Loew.	2	lat.	Stem.
Drosophilidae			
Drosophila sp.	2		Stem.
Family unknown			
Corodonta dorsalis Lw.	2	lat.	Stem.
Hymenoptera			
Chalcididae			
Eurytoma bicolor Walsh.	2	lat.	Gall in dry stem.

TABLE 17--Continued

Species and classification	Bibliogr. Reference	Typha species	Part of plant infested
Arachnida			
Tetranychidae			
Tetranychus sp.	4		Leaf.

PARASITES

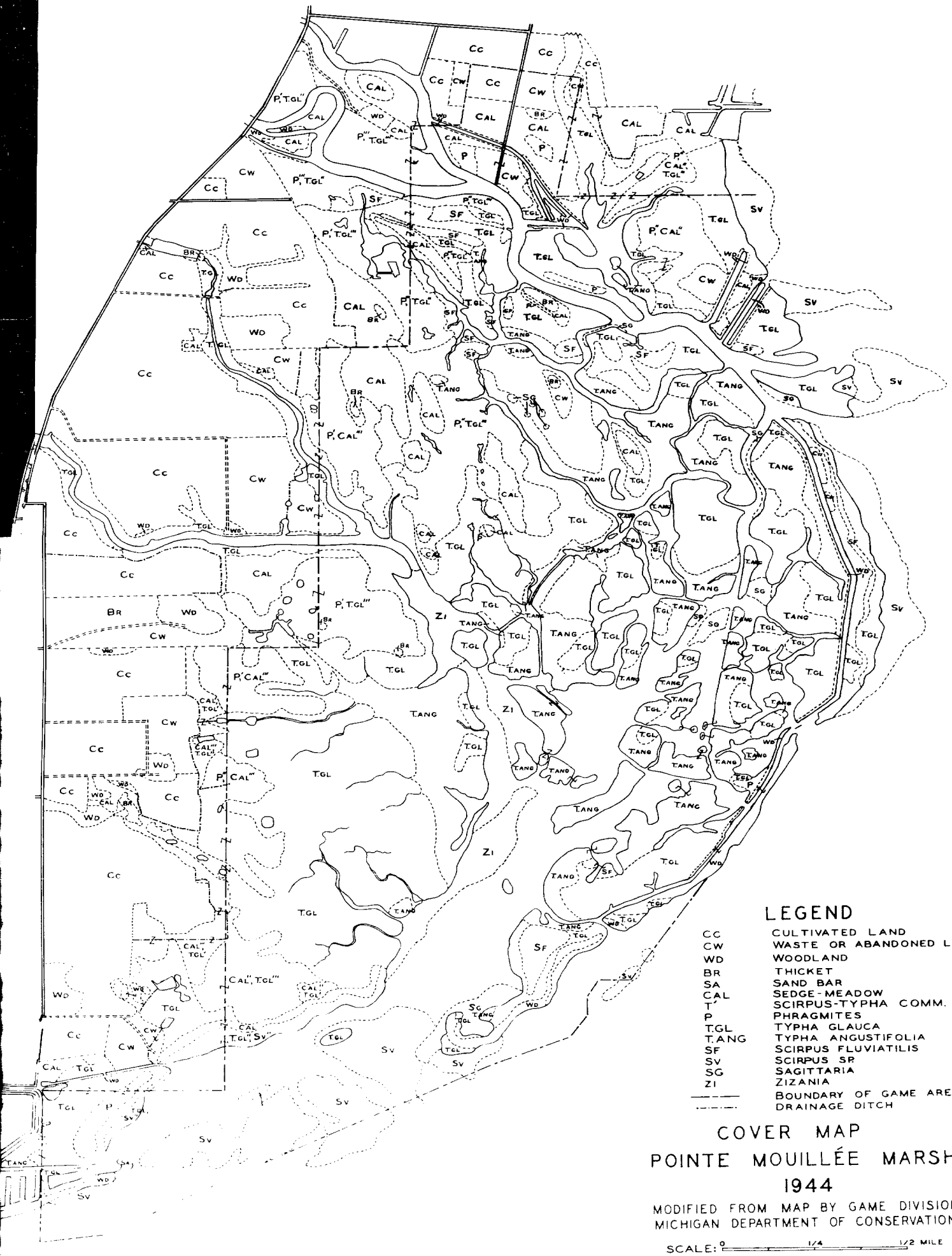
Species of Parasite	Host	Bibliogr. Reference
Macrotelaia sp.	Conocephalus sp.	2
Tumidiscapus sp.	Conocephalus sp.	2
Elachertinae	Lymnaecia phragmitella	1
Scelionron cementarium Drury	Anatela oblinita	2
Casinaria genuina Nort.	Anatela oblinita	2
Aleiodes intermedius Cress.	Arsilonche albovenosa	1
Blacus sp.	Arsilonche albovenosa	2
Exorista larvarum L.	Arsilonche albovenosa	2
Microbracon sp.	Arsilonche albovenosa	2
Macrocentrus ancylivora Roh.	Arsilonche albovenosa	2
Pimpla inquisitoriella D. T.	Arsilonche albovenosa	1,2

TABLE 17--Continued

Species of Parasite	Host	Bibliogr. Reference
Roxas stigmator Say	Arsilonche albovenosa	2
Musgina stabulans Fall.	Archanara subcarnea	2
Masicera sanilis Mg.	Archanara subcarnea	2
Sturmia nigrita Town.	Archanara subcarnea	2
Sturmia nigrita Town.	Arzama obliqua	1
Apanteles cinctiformes Vier.	Nonagria oblonga	1
Microbracon sp.	Endothaenia hebesana	2
Eulophus sp.	Unknown lepidopteran	2
Diaulinus pulchripes Cwfd.	Macrosargus clavis	2
Tumidiscapus sp.	Macrosargus clavis	2
Chalcid	Corodonta dorsalis	2
Pimpla indagatrix Walsh	.....	1

BIBLIOGRAPHIC REFERENCES

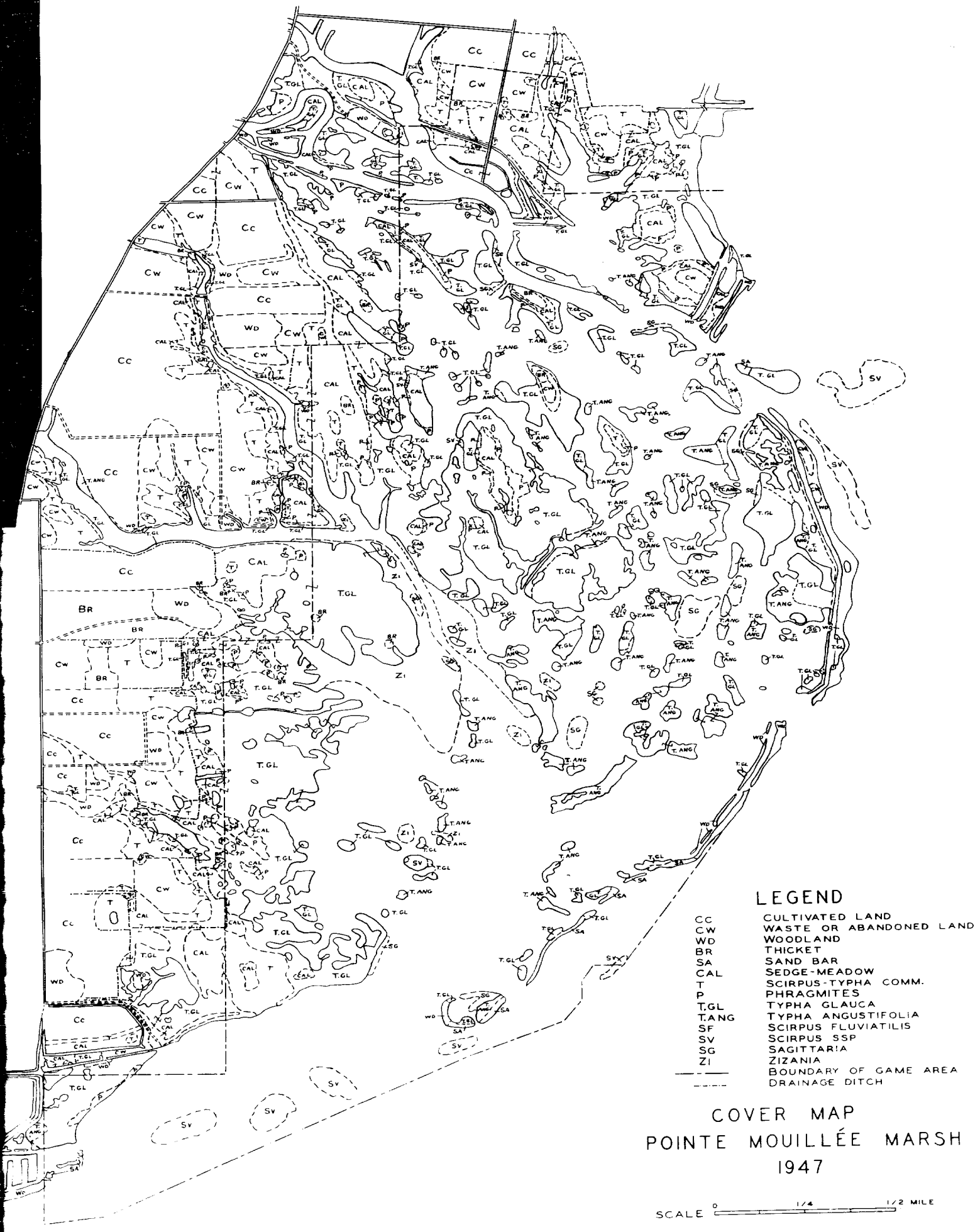
1. Claassen, 1921. 2. Cole, 1931. 3. Comstock, 1944. 4. Davidson, 1917. 5. Hefley, 1937. 6. Hoffman, 1940. 7. Hottes and Frison, 1931. 8. Sanborn, 1906. 9. Walton, 1908. 10. Wilson and Vickery, 1918.

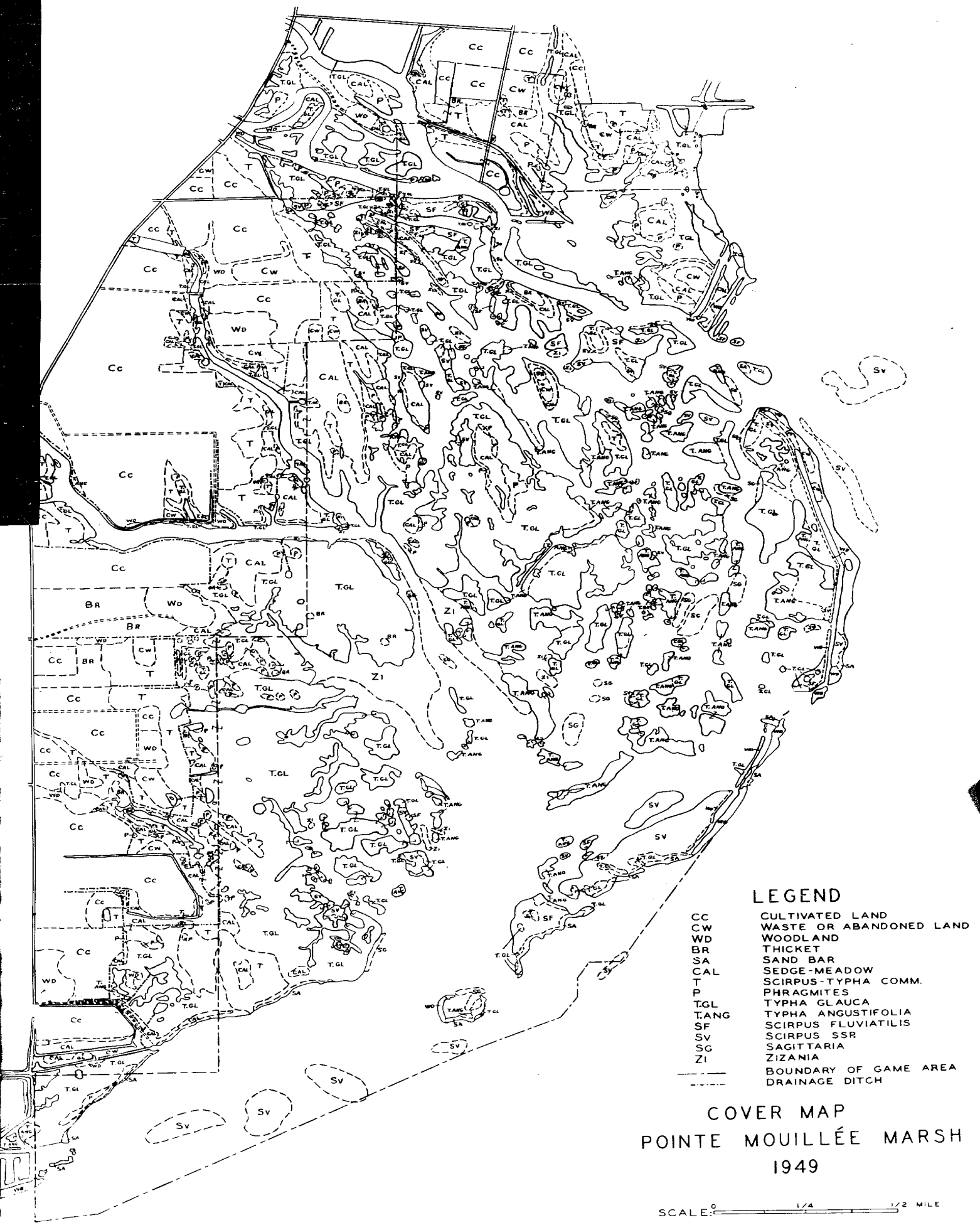


COVER MAP
POINTE MOUILLÉE MARSH
1944

MODIFIED FROM MAP BY GAME DIVISION
MICHIGAN DEPARTMENT OF CONSERVATION

SCALE: 0 1/4 1/2 MILE


LEGEND
CC CULTIVATED LAND
CW WASTE OR ABANDONED LAND
WD WOODLAND
BR THICKET
SA SAND BAR
CAL SEDGE-MEADOW
T SCIRPUS-TYPHA COMM.
P PHRAGMITES
T.GL TYPHA GLAUCA
T.ANG TYPHA ANGUSTIFOLIA
SF SCIRPUS FLUVIATILIS
SV SCIRPUS SSP
SG SAGITTARIA
ZI ZIZANIA
BOUNDARY OF GAME AREA
DRAINAGE DITCH
COVER MAP
POINTE MOUILLÉE MARSH
1947
SCALE 0 1/4 1/2 MILE


LEGEND
CC CULTIVATED LAND
CW WASTE OR ABANDONED LAND
WD WOODLAND
BR THICKET
SA SAND BAR
CAL SEDGE-MEADOW
T SCIRPUS-TYPHA COMM.
P PHRAGMITES
T.GL TYPHA GLAUCA
T.ANG TYPHA ANGUSTIFOLIA
SF SCIRPUS FLUVIATILIS
Sv SCIRPUS SSR
SG SAGITTARIA
ZI ZIZANIA
BOUNDARY OF GAME AREA
DRAINAGE DITCH
COVER MAP
POINTE MOUILLÉE MARSH
1949
SCALE: 0 1/4 1/2 MILE