A SURVEY OF GREAT LAKES MARSHES IN THE NORTHERN HALF OF MICHIGAN'S LOWER PENINSULA AND THROUGHOUT MICHIGAN'S UPPER PENINSULA

prepared by

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ABSTRACT

In 1987, a multi-year project to survey marshes along the Great Lakes shorelines of Michigan was initiated by the Michigan Natural Features Inventory (MNFI) and funded through a Michigan Coastal Zone Management grant. Information from aerial photograph interpretation and data from intensive field surveys were compiled by MNFI in 1987 for the Upper Peninsula. In 1988, marshes along the shores of the southern half of the Lower Peninsula were surveyed. In 1989, marshes were surveyed in the northern half of the Lower Peninsula and throughout the Upper Peninsula. This report summarizes surveys completed in 1989 that investigated the natural communities, abiotic factors, flora, observed fauna, and disturbances, both human and natural, within marshes along the shorelines and estuaries of Saginaw Bay, Lake Erie, Lake Huron, Lake Michigan, and Lake Superior.

INTRODUCTION

The importance of the marshes along the shores of the Great Lakes for wildlife, shoreline protection, and recreation has long been recognized. However, there is a need for additional data to supplement our understanding of these coastal marshes to allow us to more adequately make management decisions. This is the third year of a three year study conducted along the shorelines and estuaries of Michigan's Great Lakes. The study provides valuable baseline data on the vegetation, substrate, and disturbances characteristic of Great Lakes Marshes.

The primary purpose of this year's study was to inventory the marshes along the Great Lakes shoreline of the northern half of Michigan's Lower Peninsula and the Upper Peninsula. As in the previous 2 years, biotic and abiotic data were collected, from which marshes of significant natural quality were identified.

The study had several other objectives as well. The first objective was to document the type and extent of disturbances within the 29 marshes studied and to evaluate their impact on the component natural communities. The least disturbed marshes were identified and appropriate management suggested to ensure preservation of these relatively undisturbed marsh ecosystems as natural areas for research, education, protection of native species and their habitats, and as examples of Michigan's natural heritage.

A second objective of the study was to contrast similarities and differences among the marshes present on different substrates or in different climatological areas. We assumed that the natural communities were determined by differing abiotic conditions, such as levels of wind and wave activity, water depth, distance from the shoreline, and soil or

substrate texture, composition, and chemistry. By identifying major differences among marshes, critical information can be provided for effective wildlife management, shoreline protection, and other natural resource aspects. The data collected during 1987 through 1989 will be analyzed following the 1989 field season.

Few wetland studies have dealt with both the biotic and abiotic components of marsh systems. Recently, two such studies have been completed in Michigan, though both were limited in geographic scope. A study of the St. Mary's River (Liston and McNabb 1987), provides detailed information on marshes along the St. Mary's River shipping channel. This study concentrated on permanently submerged portions of the marshes, thus providing little information on the wet meadow and shrub swamp zones. It also emphasized the vegetation of the submergent marsh zone (beyond the emergent marsh), a zone that the present study was not able to sample in detail.

Another recent study provides a community profile of the Lake St. Clair Wetlands (Herdendorf, Raphael, and Jaworski 1986). That study also has a detailed section on the vegetation of the marshes and the factors, both biotic and abiotic, that determine and influence the natural communities.

A third objective of surveying the vegetation of the coastal marshes was to determine the ecological zones and vegetational composition of each marsh.

METHODS

Great Lakes Marshes in the northern part of Michigan's Lower Peninsula and in Upper Michigan (Figure 1 and Appendix I) were identified for this study on the basis of size and quality, as determined through color infrared aerial photograph interpretation. Only marshes greater than 100 acres in area with minimal disturbance were initially selected for sampling. Additional marshes, most of which had been identified as Environmental Areas under the Shorelands Protection Act (P.A. 245, 1970), were suggested for sampling by Michigan Department of Natural Resources Shorelands Protection Program staff.

Aerial photograph interpretation was used to identify the natural communities and transects for sampling at each of the 29 marshes. Prior to field sampling, the natural communities at each marsh were identified and their boundaries determined from aerial photos and topographic maps. The major natural communities delineated were: Swamp Forest, Shrub Swamp, Floodplain Forest, Wet Meadow, Emergent Marsh, and Submergent Marsh (Michigan Natural Features Inventory, 1986). Transects were then selected to include all natural communities and to minimize sampling within areas disturbed by human activities such as wildlife management, road construction, etc. Community boundaries and sampling transects were mapped on mylar overlays. These overlays, as well as aerial photographs of the site, were used during the field surveys to verify and improve accuracy of the community boundaries.

Vegetation was typically sampled along the transects at 20 m intervals. Sampling points were occasionally shortened to 10 m where natural community zones were narrow and lengthened to 40 or 60 m where

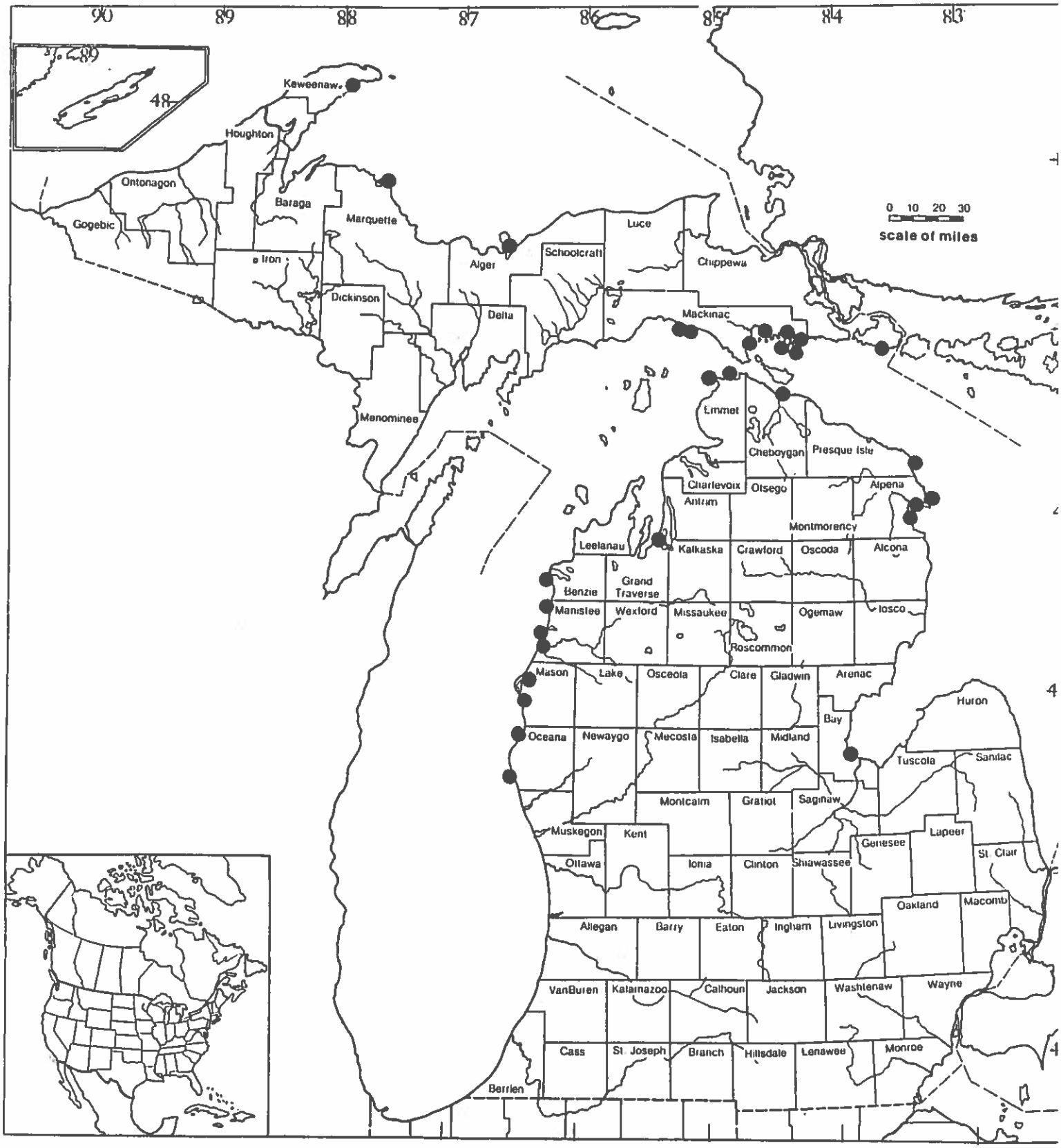


Figure 1. Location of Great Lakes Marshes surveyed in 1989.

natural community zones were broad. A nylon rope, marked at 5 m intervals, was used to measure the distance between sampling points. The direction of the transect line was maintained using a magnetic compass. The transects typically began at the ecotone between upland and wetland. The ecotone, as well as all arborescent- and herbaceous-dominated natural communities encountered along the transect were sampled. Sample points were taken along the transect until either a) water depth reached approximately 5 feet, or submergent vegetation disappeared, b) the upland/wetland ecotone was reached at the opposite end of the transect, or c) an impassable river was encountered.

The vegetation within each 0.5 m quadrat was sampled using a circular hoop of plastic tubing as a sampling frame. Coverage values were recorded on a sampling form (Appendix II) for each plant species within the sampling frame, including submerged aquatic plants beneath the frame. Coverage values of 1-5 were estimated, denoting 1-20%, 21-40%, 41-60%, 61-80%, and 81-100% coverage classes, respectively. Unknown species were collected for later identification.

Sampling at each point also included determination of the natural community, soil texture of the substrate, depth of organic material, and water depth. At sampling points where these designations were inadequate, the surveyors had the option to code other information. Soil textures were recorded as sand, loam, or clay, with additional modifiers, such as silty, rocky, or gravelly added as necessary. Depths of water and organic material were both recorded in inches. Additional notes on fauna and disturbance were recorded on the sampling form. Notes describing the location of the transect and distances between sampling points were also

included. Natural community boundaries (on the mylar overlays) were refined following sampling using the latest available aerial photography.

Natural community types used in this report were generalized from the Michigan Natural Features Inventory (MNFI) draft Natural Community Classification (MNFI, 1986). For example, in four natural communities, Wet Meadow, Shrub Swamp, Treed Swamp, and Floodplain Forest, no distinction was made between "Northern" and "Southern" modifiers to this community type. The grade of each marsh was determined using MNFI natural quality and condition grading criteria (MNFI, 1987; APPENDIX III).

Three additional marshes not included here were identified for field sampling, two on Drummond Island, and one near Epoufette on Lake Michigan. All three areas were too scoured by wave activity to support extensive, well-developed marshes, even though there appeared to be marsh vegetation on the 1978 color infra-red photographs.

RESULTS

Natural Communities

The locations of the 29 Great Lakes Marshes visited and/or sampled during the 1989 field season are identified in Figure 1. The data collected pertaining to these sites are presented in Tables 1-3. Table 1 summarizes the geographic, political, and physical characteristics of the marshes sampled, while Tables 2 and 3 characterize the biota of these marshes.

Most of the marshes contained a very predictable assemblage of species, that had distributions limited by water depth, amount of wave energy, and protection from wave activity by other vegetation. The most common sequence of zones was 1) Submergent Marsh, 2) Emergent Marsh, 3) Wet Meadow, 4) Shrub Swamp, and 5) Swamp Forest.

The Emergent Marsh zone was typically dominated by Scirpus validus (softstem bulrush), S. americanus (threesquare), and S. acutus (hardstem bulrush), with some Typha spp. (cat-tail). Within the Emergent Marsh common submergent species included Elodea canadensis (water-weed), Najas flexilis (naiad), Vallisneria americana (wild-celery), Potamogeton spp. (pondweed), and Myriophyllum spp. (water-milfoil). In the shallow waters near the shoreline, where wave action is weaker, the Emergent Marsh supports a greater diversity of plants. These include the above mentioned species of Emergent Marsh, as well as others such as Pontederia cordata (pickerel-weed), Sagittaria latifolia (wapato or duck-potato), Sparganium eurycarpum (bur-reed), S. chlorocarpum, Nuphar advena (spatterdock), N. variegata, and Nymphaea odorata (water-lily). During the relatively low water years of 1988-1989, some species, such as Sagittaria

Table 1. Geographical, political and physical characteristics of Great Lakes Marshes of the northern half of Michigan's Lower Peninsula and of Michigan's Upper Peninsula.

#	Marsh	County	Body of water	Acreage (Total/ Natural)	Landform						Ownership		
					Estuary	Narrow Coast	River Mouth	Bay	River Island	Inter-dunal Swale	Private	State Gov't	Local Gov't
1	Tobico	Bay	Saginaw Bay	1300/800							x	x	
2	Squaw Bay	Alpena	Lake Huron	720/400				x			x		
3	Whitefish Bay	Alpena	Lake Huron	300/300				x		x	x		
4	El Cajon Bay/Misery Bay	Alpena	Lake Huron	440/420		x		x			x		
5	False Presque Isle	Presque Isle	Lake Huron	340/290	x		x				x		
6	Cheboygan State Park	Cheboygan	Lake Huron	280/280				x				x	
7	Carp/Pine Rivers	Mackinac	Lake Huron	220/220		x	x	x		x	x	Fed.	
8	St. Martin Bay	Mackinac	Lake Huron	270/240		x		x			x	Fed.	
9	Hessel	Mackinac	Lake Huron	305/270				x			x		
10	Peck Bay	Mackinac	Lake Huron	70/70				x			x		
11	Voight Bay	Mackinac	Lake Huron	120/120				x			x	x	
12	Duck Bay	Mackinac	Lake Huron	240/220				x			x	x	
13	Big Shoal Cove	Chippewa	Lake Huron	200/200				x			x		
14	Stony Creek	Oceana	Lake Michigan	200/200	x		x				x		
15	Pentwater Marsh	Oceana	Lake Michigan	240/240	x		x				x	x	

Table 1. (continued).

#	Marsh	County	Body of water	Acreage (Total/ Natural)	Landform						Ownership		
					Estuary	Narrow Coast	River Mouth	Bay	River Island	Inter-dunal Swale	Private	State Gov't	Local Gov't
16	Pere Marquette River	Mason	Lake Michigan	760/0	x		x				x	x	
17	Big Sable River	Mason	Lake Michigan	220/0	x		x				x	Fed.	
18	Manistee River	Manistee	Lake Michigan	1190/1190	x		x				x	x	
19	Bar Lake	Manistee	Lake Michigan	260/260	±		±				x		
20	Arcadia Lake	Manistee	Lake Michigan	270/0	±		±				x		
21	Betsie River	Benzie	Lake Michigan	100/0	x		x					x	
22	Petobego Pond	Grand Trav.	Lake Michigan	110/110						x	x	x	
23	Waugoshance Point	Emmet	Lake Michigan	650/650				x				x	
24	Cecil Bay	Emmet	Lake Michigan	135/55		x		x			x		
25	Epoufette Bay	Mackinac	Lake Michigan	130/110				x			x	x	
26	Kenyon Bay	Mackinac	Lake Michigan	100/100				x			x		
27	Grand Island	Alger	Lake Superior	120/120				x(Tombolo)		x	x		
28	Independence Lake	Marquette	Lake Superior	320/320	x		x	x(Tombolo)		x	x	x	
29	Lac La Belle	Keweenaw	Lake Superior	500/460	x					x	x		

Table 2. Biotic characteristics of Great Lakes Marshes of the northern half of Michigan's Lower Peninsula and Michigan's Upper Peninsula.

#	Marsh	EO Rank	# Plant Species	Natural Communities									Disturbance Codes1	
				Submerg. Marsh	Emerg. Marsh	Wet Meadow	Floodplain Forest	Cobble Beach	Treed Swamp	Bog	N.Fen	Shrub Swamp	Natural	Artificial
1	Tobico	C-D	44	x	x	x			x			x	M	DA,DI,A,H
2	Squaw Bay	B-C	56	x	x	x		x	x			x	HI	B,DI,F,RO
3	Whitefish Bay	B-C	59		x	x			x		x	x		O,RO
4	El Cajon Bay/Misery Bay	A	39	x	x	x			x		x		HI	
5	False Presque Isle	B	36		x	x			x			x	HI	
6	Cheboygan State Park	A	98		x	x			x		x	x		
7	Carp/Pine Rivers	A	44		x	x			x			x	HI,M,BE	O
8	St. Martin Bay	A-D	72		x	x			x			x	HI	F,RO
9	Hessel	B-D	58		x	x			x			x	HI	B,C,F,RO
10	Peck Bay	A	50	x	x	x			x		x	x	HI	B
11	Voight Bay	A	30	x	x	x			x		x	x	HI	
12	Duck Bay	A	43	x	x	x			x					B
13	Big Shoal Cove	B	39		x	x			x		x		HI	B
14	Stony Creek	BC-C	49	x	x	x						x		DI,DR,H
15	Pentwater River	BC	71	x	x	x						x	HI	H,RO

Table 2. (continued).

#	Marsh	EO Rank	# Plant Species	Natural Communities: Submerg. Marsh	Emerg. Marsh	Wet Meadow	Floodplain Forest	Cobble Beach	Treed Swamp	Bog	N.Fen	Shrub Swamp	Disturbance Codes1: Natural	Artificial
16	Pere Marquette River	CD	52	x	x	x			x			x		H,D,RO
17	Big Sable River	CD	65	x	x	x			x			x	HI	DA
18	Manistee River	C	54		x	x	x		x			x		H,D,RO
19	Bar Lake	B	42	x	x				x			x		
20	Arcadia Lake	CD	50	x	x	x							HI	H,DI,DR,RO
21	Betsie River	C	73	x	x	x			x			x	HI	H,R
22	Petobego Pond	AB	68	x	x						x		HI	
23	Waugoshance Point	A-AB	64		x			x					HI	B,O
24	Cecil Bay	B-D	79		x								HI	F,RO
25	Epoufette Bay	B-D	38	x	x	x			x			x	HI	B,DI,F
26	Kenyon Bay	B	28	x	x	x			x			x	HI	B,DI
27	Grand Island	A	67	x	x	x			x			x	HI	
28	Independence Lake	B-D	34		x	x			x	x		x		DA
29	Lac La Belle	A	62	x	x				x	x		x		C,DR

1 A = agriculture field(s); B = small boat slip(s); BE = beaver dam; C = channelization; D = dike(s); DA = dam; DI = ditch(es); DR = dredging; F = fill; H = hay; HI = high water; M = muskrat ponds; O = off-road vehicle damage; R = railroad right-of-way; RO = road; S = ship or boat wakes; W wildlife openings.

Table 3. Special plants, special animals and selected other animals from Great Lakes Marshes of the northern half of Michigan's Lower Peninsula and of Michigan's Upper Peninsula.

#	Marsh	Special plant(s)	Special animal(s)	Other animals
1	Tobico	Platanthera ciliaris	*Bald eagle	Muskrat
2	Squaw Bay	*Iris lacustris		
3	Whitefish Bay	*Iris lacustris		
4	El Cajon Bay/Misery Bay	*Iris lacustris		
5	False Presque Isle	Cypripedium arietinum		
6	Cheboygan State Park	*Solidago houghtonii *Iris lacustris	*Bald eagle *Piping plover	
7	Carp/Pine Rivers		*Bald eagle	Beaver, Muskrat
8	St. Martin Bay			
9	Hessel			
10	Peck Bay			
11	Voight Bay	*Iris lacustris		
12	Duck Bay			
13	Big Shoal Cove	Astragalus neglectus Carex concinna Carex richardsonii Carex scirpoidea Cirsium hillii Cypripedium arietinum Platanthera unalascensis Sporobolus heterolepis	*Bald eagle	
14	Stony Creek		Harrier	
15	Pentwater River			
16	Pere Marquette River			
17	Big Sable River	Armoracia aquatica		
18	Manistee River		Lake sturgeon *Bald eagle Harrier Great Blue Heron Rookery	

Table 3. (continued).

#	Marsh	Special plant(s)	Special animal(s)	Other animals
19	Bar Lake			
20	Arcadia Lake	Zizania aquatica var. aquatica		
21	Betsie River	*Cirsium pitcheri		
22	Petobego Pond		*Bald Eagle	
23	Waugoshance Point	Bromus pumpellianus Pinguicula vulgaris *Solidago houghtonii Tanacetum huronense *Cirsium pitcheri Calypso bulbosa	*Piping plover	
24	Cecil Bay	*Iris lacustris *Cirsium pitcheri Tanacetum huronense Cypripidium arietinum Calypso bulbosa	Grizzled skipper	
25	Epoufette Bay	Mimulus glabr. var. mich. Tanacetum huronense		
26	Kenyon Bay			
27	Grand Island		*Bald eagle	
28	Independence Lake		*Bald eagle Osprey	
29	Lac La Belle	Aster nemoralis Epilobium palustre		

* Federally threatened or endangered species.

graminea (arrowhead) and Sagittaria montevidensis, appeared to be more numerous, probably indicating that they do not tolerate the erosive forces present when water levels are higher.

Shoreward of the Emergent Marsh, where flooding is only occasional, lies the Wet Meadow zone, typically dominated by grasses and sedges. The common dominants, both in Upper Michigan and Lower Michigan were Calamagrostis canadensis (bluejoint) and Carex stricta (sedge). Clumps of Salix ssp. (willow), Cornus ssp. (dogwood), and/or Cephalanthus occidentalis (buttonbush) were scattered within this zone. Past human disturbance was common within this zone, in the form of haying and row cropping. Whereas farming was unsuccessful in most Wet Meadows in Upper Michigan, more extensive drainage coupled with a longer growing season resulted in continued agricultural use of these lands in southern Lower Michigan. Only the wettest of the meadows were abandoned or never farmed.

Shrub Swamp and Swamp Forest occupied the higher lands adjacent to the Wet Meadow, where flooding is less severe. It was noted that the trees and sometimes the shrubs nearest to the shore were killed by the high water levels of 1986-7. Whereas Hardwood-Conifer Swamp, Rich Conifer Swamp, or Poor Conifer Swamp were common along the marshes in Upper or northern Lower Michigan, those in southern Lower Michigan are characterized by Southern Swamp dominated by hardwoods. Common tree species in the Hardwood-Conifer or Conifer Swamp include Thuja occidentalis (northern white-cedar), Abies balsamea (balsam fir), Picea mariana (black spruce), Picea glauca (white spruce), Acer rubrum (red maple), Populus balsamifera (balsam poplar), Betula papyrifera (paper birch), and Populus tremuloides (trembling aspen). Common species in Southern Swamps include Populus deltoides (cottonwood),

Fraxinus pensylvanica (red ash), Acer saccharinum (silver maple), Ulmus americanus (American elm), Quercus bicolor (swamp white oak), Quercus macrocarpa (bur oak), and Quercus palustris (pin oak).

Physiographic Features

The type of physiographic feature upon or within which a marsh develops appears to be important in determining the nature of the vegetative zonation. The landforms noted in this study include estuaries, river mouths, narrow, unprotected shorelines, bays, islands, tombolos, and interdunal swales.

Estuaries are located along streams which are influenced by the Great Lakes water levels. Along the Lake Michigan shoreline of Lower Michigan, almost all of the rivers north of the Black River in Allegan County, flow into small lakes separated from Lake Michigan by sand spits and/or sand dunes. Many of these small lakes were bays of Lake Michigan prior to the Lake Nippising low water stage (approximately 4,000 years ago). Most of the large rivers in Lake Superior with marshes near their mouths also flow into lakes which were originally embayments of Lake Superior. The estuaries are protected from the wave action of the Great Lakes, and typically have thick deposits of organic soil, capable of supporting Wet Meadow, Shrub Swamp, and Swamp Forest. In the south, estuaries often contain large, unstable areas of floating aquatic vegetation, including Peltandra virginica (arrow-alum), Nymphaea odorata, Decodon verticillata (water-willow), and Nuphar advena. In the north, typical aquatic vegetation in the unstable areas includes Carex exilis (sedge), Carex limosa, Dulichium arundinacea (sedge), Cladium mariscoides (twig-rush),

Rhynchospora alba (beak-rush), and sphagnum mosses. None of the Lower Peninsula estuaries sampled in 1989 were of statewide natural area significance; the Lac La Belle estuary in Keweenaw County was an extensive and significant wetland.

River mouths typically support a broad Wet Meadow zone, with an equally well developed Emergent Marsh zone. Swamp Forest and Shrub Swamp zones are usually present. Most of the river mouths do not have thick organic substrates like those found in the protected environment of the estuaries. Many of the rivers surveyed had major deltas where they entered the Great Lakes. The changing course of the river across the delta typically resulted in the formation of abandoned oxbow lakes, which initially supported submergent or floating vegetation, but eventually succeeded to Wet Meadow, Shrub Swamp, or Swamp Forest. The best examples of this are the St. Clair River Delta, portions of Pointe Mouillee Marsh on the Huron River, and the Portage Lake Marsh on the Sturgeon River in Houghton County.

Islands are present within many of the large rivers. The vegetation along the edges of these islands is similar to that found on the river's mainland shoreline. Typical island with marshes include the St. Clair River Delta (Dickinson Island) and several small islands in the Grand River.

Most of the Bays occupy erosional depressions or basins in the shoreline where a river or creek entered into one of the Great Lakes or into a larger river (such as the St. Marys River in the eastern Upper Peninsula). Some of the depressions are pre-glacial valleys which were not completely destroyed by glacial erosion. Other basins were formed by

glacial outwash streams and are now occupied by post-glacial streams. Still other basins were formed by post-glacial streams eroding into glacial drift. The previous discussion of river mouths describes the vegetal zones of these bays adequately.

Most of the larger bays contain the mouth of one or more rivers, and typically are the sites of the larger marshes. Saginaw Bay, which contains several of the marshes sampled in 1988, receives waters from a number of rivers, including the Rifle, Pine, Saginaw, Kawkawlin, Quanicassee, and Sebewaing. In Upper Michigan, St. Martin Bay contains two large rivers, the Carp and the Pine. Both of these large rivers, and in Lower Michigan, large rivers such as the Saginaw, occupy pre-glacial channels in the underlying bedrock. These pre-glacial channels are partially filled with glacial deposits, which, in the case of the Saginaw River, consist of tens of feet of lacustrine clays and sands.

Prevailing winds can move sands along a coastline, often forming sandspits which enclose small bays. Some of the smaller bays consist merely of a section of curved shoreline protected from the prevailing winds. These small areas of protected shoreline allow the development of Emergent Marsh, but the Swamp Forest, Shrub Swamp, and Wet Meadow zones are often absent or poorly developed. Portions of the Wildfowl Bay Wildlife Area, consists of small protected bays on the lee side of Manisou, Heisterman, and Middle Grounds Islands.

In the eastern Upper Peninsula and northern Lower Michigan, some of the small bays were carved from the soft limestone or dolomite bedrock by glacial ice. Bedrock is at or close to the surface in these marshes. Squaw Bay in Alpena County and Big Shoal Cove on Drummond Island are two

such marshes.

Unprotected shoreline sometimes supported aquatic vegetation, typically a narrow band of Emergent Marsh consisting of Scirpus acutus, S. validus, S. americanus, and Eleocharis smallii. Behind this narrow band there was usually a low beach ridge, with an Interdunal Swale farther towards the shore. The swale sometimes contained another narrow band of Emergent Marsh or Submergent Marsh with both submergent and floating species. In southern Lower Michigan, the marshes south of the Pine River in Arenac County are good examples of marsh along a relatively unprotected shoreline; in eastern Upper Michigan, St. Martin Bay and Pine/Carp Rivers are narrow marshes along a relatively unprotected shoreline.

Along some shorelines, wave activity is intense enough that no marsh can develop. Occasionally conditions are right to allow large interdunal swales to be created just behind the foredune, providing a site for marshes to develop. In southern Lower Michigan, Tobico marsh occupies such a swale. Other examples of marshes developing in swales are at Petobego Pond in Grand Traverse County and near Independence Lake in Marquette County.

A Tombolo is an island, or islands, connected to a mainland by sand bars or a shallow bedrock shelf. Two very good examples of wetlands forming on tombolos are found in Upper Michigan. Pequaming, in Baraga County, consists of a sedge- and sphagnum moss-dominated Bog or Poor Fen developed on deep, unstable peat deposits, between two well-developed, relatively high sand bars. The tombolo on the eastern end of Grand Island, in Alger County, in contrast, consists of numerous parallel, low sand bars, with shallow adjacent swales. The swales contain shallow, firm peat deposits upon which sedges are dominant. A third, less evident tombolo is

found at Independence Lake, where two (rather than only one) upland "islands" are connected by series of sand bars parallel to the adjacent mainland, creating Independence Lake in the process. The wetland swales at Independence Lake also contain Bog or Poor Fen vegetation.

Special Plants

In the 1989 surveys, Zizania aquatica var. aquatica (wild rice, state threatened), was found at Arcadia Lake in Manistee County, growing on deep muck soils. This represents one of the northern-most records for this taxon. In the southern half of the Lower Peninsula, this species is found in estuaries along the Galien, Macatawa, and Grand Rivers.

Iris lacustris (dwarf lake iris, state and federally threatened) was found, in 1989, along the upland edge of four marshes; Whitefish and El Cajon Bays in Alpena County, Voight Bay on Marquette Island in Mackinac County, and Cecil Bay in Emmet County.

Aster nemoralis (bog aster, state special concern) was also encountered in large numbers at Lac La Belle, in Keweenaw County, the most northwesterly known locality for the species.

SITE SUMMARIES

A short discussion of each marsh sampled or visited during the 1989 field season follows. Sampling was limited at Independence Lake because we could not get permission from the landowners to sample on their land, or to get access to state-owned lands. At El Cajon Bay/Misery Bay, sampling was limited to El Cajon Bay. Storm winds from the east caused us to abandon attempts to sample Misery Bay on two occasions. Misery Bay has abiotic and biotic conditions similar to nearby El Cajon and Whitefish Bays. Each sampled marsh was mapped to show plant communities, sampling transect, and usually adjacent land use (Appendix IV). Ownerships were obtained from the most recently available plat books.

Lake Huron

1. Tobico (Bay Co., C-D) This 1300 acre marsh, located in a large swale along the shore of Saginaw Bay, is part of the Tobico Marsh State Game Area and the Tobico Marsh Wildlife Refuge. It was sampled both in 1988 and 1989. This marsh probably formed when a sandspit formed to entrap a small embayment, forming a pond. Although the area has undergone management by the DNR, which possibly includes some water-level manipulation, the pond is a natural feature which was mentioned by General Land Office (GLO) surveyors in the early 1800's. The northern portion of the marsh complex is dominated by a broad Emergent Marsh of cattails. This portion is low in plant diversity, but is probably of significance for waterfowl and muskrat production. East and west of the pond the zonation of the marsh is better and plant diversity is probably higher. On the eastern shoreline low beach ridges and sand spits separate Saginaw Bay from

the pond. Black oak dominates the tops of the dry sand spits, while the ground cover consists of drought-tolerant grasses and sedges.

Between the oak-dominated sand spits, swales (which are part of the pond) support broad expanses of Wet Meadow. The Wet Meadow community is typical of that found in most of the embayments along Saginaw Bay, with Calamagrostis canadensis (blue-joint grass) and Carex stricta (sedge) dominating. Similar zonation exists along the western shore of the pond, where Southern Swamp Forest dominates a series of parallel beach ridges and swales. Some of the larger swales are dominated by Wet Meadow. A second small, shallow embayment was trapped further to the southwest by these beach ridges. This embayment was completely occupied by Emergent Marsh and Southern Wet Meadow.

The transect plots sampled during the 1989 field season contained 44 species, which are much more representative of the marsh than the species encountered in the 1988 transect, which contained only 14 species. The 1988 transect was placed in a region dominated almost entirely by cat-tail. Approximately half of the sampling points were within the Wet Meadow zone, where the majority of the 44 species were found. The other sampling points were within the Emergent Marsh zone, which was dominated by cat-tail. The Emergent Marsh had low diversity, much like the cat-tail dominated area sampled in 1988. Occasional roundish openings within the cat-tail zone were likely the result of muskrat activity.

There is a known occurrence of bald eagle (state and federally threatened) within the marsh area. Platanthera ciliaris (yellow fringed-orchid, state special concern) is also known from the edge of the marsh.

Extensive sand mining has occurred at the south end of this embayment,

but the Emergent Marsh, Shrub Swamp, and Wet Meadow at the northern end do not appear to have been greatly impacted by this activity. Several other types of disturbance have occurred within the marsh complex. At least 4 ditches enter the pond along its western shore. These ditches drain adjacent fields to the west and probably have little impact upon the water levels or vegetation of the pond. The fields that abut the marsh on the west, were previously occupied by Swamp Forest, Shrub Swamp, and Lakeplain Wet-Mesic Prairie. ORV damage is apparent in portions of the marsh. A railroad line runs along the eastern edge of the marsh, possibly causing ground fires which mimic the effect of Indian-set fires upon the natural vegetation. A road and residential development along Saginaw Bay have degraded the natural area value of the shoreline.

Although the majority of the wetland is state-owned, there are four private owners in the northwest corner, in Sections 13 and 25, and two private owners in Section 25 to the south. Hartley and Hartley, Inc., a large ownership in Section 25, is doing extensive sand mining.

2. Squaw Bay (Alpena Co., B-C) This 720 acre marsh is located in a small embayment of Lake Huron, approximately 3 miles south of the city of Alpena. The shoreline of the marsh consists of a limestone bedrock beach overlain with cobbles and similar rubble. There has been little or no development of organic soils near the shoreline. The Squaw Bay Environmental Area, designated by the Shorelands Protection Program, is included within the area mapped as Great Lakes Marsh.

Approximately 400 acres of the marsh is of high natural quality, with the other 280 acres impacted by either rapidly encroaching residential development along the north side of the bay or by the proximity of U. S.

Route 23 on the west side of the bay. The residential development has impacted both the Wet Meadow zone, adjacent to where most of the houses are located, and the Emergent zone, where small boats have destroyed most of the emergent vegetation. Earlier grazing of the north shoreline by cattle also altered the vegetation of the Wet Meadow zone. A portion of the Wet Meadow and Emergent Marsh zones, located west of U. S. Route 23, has undergone hydrologic alteration. There is also a ditch along the west side of the highway.

The remaining high-quality marsh consists of a dense zone of emergent vegetation in the shallow waters of the bay, with a Wet Meadow zone or Shrub Swamp zone along the moist shoreline. Cedar swamp borders almost the entire upland edge of the wetland. The Emergent Marsh, which extends approximately 400 meters into the bay, consists of a relatively dense bed of Scirpus acutus (hardstem bulrush) and Eleocharis smallii (spike-rush), with some Typha Xglauca (hybrid cat-tail), Potamogeton gramineus (pondweed), and Sagittaria latifolia (duck-potato). The Emergent zone ends at a water depth of less than 30 cm (12 in), where the substrate consists of a thin veneer of sand upon cobbles. The shallowness of the water probably indicates that wave erosion during storms is the factor controlling the breadth of the Emergent zone.

The first sampling point was located on a low cobble ridge near the upland margin; the second point was located on a cobbly beach flat. Over 80% of the species identified in the transect were within the first three sampling points. Many of these species were consistently found along the calcareous shorelines of the marshes within the Mackinac Straits area, including Carex viridula (sedge), Cladium mariscoides (twig-rush), Lobelia

kalmii (Kalm's lobelia), Satureja arkansana, and Eleocharis pauciflora (spike-rush). Chara sp. was also common in the Emergent zone of the marshes along the calcareous Straits area. Dwarf lake iris is known from the margins of the bay.

This marsh is not a high priority for natural areas protection for several reasons. The first is the intensive development already existing within the boundaries of the marsh, primarily U. S Route 23 and residential development. Second, Realty Development Corporation can be expected to continue shoreline development, especially near rapidly growing Alpena. Third, land acquisition for protection would probably be very expensive due to local shoreline land values. Fourth, the heavy adjacent residential land-use is the source of ORV and other recreational uses which degrade the quality of the marsh.

The center of the marsh at Squaw Bay consists of small tracts; the northeastern end of the marsh, in Section 11, is owned by one owner, Realty Development Corporation. The southwestern portion of the marsh, in Sections 9 and 16, consists of two large ownerships, one by E. Schemanski and the other by Phil G. Smith.

3. Whitefish Bay (Alpena Co., B-C) This 300 acre wetland, which contains about 170 acres of marsh, is located approximately 3 miles east of Alpena along the east shore of Whitefish Bay, a small embayment within larger Thunder Bay. The Whitefish Bay Environmental Area, designated by the Shorelands Protection Program of the Michigan DNR, is located within the area mapped. The location of a large cement factory and quarry between the marsh and Alpena appears to have restricted residential development in the area. South of the marsh scattered, large single-family homes are

located along the shoreline.

The marsh, which is generally less than 500 m (1640 ft) wide, consists of a relatively wide zone of shallow Emergent Marsh on a clay substrate, with a narrow Wet Meadow zone bordered by dense cedar swamp. During 1989 sampling the Emergent Marsh was saturated, but there was almost no standing water. Sandspits along the shoreline, which separated the Emergent Marsh zone from open water, had little vegetation and, based on 1987 aerial photos, appeared to have been produced by the 1986 high-water levels of the Great Lakes. During this high-water period, water levels would have been approximately .6 m (2 ft) deep in most of the Emergent Marsh. Four typical species of Emergent Marshes, Scirpus americanus (threesquare), Scirpus acutus (hardstem bulrush), Juncus balticus (rush), and Cladium mariscoides (twig-rush) were common. Most of the remainder of the 59 species found in the marsh were also found in the Emergent zone. Many of these species are typical of the moist, calcareous clay, marl, or cobble flats of the Straits area. Among the more common are Lobelia kalmii (Kalm's lobelia), Eleocharis rostellata (spike-rush), Eleocharis pauciflora (spike-rush), Potentilla fruticosa (shrubby cinquefoil), Tofieldia glutinosa (false asphodel), Primula mistassinica (primrose), and Sarracenia purpurea (pitcher-plant).

The Wet Meadow zone, located between the Emergent Marsh and the Rich Conifer Swamp, is narrow and somewhat arbitrarily defined on the presence of Calamagrostis canadensis (blue-joint grass), Carex stricta (sedge), Carex interior (sedge), and two species of shrub, Aronia melanocarpa (black chokeberry) and Myrica gale (sweet gale).

The Rich Conifer Swamp, dominated by Thuja occidentalis (northern

white-cedar), also contained small Abies balsamea (balsam fir). The soils beneath the swamp consist of 25-30 cm (10-12 in) of muck over sand. A virtual carpet of Iris lacustris (dwarf lake iris, state and federal threatened) formed beneath the cedars, between the Wet Meadow and a small road to the east.

The majority of the marsh has suffered little damage. ORVs have damaged the shoreline near the north edge of the bay, but have not damaged the Emergent Marsh or Wet Meadow zones. A small two-track road extends to the edge of the marsh from the south along a sandspit. The dirt road along the east side of the marsh, which continues to Whitefish Point and further south, does not appear to impact the marsh. The road is located on an old beach ridge. A small portion of the marsh at the north has been filled to construct North Point/Misery Bay Road. Within the marsh, cut sections of cedar and white pine logs, apparently from early logging operations in the area, are relatively common.

The marsh is shown to by owned by one large owner, the Huron Portland Cement Co. According to workers at the Huron Portland Cement Co., this company and an adjacent private club east of Whitefish Bay, have been recently sold to another party. The private club consists of several single-family residences owned by members.

Protection should be sought for the marsh and adjacent swamp, both because of the large population of dwarf lake iris and the diverse Emergent Marsh. Single ownership of the tract may simplify either purchase or negotiation of a management agreement.

4. El Cajon Bay/Misery Bay (Alpena Co., A) This 440 acre marsh is located approximately 8 km (5 mi) east of the city of Alpena, along the

western shore of Lake Huron. Both Crooked Island and Misery Bay Environmental Areas are within the mapped marsh. Rich Conifer Swamp accounts for an additional 1600 acres along the margins of the marsh.

El Cajon Bay is a small, shallow, well protected bay at the north end of Misery Bay. Misery Bay, in contrast, receives very little protection from easterly winds off Lake Huron. Sampling was limited to El Cajon Bay due to stormy weather during field visits.

The marsh at El Cajon Bay is very similar to that on Whitefish Bay; the Emergent Marsh zone is nearly 500 m (.3 mi) wide, while the Wet Meadow zone is very narrow. Cedar Swamp (Rich Conifer Swamp) begins at the shoreward edge of the Wet Meadow zone.

The clay surface of most of the Emergent Marsh zone was saturated, with water depths occasionally reaching 25 cm (9 in). Washed up vegetation at the shoreward margins of the Emergent Marsh marked the 1986 high-water line. As the shallow waters of the bay were reached, species diversity dropped greatly, with only Chara sp. (stonewort) and Scirpus acutus (hardstem bulrush) present. Dominants in the Emergent zone include Juncus balticus (rush), Scirpus acutus, Scirpus americanus (threesquare), and Chara sp. Other species in the Emergent Marsh, are typically common on moist, calcareous beaches. These include Cladium mariscoides (twig-rush), Carex viridula (sedge), and Lobelia kalmii (Kalm's lobelia).

The narrow Wet Meadow zone, also with a clay substrate, contained Calamagrostis canadensis (blue joint), Carex interior (sedge), Potentilla fruticosa (shrubby cinquefoil), Hypericum kalmii (Kalm's St. Johnswort), Sarracenia purpurea (pitcher-plant) and Satureja arkansana. The presence of these and other calciphiles characterizes many of the marshes within the

Mackinac Straits area. A small colony of Iris lacustris (dwarf lake iris, state and federally threatened) was found growing on an isolated low, sand beach ridge within the Wet Meadow zone.

Rich Conifer Swamp forms a 120-150 m (400-500 ft) wide zone between the uplands and the Wet Meadow. The upland forest upland of the swamp is also rich in conifers, with cedar a common dominant. Dwarf lake iris is common in the cedar swamps, covering 50-75% of the ground in a 15-20 m (50-60 ft) wide swath along the swamp's lakeward margin.

Species diversity in El Cajon Bay is relatively low; only 39 species were encountered in the transect. Sampling within the swamp forest and in Misery Bay would increase the number of species encountered significantly.

Disturbance within El Cajon Bay was minimal. There was a house built at the far west end of the bay, and there were also low levels of ORV use. The swamp and upland forest to the north had been logged in the past, but were reaching maturity. Disturbance on Misery Bay is concentrated at the east end of Misery Bay Road, where there is a small marina and several single-family homes. The three miles of marshy shoreline south of the road show little sign of major human disturbance. West of Misery Bay swampy land extends more than a mile inland in places, probably accounting for the lack of residential development.

The north half of El Cajon Bay, in Section 15, is owned by Michigan and is managed as part of the Mackinac State Forest. An occurrence of a high quality Moist Nonacid Cliff, at the west end of the bay, and an occurrence of Karst and Spring in shallow waters of the bay are on State Forest lands. The southern half of Section 15 is owned by Ken Houghmaster et al. This tract contains only one shoreline home at the extreme west end

of the bay, and should be considered for purchase to protect the marsh and shoreline. The Rich Conifer Swamp in this parcel has been identified as significant in an earlier survey. Dwarf lake iris does not appear to be common in the swamp forest in the southern half of Section 15.

The shoreline of Misery Bay, in Section 22 and the north half of Section 27, is part of Prospect Park, an unincorporated town or village. The southern part of Section 27, and all of Sections 34 and 35 are owned by one organization, Beaumont Point, Inc., c/o David Barnett. The most significant portion of the Misery Bay marsh is that in Sections 27, 34, and 35, which should be considered as a prime candidate for acquisition as a natural area. Dwarf lake iris may also be common along the shoreline of Misery Bay.

5. **False Presque Isle Bay (Presque Isle Co., B)** This 340 acre marsh is located along the Bell River, near the south end of Grand Lake. The marsh, separated from Lake Huron by a narrow wetland area at the north, consists of a 100 m (300 ft) wide zone of Wet Meadow and a 40 m (130 ft) wide zone of Emergent Marsh. The organic deposits in the Wet Meadow are only a few cm thick near the shoreline, but greater than 3 m (10 ft) thick near the boundary between the Wet Meadow and Emergent Marsh zones. The thick organic soil appears to be a floating mat, which is very unstable at the water's edge. Thirty-six species were encountered in the short transect. The upland forest to both the east and west of the marsh has been removed and removal of limestone has begun almost to the edge of the wetland.

The Wet Meadow zone is dominated by Calamagrostis canadensis (blue-joint grass), Carex stricta (sedge), and an unidentified sedge species.

The Emergent Marsh zone is dominated by Scirpus acutus (hardstem bulrush), Eleocharis rostellata (rush), and Typha angustifolia (narrow-leaved cat-tail). Chara sp. (stonewort) and Leersia oryzoides (cut grass) are also present.

Part of the Wet Meadow, Shrub Swamp, and Rich Conifer Swamp have been cut by a road, locally altering the hydrology of these zones. Quarrying of limestone on the adjacent uplands has probably resulted in at least some degradation and impact to the wetland plant communities. The extreme alteration of the uplands by quarrying reduces the natural area value of this marsh, even though the marsh probably remains functional as habitat for fish, waterfowl, and other wetland species. The marsh is low priority for land acquisition, due primarily to its moderate quality and the poor potential for protection. There are previously known occurrences of bald eagle (state and federally threatened) and Cypripedium arietinum (ram's-head lady-slipper, state special concern) from the site.

The entire marsh is under the ownership of Quile Corporation, the manager of the adjacent, large-scale, limestone quarry operation.

6. Cheboygan State Park (Cheboygan Co., A) This 280 acre marsh, located entirely within Cheboygan State Park, is on the east side of Duncan Bay, which is located in the Straits of Mackinac. Part of the marsh is designated as the Duncan Bay Environmental Area. Three transects were conducted at this marsh, resulting in the identification of 98 species, the highest number of species found at any of the marshes sampled in 1989. The number of species found in single transects ranged from 53 to 69, demonstrating that all transects were located in species-rich areas. The zones represented in this marsh complex include Rich Conifer Swamp, Shrub

Swamp, Wet Meadow, Sand and Cobble Beach, and Emergent Marsh.

The Wet Meadow zone was up to 160 m (500 ft) wide. The dominant plants of the Wet Meadow included Calamagrostis canadensis (blue-joint grass), Carex stricta (sedge), Carex viridula (sedge), Carex lasiocarpa (sedge), Phalaris arundinacea (reed canary grass), and Cladium mariscoides (twig-rush). Myrica gale (sweet gale), Spiraea alba (meadowsweet), and several species of Salix (willow) are also common within the Wet Meadow, along with several other calciphiles characteristic of moist beaches and other calcareous shores.

The Emergent Marsh zone was also broad, greater than 300 meters wide in one transect. Due to low water levels, a large portion of this zone was saturated but had no standing water in 1989. As a result of these low water levels, the zone contained species typical of both the moist beach and the Emergent Marsh. Species typical of the Emergent Marsh included Scirpus acutus (hardstem bulrush), Scirpus americanus (threesquare), Scirpus validus (softstem bulrush), and Sagittaria latifolia (duck-potato). Species typical of the moist beach include Utricularia cornuta (bladderwort), Juncus brevicaudatus (rush), Juncus canadensis (rush), and Eleocharis pauciflora (spike-rush). Rich Conifer Swamp borders the marsh, accounting for approximately 400 acres of wetland.

There is little sign of human disturbance within the marsh. Potential for protection and management for the marsh system is high, since it is within state park boundaries. Adjacent land use in the park include a campground and a swimming beach.

The park is a known site for bald eagles (state and federally threatened), although it is not known if there is an occupied nest within

the park. Eagles have been sighted over the marsh in 1985 (during previous CZM surveys of coastal dune areas) and also during this survey. Duncan Bay is known as an historic site for eagles, and a nesting site on Lighthouse Point has been documented (Tom Weise, pers. comm.) Piping plovers (state and federally endangered) nested here in 1989.

Special plants present within the park include Solidago houghtonii (Houghton's goldenrod) and Iris lacustris (dwarf lake iris), both of which are federally threatened species. Houghton's goldenrod is very localized in the park, occupying the foredune areas fringing the bay. Dwarf lake iris occurs in localized, but dense colonies that are concentrated near the campground, extending into the cedar-dominated areas north of the bay.

The entire marsh is within Cheboygan State Park ownership. Grass Bay, a preserve of The Nature Conservancy located immediately to the east, provides protection and management to an additional large stretch of Lake Huron shoreline.

7. **Carp/Pine Rivers (Mackinac Co., A)** This 220 acre marsh, which stretches from the Carp River to the Pine River, consists of a narrow band of Wet Meadow and Emergent Marsh along two and a half miles of Lake Huron shoreline. The entire shoreline between the rivers is designated as the Carp River Environmental Area by the Shorelands Protection Program of the Michigan DNR. Interdunal swales comprise narrow zones of Emergent Marsh separated by low beach ridges. Plants characteristic of the Emergent Marsh zone occupy the lower portions of the beach ridges and foredune, continuing into the shallow waters of Lake Huron. Behind the open marsh is a broad zone of Hardwood-Conifer Swamp, which occupies narrow swales between several low, forested beach ridges. The swamp accounts for an additional

300 acres of wetland.

The erosive force of the lake is strong, causing extensive alteration of the marsh within only a few years time. When the marsh was first visited during the high water levels of 1986 and 1987, the Emergent Marsh zone had been greatly altered, with most of the Juncus balticus (rush) buried by recently deposited foredune and the Scirpus acutus (hardstem bulrush) culms and rhizomes eroded by waves. Parts of the Wet Meadow were still intact, but the grass and sedge mats along with underlying organic soils in other parts were heavily eroded, often down to the underlying limestone bedrock. When the marsh was revisited in 1989, the Emergent Marsh and foredune were being revegetated. The eroded organic materials at the edge of the Wet Meadow zone were still evident. The entire marsh was less than 160 m (500 ft) wide, from the edge of the forest to open water.

The Wet Meadow zone, less than 60 m (180 ft) wide, is dominated by Calamagrostis canadensis (blue-joint grass), Carex aquatilis (sedge), Carex stricta (sedge), and Carex lasiocarpa (sedge). Salix candida and Salix pedicellaris (willows), Alnus rugosa (speckled alder), Lysimachia terrestris (loosestrife), and Campanula aparinoides (marsh-bellflower) are also common in this zone.

Dominants within the Emergent Marsh, less than 100 meters wide, include Scirpus acutus (hardstem bulrush), Eleocharis smallii (spike-rush), Pontederia cordata (pickerelweed), and Sagittaria latifolia (wapato). Isoetes sp. (quillwort) also grows in the saturated sands at the edge of the foredune and in the shallow waters of the Emergent Marsh.

Only 44 species were encountered in the sampling transect. Additional species could be expected if a second transect had been located further to

south, where exposed limestone was encountered during 1987 field surveys. Exposed limestone and cobble beach support calciphiles not encountered on the sand soils of the sampling transect. The higher diversity found further to the east on St. Martin Bay (see St. Martin Bay marsh) reflects the presence of cobble beach and limestone bedrock.

Bald eagles (state and federally threatened) are known to nest in the general area around the marsh. No other Special Plants or Animals are known from the site.

Beaver floodings and muskrat lodges are common, contributing to the natural disturbance within the marsh complex. Fluctuating water levels of the Great Lakes and storm waves account for most of the natural disturbance occurring within this marsh. Limited ORV damage occurs, but is restricted primarily to the foredune and beach area. The entire marsh complex is of natural area quality, even though natural disturbance levels are high.

The southern portion of the marsh, in Sections 9, 16, and 21, is part of the Hiawatha National Forest. At the north end of the marsh, in Section 10, there are six landowners, each owning less than 40 acres of shoreline property. At present, it appears that none of these owners has significantly altered the shoreline wetland. Although the northern section of the marsh is privately owned, it is of relatively low priority for purchase, since most of the marsh is under public ownership.

8. St. Martin Bay (Mackinac Co., A-D) This 270 acre marsh occurs along a 4 mile stretch of shoreline on St. Martin Bay, extending from Pontchartrain Point in the northwest nearly to St. Martin Point in the southeast. The Pontchartrain Environmental Area is located within the marsh. Scattered marshes also occur in the 6.6 km (4 mi) stretch between

the Pine River (further to the west) and Ponchartrain Point, but the marshes are narrow and small.

The St. Martin Bay marsh consists of a narrow zone of Wet Meadow, typically less than 100 m (300 ft) wide, and a slightly wider zone of Emergent Marsh, 200-300 m (660-1000 ft) wide. Rich Conifer Swamp or cedar-dominated upland forests form the landward boundary of the marsh.

The Wet Meadow zone is dominated by Calamagrostis canadensis (blue-joint grass), Carex stricta (sedge), and Carex lasiocarpa (sedge). Other sedges are common. Common shrubs include Myrica gale (sweet gale) and Alnus rugosa (speckled alder). Other common species of the zone are Campanula aparinoides (marsh-bellflower), Lathyrus palustris (vetch or beach pea), and Scutellaria galericulata (skullcap).

The Emergent Marsh occupies sandy substrate with water ranging from saturated to 94 cm (37 in) in depth. Rocks are common in the shallow water. There are indications that the emergent vegetation was heavily eroded by high water in the past. The Emergent zone, from 200-300 m (660-1000 ft) wide, consists of a dense band of Scirpus acutus (hardstem bulrush), Scirpus americanus (threesquare), and Eleocharis smallii (spike-rush). Common submergent species include Potamogeton gramineus (pondweed) and Chara sp. (stonewort).

Although the diversity of this marsh is relatively low, it is characteristic of the narrow marshes located along shorelines where only minimal protection from erosive storm waves exists. It is probably one of the longest continuous areas of narrow marsh remaining on the shores of Lakes Huron, Michigan, or Superior.

Bald eagles (state and federally threatened) are known to nest in the

general area of the marsh. No other Special Plants or Animals are known from the site.

Human disturbance within the marsh is restricted to roadfill for Michigan Highway 134 and a small boat dock to the south of Michigan Highway 134 in Section 16. Minor ORV damage is also present along the shoreline.

A large part of this narrow marsh, approximately 3.3 km (2 mi) of shoreline in Sections 17, 20, 27, and 28, is within the Hiawatha National Forest. Another tract in Section 27 is owned by the Nature Conservancy. The shoreline in Section 16, and part of the shoreline in Section 27, is privately owned by several owners. Sections 3 and 33 to the south are under multiple small ownerships. The extent of protected coastal marsh could be increased either by management agreement with owners or by purchasing the shoreline. Because of the extensiveness of the shoreline remaining in private ownership, management agreements are probably a more realistic approach.

9. Hessel (Mackinac Co., B-D) This 305 acre marsh, located within the city of Hessel, along the shore of Mackinac Bay, is protected from the severe storm waves of Lake Huron by the Les Cheneaux Islands. The marsh is designated as the Lone Susan Environmental Area. Michigan Highway 134 crosses the northern edge of the marsh, altering the hydrology of at least 40 acres of marsh.

Fifty-eight species were encountered in this marsh, which consists primarily of broad zones of Wet Meadow and Emergent Marsh. Shrub Swamp and Rich Conifer Swamp (northern white-cedar dominated) are also present.

The Wet Meadow was approximately 120 m (390 ft) wide on the sampling transect. The soils are 23-56 cm (9-22 in) deep organic deposits over

sand. Dominants included Calamagrostis canadensis (blue-joint grass) and Carex stricta (sedge). Other species common within the zone include Lysimachia thyrsiflora (loosestrife), Potentilla palustris (swamp cinquefoil), Campanula aparinoides (marsh-bellflower), and several species of Salix (willow).

The soils of the Emergent Marsh consist of organic deposits over sand for the 80-100 m (260-330 ft) nearest to shore, with sand at the surface for the remainder of the transect. Organic soils are 91-97 cm (36-38 in) deep at the ecotone between the Wet Meadow and Emergent Marsh, where water is less than an inch deep. Forty meters further into the bay, in the last transect point where organic soils are encountered, organic depth is 18 cm (7 in) and water depth is 15 cm (6 in). At the ecotone, organic soils are most susceptible to erosion during high-water periods. Dominant vegetation probably alters between that typical of Wet Meadow and Emergent Marsh zones, depending on fluctuations of water depth.

Dominants within the Emergent Marsh, which is 300 m (1000 ft) wide, include Scirpus acutus (hardstem bulrush), Scirpus subterminalis (bulrush), Ceratophyllum demersum (coontail), Nuphar variegata (spatterdock), and several species of Potamogeton (pondweed). The Emergent Marsh is relatively diverse, containing about 20 species.

Human disturbance is remarkably limited, considering the nearness of the town of Hessel. Filling along the highway and scattered boat docks along the margins of the marsh are the only evident alteration of the marsh, other than the apparent channelization of a portion of a stream inlet in the northwest region of the marsh just south of M-134.

Small tracts account for the ownership of most of this marsh. A

relatively large tract in the center of the north shoreline is owned by Norm L. Blissell, Jr. et al. Located along M-134, the scenic value of the marsh is high. Perhaps management agreements could be arranged between the many owners and the state to maintain the natural condition of the marsh. Shallow waters and weedbeds within the bay, combined with open, weedless shoreline to the west in Hessel Bay, may account for the lack of development within the marsh.

10. Peck Bay (Mackinac Co., A) This 70 acre marsh is one of the smallest marshes sampled, but it is typically of many of the small marshes found on the glacier-eroded limestone bedrock along the northern shore of Lake Huron. The marsh, located on compact gray clay, consists of three zones, a very narrow Submergent Marsh, a 100 m (330 ft) wide Emergent Marsh, and a Wet Meadow greater than 300 m (1000ft) wide. The Wet Meadow zone is probably more accurately described as a Northern Fen, dominated by calciphiles. Approximately 370 acres of Rich Conifer Swamp are located along the shoreline adjacent to the marsh.

The Submergent Marsh has been heavily eroded by recent high water levels. Presently only Chara sp. (stonewort) is found growing in the shallow waters of the bay.

The Emergent Marsh zone has also been heavily eroded by high water; at the first two sampling points in this zone, dead Scirpus acutus (hardstem bulrush) rhizomes are common at the surface of the clay. Eleocharis pauciflora and E. rostellata (spike-rushes), Cladium mariscoides (twig-rush), and Scirpus acutus are common within the remainder of the Emergent zone. Several calciphiles characteristic of the Northern Fen are also found near the upland edge of the Emergent Marsh.

The Northern Fen zone contains marly pools and "islands" of graminoids supporting shrubs and small cedars, tamaracks, and black spruces. Common species in the Fen include Juncus balticus (rush), Lobelia kalmii (Kalm's lobelia), Potentilla fruticosa (shrubby cinquefoil), Parnassia glauca (grass-of-Parnassus), Tofieldia glutinosa, and Sarracenia purpurea (pitcher plant). Most of the 50 species noted in the marsh are within the Northern Fen.

There is little human disturbance within the majority of the wetland. A home with a boat dock is located at the mouth of the bay, but does not impact the wetland. High water levels have altered the Emergent and Submergent Marsh zones, but have little effect on the broad Northern Fen zone.

The majority of the marsh is owned by two owners, Technical Rubber Co. and Valentine Dauber. These parcels should be considered for purchase to protect the marsh. The southeastern quarter of the marsh has several smaller owners.

11. **Voight Bay (Mackinac Co., A)** This relatively small marsh (120 acres), like Peck Bay marsh, is located in an embayment eroded from the limestone bedrock by glacial ice. Marly seeps and pools line the edges of the marsh. The marsh is designated as the Voight Bay Environmental Area by the Shorelands Protection Unit of the Michigan DNR. Sampling within the marsh was restricted to the Wet Meadow, Emergent Marsh, and Submergent Marsh zones. The more diverse Northern Fen zone, with its seeps and pools, was not sampled. The species present within the Northern Fen were the same species recorded at Peck Bay. The shallow waters of the bay were less protected than Peck Bay. As a result of greater wave activity and along-

shore currents, a thin veneer of sand blanketed the clay in all but one sampling point. Approximately 200 acres of Rich Conifer Swamp are located along the marsh's upland boundary.

The only species present in the 5-15 cm (2-6 in) deep water of the shallow Submergent Marsh was Chara sp. (stonewort). A storm beach with Scirpus acutus (hardstem bulrush) stems demonstrated the erosive effect of waves from the southeast.

The Emergent Marsh was also low in diversity, dominated by Scirpus acutus, Eleocharis pauciflora (spike-rush), Eleocharis rostellata, and scattered Cladium mariscoides (twig-rush). The Emergent Marsh, which was approximately 100 m (330 ft) wide, had also undergone heavy erosion during the recent high-water period; a dense mat of Scirpus acutus rhizomes was present within most of the zone, but most of the stems had been broken off, resulting in the death of the rhizomes. Scattered patches of bulrush still persisted near the upland margins of the emergent zone. The spike-rushes had established over the surface of most of the Emergent Marsh zone.

A narrow zone of Wet Meadow, only 40-50 m (120-150 ft) wide, occupied the margins of the embayment. Diversity was low. Calamagrostis canadensis (blue-joint grass) and Carex viridula (sedge) were common, along with Cladium mariscoides. Eleocharis rostellata, Potentilla fruticosa (shrubby cinquefoil), Sarracenia purpurea (pitcher-plant), and Satureja arkansana were also present, demonstrating the calcareous nature of the substrate.

Iris lacustris (dwarf lake iris, state and federally threatened) was present along the margins of the wetland, both on the low foredune and on abandoned gravel beach ridges above the present level of Lake Huron. Dwarf lake iris, present on the shoreline both east and west of the marsh,

probably continues along much of the sand and gravel shoreline at the south end of the island. Although Solidago houghtonii (Houghton's goldenrod) was not seen during the survey, the habitat appears to be appropriate.

Human disturbance, with the exception of past logging activity, within the marsh and along the shoreline is minimal. Old logging roads end near the marsh, both to the north and east, but there appears to be little or no destructive ORV use of these trails. Although plant diversity is low within the marsh, the low levels of human disturbance, the presence of a sizeable population of dwarf lake iris, and the high quality Northern Fen are reasons for acquiring this marsh for protection as a natural area.

A small part of this marsh, in Section 13, is owned by the State of Michigan. Important portions of the marsh in Sections 13 and 14 are owned by Douglas Szwed, Thaddeus J. Moross, and William H. and John Kindell.

12. **Duck Bay (Mackinac Co., A)** This 240 acre marsh is designated as the Duck Bay Environmental Area by the Shorelands Protection Program of the Michigan DNR.

The marsh is partially protected from storm waves, resulting in the development of broad Emergent Marsh and Submergent Marsh zones. The Submergent Marsh zone is one of the most extensive sampled, covering the center of the entire bay. Broad Emergent Marsh zones are located in the shallow waters at both the northwest and southeast ends of the bay. There are also narrow zones of Wet Meadow and Shrub Swamp and a broad band of Rich Conifer Swamp (130 acres) on the south side of the bay. Sampling was restricted to the marsh at the southeastern end of the bay, where 43 species were encountered. A brief survey of the marsh at the western end of the bay indicated that the zonation and species were too similar to

justify a second transect.

The Shrub Swamp zone was narrow, approximately 60 m (195 ft) wide. The organic soils, underlain by clay, were 91-122 cm (36-48 in) thick. Dominants included Alnus rugosa (speckled alder), Calamagrostis canadensis (blue-joint grass), and Carex lacustris (sedge). A Wet Meadow zone of approximately 40 m (130 ft) width, which contained no shrubs, was dominated by the previously mentioned graminoids and Carex stricta.

The Emergent Marsh zone, approximately 120 m (390 ft) wide, is underlain by 30-60 cm (12-24 in) of organic material at the landward edge. There are openings within the Emergent zone, probably the result of waves from the east, where Duck Bay joins the larger Muscallonge Bay. These openings are dominated by Chara sp. (stonewort), Megalodonta beckii, Nymphaea odorata (water-lily), several species of Potamogeton (pondweed), and Zizania aquatica (wild rice). Several species were common throughout the emergent zone, including Najas flexilis, Potamogeton gramineus, Scirpus acutus (hardstem bulrush), and Vallisneria americana. A very sparse bed of hardstem bulrush continues to about 400 m (1300 ft) from shore, where water depth is about 166 cm (63 in). Wild rice is quite abundant within the marsh; the greatest densities are in the Emergent Marsh at the west end of the bay.

The Submergent Marsh begins in water which is approximately 166 cm (63 in) deep, and continues across the center of the bay, where water depth is approximately 229 cm (90 in). Even in the deepest parts of the bay there is a complete cover of Vallisneria americana, Heteranthera dubia, and Potamogeton illinoiensis.

Human disturbance within the marsh is minimal. A dock and old boat

yard is located at the south end of the bay, near the edge of the Emergent Marsh. The few homes along the shoreline have caused little damage to the marsh; two docks within the marsh extend into the open Emergent Marsh zone. The high quality of the entire marsh justify its purchase and protection from further residential development.

The southeastern portion of the marsh, in Section 12, is owned by the State of Michigan. Two important ownerships in the northwestern part of the marsh are Whitaker and Schweikert, where a house is located on the shoreline, and George M. Covington. Two smaller ownerships at the north end of the marsh are G. Burkholder and C. H. Shoberg.

13. **Big Shoal Cove (Chippewa Co., B)** This relatively small, 200 acre marsh, is located in Big Shoal Cove at the south end of Drummond Island. Although human disturbance is minimal, the marsh is low in diversity (39 species in transect), probably due to erosive wave action from Lake Huron. Most other bays on the south side of Drummond Island do not support extensive marshes due to the extreme erosion by Lake Huron's waves.

The sampling transect was approximately 200 m (660 ft) long, consisting of 100 m (330 ft) of Wet Meadow and 100 m of Emergent Marsh. The substrate of both zones consisted of thin sand deposits over limestone bedrock.

The Wet Meadow is dominated by Carex viridula (sedge), Carex lasiocarpa (sedge), Calamagrostis canadensis (blue-joint grass), Eleocharis pauciflora (spike-rush), Juncus brevicaudatus (rush), and Scirpus acutus (hardstem bulrush). Several other plant species common to calcareous shorelines were present, including Lobelia kalmii (Kalm's lobelia), Primula mistassinica (primrose), Potentilla fruticosa (shrubby cinquefoil),

Selaginella eclipes (spike-moss), and Satureja arkansana.

Dominants of the Emergent Marsh include Eleocharis smallii (spike-rush), Scirpus acutus (hardstem bulrush), Potamogeton gramineus (pondweed), Potamogeton richardsonii (pondweed), and Chara sp. (stonewort). Water depths in the Emergent Marsh were 46 cm (18 in) or less.

The shoreline area is an occurrence of Bedrock Beach in MNFI's data base. Known Special Plants from the area include Carex scirpoidea (sedge, state threatened), Carex concinna (state special concern), Carex richardsonii (state special concern), Cirsium hillii (Hill's thistle, state special concern), Cypripedium arietinum (ram's-head lady-slipper, state special concern), Astragalus neglectus (Cooper's milk-vetch, state special concern), Habenaria unalascensis (Alaska orchid, state special concern), and Sporobolus heterolepis (prairie dropseed, state threatened). Bald eagles (state and federally threatened) are also known from the area.

The ownership of the Big Shoal Cove coast consists of several small tracts. The marsh alone does not appear to be of high enough quality to recommend purchase.

Lake Michigan

14. Stony Creek (Oceana Co.,BC-C) This 200 acre marsh is located where Stony Creek and Stony Lake join, approximately one and one-half miles east of the village of Stony Lake. Originally Stony Creek entered into a bay of Lake Michigan; then the bay was separated from Lake Michigan by sand dunes, thus creating a small lake. The presettlement vegetation of this marsh was a "cedar swamp," along the section 33/34 and 27/34 common lines. These lines are 1.3 km (0.8 mi) and 1.8 km (1.2 mi) upstream of Stoney

Lake. No description of the vegetation in the lower 1.3 km of Stony Creek was made.

Presently, four natural communities are found in the Stony Creek marsh: Emergent Marsh, Shrub Swamp, Wet Meadow, and Submergent Marsh. The Emergent Marsh was dominated by Impatiens biflora, Urtica dioica, and Typha latifolia, on saturated muck of variable depth. The Shrub Swamp was dominated by Alnus rugosa and Cornus stolonifera in the shrub layer and Carex lacustris and I. biflora in the groundlayer. The soils were saturated mucks from 2.4-2.7 m (8-9 ft) deep. The Wet Meadow was dominated by Carex aquatilis, Solidago sp., and Eupatorium maculatum, on saturated mucks of variable depth. The Submergent Marsh was not sampled.

This site was owned, in 1987, by the following private owners: Hannah Mikkelsen; Andrew Sundell; Howard Hill, et al.; L. & I. Beckman; John Post; and Gerald and Leverna Moschke. Much of the Submergent Marsh lies in public waters under the jurisdiction of the State of Michigan.

There were no Special Plants or Special Animals found, nor are any known from this marsh.

15. **Pentwater Marsh (Oceana Co., BC)** This 240 acre marsh, an estuary located at the confluence of the Pentwater River and North Branch of the Pentwater River, lies approximately 3.3 km (2 mi) southeast of the city of Pentwater. The river originally flowed into a bay of Lake Michigan. The bay was eventually separated from Lake Michigan by sand spits or sand dunes, thus creating Pentwater Lake. Within the upland forest boundary to the south is a steep ridge that displays the lake level of the former bay. The presettlement vegetation of this marsh was described as a "lake," except along the Pentwater River in Section 30 where there were "low

bottomlands."

Presently, four natural communities are found in the Pentwater Marsh: Shrub Swamp, Wet Meadow, Emergent Marsh, and Submergent Marsh. The Shrub Swamp type, dominated by Alnus rugosa (Speckled alder), was not sampled and was of limited extent within the site. The Wet Meadow type was dominated by Calamagrostis canadensis, Carex stricta, and C. aquatilis and occupied dry to saturated organic soils up to 1.5 m (5 ft) deep. The Emergent Marsh, dominated by Typha Xglauca, Sparganium eurycarpum, and Carex aquatilis, had a saturated muck substate that was over 3 m (10 ft) thick. The Submergent Marsh type was dominated by Ceratophyllum demersum, Myriophyllum exalbescens, and Nymphaea odorata in 23-46 cm (9-18 in) of water over muck of greater than 3 m (10 ft) depth.

Most of this site lies within the Pentwater River State Game Area and is administered by the Wildlife Division of the Michigan Department of Natural Resources. In addition, there were, in 1987, multiple private inholdings and adjacent private and corporate parcels, including: J.R. Hepworth; Jack Glover; D. & L. Van Gills; Gregory Van Boxel; E. Kokx, Tr.; and three tracts identified only by initials.

There are no Special Plants or Animals known from this marsh.

16. **Pere Marquette River (Mason Co., CD)** This 760 acre marsh is located where the Pere Marquette River meets Pere Marquette Lake, approximately 3.3 km (2 mi) southeast of the city of Ludington. The river originally flowed into a bay of Lake Michigan which became separated from Lake Michigan by sand spits and dunes, probably during Lake Nipissing times. The presettlement vegetation of this marsh was variably described as a cedar swamp (in the southern part), with "lake/overflowed bottoms,"

"bayou," and "water deep and brush so thick cannot run the line" along the Section 25/26 common line.

Presently, five natural communities are found in the Pere Marquette River marsh: Wet Meadow, Shrub Swamp, Emergent Marsh, Treed Swamp, and Submergent Marsh. The Wet Meadow was dominated by Calamagrostis canadensis with Carex comosa as the only major associate. The soils were saturated muck, 0.6-2.0 m (2-6.5 ft) deep. The Emergent Marsh was dominated by Lythrum salicaria with Urtica dioica and Impatiens biflora as the only major associates. It was found on saturated muck which was .75-2.0 m (2.5-6.75 ft) deep. The Treed Swamp and Shrub Swamp was not sampled.

Much of this site lies within the Pere Marquette State Game Area and is administered by the Wildlife Division of the Michigan Department of Natural Resources. The remainder of the site was owned, in 1988, by Dow Chemical Company; Robert E. & Rose Sobieralski; Eric Johnson, etux.; S. Jansen; Nancy Hogenser, et al.; and other small tracts and unidentified owners. Most of the Dow Chemical Company property to the west of U.S. Highway 31 has been converted to an evaporation pond, with the exception of an outlying area of unconverted marsh. An alien plant, Lythrum salicaria (Purple loosestrife) has invaded and presently dominates broad areas of the state property. No efforts at eradication are being undertaken.

There are no Special Plants or Animals known from this marsh.

17. **Big Sable River (Mason Co.,CD)** This 220 acre marsh is located where the Big Sable River flows into the artifically impounded Hamlin Lake. It is located approximately 17 km (10 mi) northeast of the city of Ludington. This marsh is representative of an estuary on a river which originally entered into a bay of Lake Michigan. This bay was separated

from Lake Michigan by sand spits and sand dunes, creating Lake Hamlin. A small dam on the outlet of Hamlin Lake has increased the water level of the Lake, flooding this site which was reported by the original land surveyors as being a cedar swamp.

Presently, five natural communities are found in the Big Sable River marsh: Emergent Marsh, Wet Meadow, Shrub Swamp, Treed Swamp, and Submergent Marsh. The Emergent Marsh was dominated by Typha latifolia and Sagittaria latifolia on shallowly- to moderately-inundated floating muck of over 1.5 m (5 ft) in depth. The Wet Meadow was dominated by Carex lasiocarpa and Dulichium arundinaceum on shallowly inundated muck of over 1.5 m (5 ft) in depth. The Shrub Swamp was dominated by Betula papyrifera in the subcanopy, Alnus rugosa in the shrub layer, and Thelypteris palustris in the understory. The soils were saturated muck over 1.5 m (5 ft) in depth. The Treed Swamp and Submergent Marsh were not sampled.

Most of this site lies within the Huron-Manistee National Forest and is administered by the U.S. Forest Service. A private tract on the east side of the marsh was owned, in 1989, by Jill C. Schulz. Much of the Submergent Marsh lies in public waters under the jurisdiction of the State of Michigan.

A Michigan threatened plant, Armoracia aquatica (lake cress), has been reported from this site. No Special Plants or Animals were found from this marsh during the course of survey work.

18. Manistee River (Manistee Co., C) This 1190 acre marsh is located where the Manistee River flows into Manistee Lake, beginning approximately 3.3 km (2 mi) east of the city of Manistee. It is representative of an estuary on a river which originally flowed into an embayment of Lake

Michigan. Sand spits and low dunes eventually separated the embayment from Lake Michigan, creating Manistee Lake. The presettlement vegetation of this marsh was variously described as "bayou", "marsh", "wet and mirey swamp", "drowned and dead timber", "drowned wet bottoms and swamp", and "pond". On the south side of Section 32, the surveyors noted "...water from six inches to two feet deep. Once apparently well timbered. But with the rise of the Lake and sand filling the channel of the River, it has become a perfect dead swamp almost impassable." In Section 31, on the south side of the river, they described the riverside wet meadows as "...a few chains wide in some places of good Grass Marsh, the balance flags and rushes."

Presently, five natural communities are found in the Manistee River marsh: Treed Swamp, Wet Meadow, Emergent Marsh, Shrub Swamp, and Floodplain Forest. The Treed Swamp is dominated by Fraxinus nigra in the overstory and both Leersia oryzoides and Phalaris arundinacea in the understory. The dry, mineral soils here were silty loam and silty clay loam. The Wet Meadow was dominated by Calamagrostis canadensis, with only localized Carex, primarily C. stricta. The saturated to shallowly inundated organic soils here were 0.8-1.5 m (2.75-5 ft) deep. The Emergent Marsh was dominated by Polygonum amphibium, on saturated to inundated muck that was 1.2-1.5 m (4-5 ft) thick, or thicker (only a 1.5 m probe was used on this marsh). The Treed Swamp was not sampled.

Much of this marsh is part of Manistee River State Game Area and is administered by the Wildlife Division of the Michigan Department of Natural Resources. Private tracts ownership was not determined.

A Great Blue Heron Rookery is known to occur on this marsh, but was

not verified in this survey. Two Special Animals are known from this site: the lake sturgeon (Michigan threatened and federal C2 status), and the bald eagle (state and federally threatened). No other Special Animals or Plants are known or were collected from here.

19. Bar Lake (Manistee Co., B) This 260 acre marsh is located along the eastern shores of Bar Lake, approximately 7.5 km (4.5 mi) north northeast of the city of Manistee. This marsh is an estuary on a small stream. The stream originally flowed into a small embayment of Lake Michigan, which has been separated from Lake Michigan by sand spits and dunes, thus creating Bar Lake, into which the stream now flows. A floating peat mat is now expanding into Bar Lake. The presettlement vegetation of this marsh was described as cedar swamp grading into "open, mirry grass marsh." Dead timber was noted, but no comment was made on its extent.

Presently, four natural communities are found in the Bar Lake marsh: Submergent Marsh, Emergent Marsh, Shrub Swamp, and Treed Swamp. The Submergent Marsh was dominated by Ceratophyllum demersum with Nuphar varigata as a common associate. Water depth here was 1.5 m (5 ft) with a substrate of loose muck at least an additional 1.5 m (5 ft) thick. The Emergent Marsh was dominated by occassional Myrica gale or Decadon verticillata in the shrub layer, with Carex lasiocarpa and Typha Xglauca in the groundlayer. The muck soils were shallowly inundated. The muck was either 1.2-1.5 m (4-5 ft) thick and underlayed by water, or over 3 m (10 ft) thick. The Shrub Swamp was dominated by Salix discolor and/or Alnus rugosa, on .75-3 m (2.5-10 ft) of saturated muck. The Treed Swamp was not sampled, but was dominated by Fraxinus nigra in shallow to .75 m (2.5 ft) of muck.

This site was owned, in 1986, by: Rich Horaszewski; Myra Sundbeck; Lawr. Hargreaves; Gary Bentley; Carol Kruger; Gordon Kruse; and Chas. Miller, etux. Much of the Submergent Marsh lies within public waters under the jurisdiction of the State of Michigan.

There are no Special Plants or Animals known from this marsh.

20. **Arcadia Lake (Manistee Co., CD)** This 270 acre marsh is located 1.7 km (1 mi) south of the village of Arcadia on the eastern shore of Arcadia Lake. It is an estuary on a small stream, Bowens Creek, which flows into Arcadia Lake. Arcadia Lake was a bay of Lake Michigan until it was separated from Lake Michigan by sand spits and dunes. Thick peat deposits have developed at the margins of Arcadia Lake. The presettlement vegetation along the edges of this marsh were described as hardwood and hardwood-conifer swamp. However, much of the marsh was "impassable swamp."

Presently, three natural communities are found in the Arcadia Lake marsh: Submergent Marsh, Emergent Marsh, and Wet Meadow. The Submergent Marsh occupies what was just 50 years ago an Emergent Marsh or Wet Meadow. Presumably, hydrologic impact from the construction of a causeway for Michigan Route 22 backed water up and converted the vegetation to dominance by Myriophyllum sp. Water depth is typically 30 cm (12 in) over a muck substrate that is greater than 3 m (10 ft). The Emergent Marsh is presently dominated by Leersia oryzoides and Scirpus validus on shallowly inundated muck 0.6-2.6 m (2-8.5 ft) thick. The Wet Meadow is highly variable in composition due to recovery from high water levels in 1987 and 1988. It occupies saturated mucks 40-60 cm (1.5-2.0 ft) thick.

This site was owned, in 1986, by: Milard Brooks; R.L. Peitz, et al.; Grebe Company; John C. Miller; M.M. Arthur, etux.; V. Organ; and a number

of small, ambiguous holdings. Much of the Submergent Marsh lies in public waters under the jurisdiction of the State of Michigan.

Zizania aquatica var. aquatica (wild rice, state threatened) was found in this marsh; this is one of the northern-most known occurrences of this species in Michigan. No other Special Plants or Animals are known.

21. Betsie River (Benzie Co., C) This 100 acre marsh is located 2 km (1.25 mi) east southeast of the village of Elberta and 4 km (2.5 mi) southeast of the city of Frankfort. This estuary is located where the Betsie River flows into Betsie Lake. Betsie Lake was originally an embayment of Lake Michigan before it was separated from Lake Michigan by sand spits and dunes. The presettlement vegetation of this marsh was described as a conifer swamp with part of the Section 34/35 common line a "lake."

Presently, five natural communities are found in the Betsie River marsh: Treed Swamp, Shrub Swamp, Wet Meadow, Emergent Marsh, as well as Submergent Marsh in meanders of the river. The Treed Swamp was not sampled, but was a mosaic of logged hardwood and conifer swamp with a rich understory resulting from opening of the canopy. The Shrub Swamp was dominated by colonies of Alnus rugosa with Carex pseudo-cyperus as the dominant herb. It occupied saturated mucks, 91-167 cm (3.0-5.5 ft) thick. The Wet Meadow was dominated by Calamagrostis canadensis with Carex stricta an important associate. It occupied saturated muck from 46-122 cm (1.5-4.0 ft) thick. The Emergent Marsh was confined to the river margins and was early successional and variable in species composition. The muck or stratified muck/sand soils were shallowly inundated and up to 137 cm (4.5 ft) thick. Sand substrate was also present. The Submergent Marsh was

confined to the backwaters of the Betsie River. The dominant vegetation was Myriophyllum verticillata with Potemogeton pectinatus an associate.

This site lies within the Betsie River State Game Area and is administered by the Wildlife Division of the Michigan Department of Natural Resources.

Cirsium pitcheri (Pitcher's thistle, state and federally threatened) has been reported from this marsh. No other Special Plants or Animals are known.

22. **Petobego Pond (Grand Traverse Co., AB)** This 110 acre marsh is located 18 km (11 mi) northeast of Traverse City. It is representative of a large interdunal swale located where Tobeco Creek flows into Lake Michigan. The presettlement vegetation of this marsh was described as a "lake" with "marshy" shores.

Presently, three natural communities are found in Petobego Pond: Submergent Marsh, Emergent Marsh, and a Wet Meadow/Northern Fen mosaic. The Wet Meadow/Northern Fen mosaic was dominated by either a) Carex lasiocarpa and Calamagrostis canadensis, growing on an average of 23 cm (9 in) of dry to saturated muck over sand, or b) Eleocharis elliptica, Scirpus americana, and Cladium mariscoides on marly sand and marl. Some areas of the former contained dead stalks of Typha Xglauca, indicating recovery after high lake levels killed Emergent Marsh vegetation. The intact Emergent Marsh areas were dominated by T. Xglauca and Impatiens biflora over 10-25 cm (4-10 in) of saturated muck. The Submergent Marsh was dominated by Nuphar varigata, Chara globularia, and Najas flexilis, in 30-60 cm (12-24 in) of water over 30-60 cm (12-24 in) of muck.

This site lies within the Petobago State Game Area and is administered

by the Wildlife Division of the Michigan Department of Natural Resources. One private inholding was owned, in 1987, by John Pulcipher, et al.

Bald eagle (state and federally threatened) has been reported from this marsh, but was not seen during the field survey. No other Special Animals or Plants are known. There is potential for both Cirsium pitcherii and Tanacetum huronense on the dune side of the marsh.

23. Waugoshance Point (Emmet Co., A-AB) This 650 acre marsh is located 22 km (13 mi) west southwest of Mackinaw City. The marsh is located in a shallow bay heavily impacted by storm waves. The presettlement vegetation of this marsh was not described. Presently, three natural communities are found here: Cobble Beach and Emergent Marsh, and Submergent Marsh. Due to the broad, slightly dipping landscape of Waugoshance Point, changes in the water level of Lake Michigan results in dramatic changes in the shoreline and the dynamic re-configurations of the natural communities. No attempt was made to delineate natural community boundaries since any such map would represent only a snapshot in time with a low probability of reoccurrence. Nevertheless, a generalized description of the three communities can be given. The Cobble Beach was characterized by a dry substrate of large cobbles mixed with sand and gravel and lacking a surface horizon of organic matter. The plant composition is highly variable and early successional, with six species of nearly equal importance: Carex viridula, Cladium mariscoides, Lobelia kalmii, Potentilla fruticosa, Panicum lindheimeri, and Satureja arkansana. The Emergent Marsh was characterized by a water depth of 2-46 cm (1-18 in) over a thin organic layer. The vegetation was sparse with the predominate plant being Scirpus acutus.

The north edge of the site fronts a long Open Dune, Interdunal Wetland, and Sand/Gravel Beach complex. This area was excluded from the Great Lakes Marsh acreage. Small inclusions of Boreal Forest throughout this area were likewise excluded.

Much of this site lies in public waters under the jurisdiction of the State of Michigan. The remainder is part of Wilderness State Park, administered by the Parks Division of the Michigan Department of Natural Resources. This entire area has been designated as the Wilderness Environmental Area by the Shorelands Protection Program. It is also a pending state Natural Area.

Numerous Special Plants are known from this site, many of which were seen during the field survey. These include Bromus pumpellianus (Pumpell's bromegrass, state threatened), Pinguicula vulgaris (butterwort, state special concerned), Solidago houghtonii (Houghton's goldenrod, state and federally threatened), Tanacetum huronense (Lake Huron tansy, state threatened), Cirsium pitcheri (Pitcher's thistle, state and federally threatened), and Calypso bulbosa (Calypso, state threatened). One special animal, Piping Plover (state and federally endangered), is also known from here. No other Special Plants or Animals were found in this survey.

24. Cecil Bay (Emmet Co., B-D) This 135 acre marsh is located 8 km (5 mi) southwest of Mackinaw City. It is a relatively narrow marsh located in a large, shallow bay. The substrate is clay overlain by a thin veneer of sand near the shoreline. Although the marsh was called Cecil Bay, Cecil Bay has no good Emergent Marsh, based on our 1989 sampling. A nearby Emergent Marsh in Trails End Bay, to the east, has been sampled annually for more than 10 years by Dr. Voss' students from the University of

Michigan's Biological Station. This marsh, typically called Cecil Bay marsh, is discussed below, following a discussion of the 1989 sampling.

Presently, three natural communities are found at this site: Emergent Marsh, Wet Meadow, and Treed Swamp (Rich Conifer Swamp). Treed Swamp is excluded from acreage figures. Wilderness Park Drive, built right along the shoreline of portions of the bay, separates Rich Conifer Swamp and Wet Meadow from the Emergent Marsh. Iris lacustris (dwarf lake iris) occurs in the highway right-of-way, where it may be adversely impacted by grading and mowing. Sampling was done from near the road in Rich Conifer Swamp, through Interdunal Wetlands, into the unaltered Emergent Marsh.

Seventy nine species were noted in the 1989 sampling transect. Most of these were actually from near the junction of the road with the wetland, and there are therefore many "weedy" species. The Emergent Marsh contained nothing but Chara sp. (stonewort). This lack of typical Emergent vegetation may be the result of heavy wave scour in recent high-water years.

The transect sampled by Voss' students in Trails End Bay is typical of those found in relatively unprotected bays. The dominant along most of the transect is Scirpus acutus (hardstem bulrush), with Eleocharis smallii and Scirpus americanus (threesquare). The substrate of most of the Emergent zone is clay with a thin veneer of sand at the surface. In sheltered, shallow water where the rhizome mat is 3-8 cm (1-3 in) thick over clay, Equisetum fluviatile (horsetail) is common. In the deeper water, where wave scour is severe, clay is exposed at the surface, and only scattered stems of Scirpus americanus are present. In 1980, emergent vegetation continued to a water depth of 75 cm (30 in); in a high-water year, such as

1986, the emergent vegetation would probably have been growing in 150 cm (60 in) of water. The greatest amount of variation in this regularly sampled transect is near the road, where soil is exposed or only shallowly covered with water. In dry years, sedges, such as Carex stricta and Carex aquatilis are common, along with Calamagrostis canadensis (blue-joint grass) and other quickly establishing seedlings of herbs and trees. In wet years the diversity of species near the road is greatly reduced.

Much of the area lies in public waters under the jurisdiction of the State of Michigan. Large areas of wetland south of Wilderness Park Drive are also under State of Michigan management.

A number of Special Plants are known from this site, some which were seen during the field survey. These include Iris lacustris (dwarf lake iris, state and federally threatened), Cirsium pitcheri (Pitcher's thistle, state and federally threatened), Tanacetum huronense (Lake Huron tansy, state threatened), Cypripedium arietinum (Ram's head lady-slipper, state special concern), and Calypso bulbosa (Calypso, state threatened). A Special Animal, the Grizzled skipper (state special concern), also occurs in the general area.

25. Epoufette Bay (Mackinac Co., B-D) This 130 acre marsh, located on the north shore of Lake Michigan, is designated as the Epoufette Environmental Area by the Shorelands Protection Program. The marsh is subject to wave activity from Lake Michigan, which probably accounts for the eroded nature of the marsh. Small islands present just off-shore were visible in the 1978 aerial photos; these same islands were not visible on the 1986 aerial photos, probably due to erosion during this high-water period. The substrate of the marsh was primarily sand, probably deposited

over the underlying clay (which is at the surface in nearby Kenyon Bay) by nearshore currents of Lake Michigan.

The sequence of natural communities encountered in the sampling transect was Rich Conifer Swamp, Shrub Swamp, Wet Meadow, Emergent Marsh, Submergent Marsh, and finally Emergent Marsh again, as we came onto a small island within the marsh. The Rich Conifer Swamp zone is broad, occupying most of the narrow peninsula. The Shrub Swamp and Wet Meadow zones are quite narrow. The Emergent zone is relatively broad, but low in diversity due to recent high water levels.

The Shrub Swamp is dominated by Alnus rugosa (speckled alder), Myrica gale (sweet gale), Potentilla fruticosa (shrubby cinquefoil), Salix pedicellaris (willow), and small trees. Many of the trees had been killed by high water. The dominant grasses and sedges of the Wet Meadow were also common in the Shrub Swamp. These included Calamagrostis canadensis (blue-joint grass), Carex stricta (sedge), and Carex viridula. Other species common in this zone include Campanula aparinoides (marsh bellflower), Lysimachia terrestris (loosestrife), and Potentilla palustris (swamp cinquefoil). A broad swath of dead bulrush stems formed a storm beach between the Wet Meadow and Emergent Marsh zone.

The present water line within the marsh begins nearly 20 m (66 ft) beyond the beginning of the typical Emergent Marsh vegetation. The Emergent Marsh is dominated by Scirpus acutus (hardstem bulrush), but also contains Scirpus americanus (threesquare), Chara sp. (stonewort), and Juncus tenuis (rush). Portions of the hardstem bulrush beds have been killed by wave erosion; only the dead rhizomes remain in the first and second sampling points of the Emergent zone. Species found in both the

Emergent Marsh and the Submergent Marsh zones include Chara sp., Nuphar variegata (spatterdock), Polygonum amphibium (water smartweed), and Potamogeton gramineus (pondweed). The marsh substrate and its vegetation both showed signs of wave erosion.

Two Special Plants are found near the marsh, Mimulus glabratus var. michiganensis (Michigan monkey-flower, state threatened and federal candidate for threatened) and Tanacetum huronense (Huron tansy, state threatened). Diversity within the marsh is not high (38 species), probably due to the heavy erosion to which the marsh is regularly subjected. Human disturbance is concentrated at the south end of the marsh, where the Frazier Fish Corporation has built a dike and dredged channels for their boats. Although the marsh is small and not botanically exciting, it is one of the more picturesque marshes in Michigan. It is viewed daily by hundreds of motorists from the U.S. 2 overlook.

The west end of Epoufette Bay is partially in State of Michigan ownership (Section 5) and partially privately owned by the Frazier Fish Corp. (Section 9). The west end is the least disturbed portion of the marsh. The north end of the bay, where the marsh is not well developed, is under multiple small ownerships.

26. Kenyon Bay (Mackinac Co., B) This small marsh, only approximately 100 acres in area, is very similar to its neighbor, Epoufette Bay marsh. With its mouth oriented toward the southwest, it is subject to even more intense erosional forces than Epoufette Bay. This heavy erosion is reflected in its low species diversity, only 28 species in the Wet Meadow, Emergent Marsh, and Submergent Marsh zones. One small island at the mouth of the bay was completely eroded by high water levels and

accompanying wave erosion, while a second was greatly reduced in size. The substrate of the marsh is clay in the center of the bay, which forms a cloudy suspension when there are waves. There are gravel bars within the bay, and rocks are common near the shoreline.

The broadest zone within the marsh is the Submergent zone, which is dominated by a 280 m (920 ft) wide, relatively dense bed of Myriophyllum verticillatum (water-milfoil) and Nuphar variegatum (spatterdock), with scattered Sagittaria graminea (arrow-head). Water depths in the Submergent zone is approximately 122 cm (48 in). Interestingly enough, water depth in the Emergent Marsh was deeper, 137 cm (54 in). Scirpus acutus (hardstem bulrush) is common in the Emergent zone; Eleocharis smallii (spike-rush) is occasional. Due to the small size of the marsh and the low species diversity, we do not consider the marsh high priority for acquisition for the purpose of natural area protection. Human disturbance within the marsh is low, with some small boat docking near its southeast end. Boat use does not appear to be degrading the vegetation. The marsh is under two ownerships, Helen Stevens and T. A. Weish.

Lake Superior

27. Grand Island (Alger Co., A) This 120 acre marsh is located at the north end of Murray Bay, on the margin of a tombolo which formed between Grand Island and what was once a smaller island to the east. The tombolo is formed of a series of parallel, arcuate sand bars which joins the two upland areas. Between the sand bars are swales. Near the present shoreline these swales contain up to 76 cm (30 in) of water; as one progresses inland across the tombolo, the water depth becomes shallower and eventually the swales are merely saturated. The saturated swales have

organic soils which were under 61 cm (24 in) in depth. The marsh is diverse; 67 species were recorded on the transect.

The Wet Meadow zone is about 180 m (590 ft) wide. Further to the north it becomes Shrub Swamp and finally Poor Conifer Swamp. There are approximately 240 acres of swamp forest adjacent to the marsh. The northern 200-300 m (656-985 ft) of the tombolo are dry beach ridges supporting upland conifers. A low shrub-dominated foredune separates the Wet Meadow zone from the Emergent Marsh in shallow Murray Bay. The Emergent zone extends approximately 220 m (721 ft) into the bay, where water depth was about 106 cm (42 in).

The Wet Meadow zone is dominated by Carex lasiocarpa (sedge), Carex stricta, and Dulichium arundinacea (sedge); Calamagrostis canadensis (blue-joint grass) is common but not a dominant. Chamaedaphne calyculata (leatherleaf), Alnus rugosa (speckled alder), and Myrica gale (sweet gale) are common shrubs within the meadow. The Wet Meadow is diverse; its species might best be considered characteristic of a Poor Fen. It is one of the few wetlands sampled along Lake Superior which is not dominated by Sphagnum species in at least some zones. Sphagnum was encountered in the first sampling plot, that is, the plot furthest from the water of the bay. If we had continued to the far northern edge of the Wet Meadow zone, where groundwater influence would be expected to be least, we might have encountered greater amounts of Sphagnum. Within the Wet Meadow zone were regularly occurring beach ridges, dominated by Gaylussacia baccata (huckleberry), Chamaedaphne calyculata, and scattered white and red pines.

The Emergent Marsh zone of the marsh was interesting; it was dominated by Eleocharis smallii (spike-rush), and was probably the only Emergent zone

sampled in the Upper Peninsula which contained no Scirpus acutus. The other dominants, Isoetes sp. (quillwort), Lobelia dortmanna (lobelia), and Myriophyllum tenellum (water-milfoil), were not common in any of the other marshes sampled.

Natural disturbance was high at the edge of the marsh, where wave action during recent high water levels had locally eroded through the foredune, piling up fallen shrubbery and trees along the water's edge. Organic material from the interdunal swales was also eroded and exposed at the water's edge. No sign of human disturbance was encountered during the survey.

There is a known site for bald eagle (state and federally threatened) along the shoreline near the marsh. This is a high priority marsh for protection due to its unusual, diverse flora and low levels of human disturbance.

The entire marsh, located in Sections 11 and 14, is owned by Cliffs Forest Products Co.

28. Independence Lake (Marquette Co., B-D) This 320 acre marsh consists of a wetland at the east end of Independence Lake and also graminoid dominated wetlands occupying both an interdunal swale along Lake Superior and the margins of the Iron River. The Squaw Beach Environmental Area, also occupying an interdunal swale, is just to the west of the sampled marsh. Independence Lake was once a bay of Lake Superior, with a mile long island at its center, a mile off shore. Two sets of parallel beach ridges, one from the west and one from the east, have connected the island to the mainland, forming a double tombolo and creating Lake Independence. The Yellow Dog River and two small creeks flow into Lake

Independence, and the meandering Iron River flows out. The Iron River is very similar in appearance to the Au Train River in Alger County, which flows from Au Train Lake (once a bay of Lake Superior) into Lake Superior through a series of parallel beach ridges. Approximately 1600 acres of Hardwood-Conifer and Conifer Swamp were located along the margins of the marsh.

Sampling was confined to a large, sand-bottomed swale adjacent to the Lake Superior shoreline because of heavy posting of NO TRESPASSING signs by the owners. Aerial photo interpretation of the expansive wetland along the east edge of Independence Lake indicates a bog-like wetland similar to that encountered in the swale. This wetland is probably not unlike that sampled along Lac La Belle in Keweenaw Co.

The vegetation of the large swale is separated from Lake Superior by a steep, lightly forested foredune and a narrow sand beach. The swale is nearly a mile long, ending along the Iron River. The vegetation within the swale is bog-like; herbaceous dominants include Carex lasiocarpa (sedge), Carex lacustris, and several species of Sphagnum moss. Shrubs, including Alnus rugosa (speckled alder), Chamaedaphne calyculata (leatherleaf), Andromeda glaucophylloides (bog rosemary), and Myrica gale (sweet gale), cover much of the wetland surface. Vaccinium macrocarpon (cranberry) is common throughout most of the swale. Red maple swamp begins at the south margin of the swale. Within the swale a low beach ridge is exposed. While there is shallow peat, 15-107 cm (6-42 in) thick, over most of the swale's surface, only a thin coating of live Sphagnum moss covers the sands of the low beach ridge. Chamaedaphne, Andromeda, and Sphagnum magellanicum are densest on the beach ridge.

Human disturbance is limited to the upland beach ridges and the shore of Lake Independence, where a small community has developed. A low dam maintains Lake Independence at 190.6 feet, which probably has some impact upon the wetland at the lake's east end, where logging has occurred.

There are nearby nesting sites for both bald eagle (state and federally threatened) and osprey (state and federally threatened). Plant diversity is relatively low, as expected in a Bog or bog-like wetland. Due to the concentration of residences and artificial control of the lake level, the wetlands are not being recommended for purchase.

The marsh at the east end of Independence Lake is owned by the State of Michigan (Escanaba River State Forest), Fred R. Walsh, et al., and small owners. The marshes located in swales along Lake Superior and along the Iron River are owned by Beatrice H. Touton.

29. Lac La Belle (Keweenaw Co., A) This 500 acre wetland, located at the east end of Lac La Belle, is separated from Lake Superior by several beach ridges. Lac La Belle was originally an embayment of Lake Superior, much like Lake Independence (Marquette Co.) and Au Train Lake (Alger Co.). The wetland is separated from Lake Superior by only a few 100 m at the north and south edges of the old embayment. Similar to Lower Herring and Upper Herring Lakes in Benzie County, Deer Lake and Lac La Belle were once part of the same large Great-Lakes embayment. Post-glacial uplift and lowering Great Lakes water levels have separated these lakes from Lake Superior.

Most of the wetland at the east end of Lac La Belle is bog-like, but a narrow zone of Emergent Marsh is found at the edge of Lac La Belle and in the shallow waters of the river draining Lac La Belle into Lake Superior.

The substrate under most of the wetland is sand, with up to 1.2 m (4 ft) of overlying peat. Gravel was encountered at two points, where the peat depth was the greatest, possibly at points where the original lake bottom was encountered, rather than one of the beach ridges. As one moved further from the lake edge the amount of shrubs and trees increased. The dominants of this Poor Conifer Swamp/Bog, which accounted for an additional 2300 acres, were northern white-cedar, tamarack, and black spruce.

The dominant herbaceous species were mosses, including Sphagnum pappillosum (golden sphagnum), Sphagnum magellanicum, and several other species of Sphagnum. Other dominants included Carex oligosperma (sedge) and Rhynchospora alba (beak-rush). Vaccinium macrocarpon (cranberry) and Aster nemoralis (bog aster) were common, as were Myrica gale (sweet gale) and Pogonia ophioglossoides (fringed pogonia).

The narrow Emergent Marsh contained Eleocharis smallii (spike-rush), Scirpus subterminalis, and several other emergent and submergent species. At the water's edge there was also a thin band of Calamagrostis canadensis (blue-joint grass) and Carex stricta (sedge).

At the edge of Lac La Belle, the Submergent Marsh consisted of scattered Isoetes sp. (quillwort), Scirpus subterminalis, and Sagittaria graninea (arrow-head) growing on 60-107 cm (24-42 in) of organic material over sand. At the mouth of the river, where the water was 60-137 cm (24-54 in) deep, there was no organic material over the sand substrate. The vegetation consisted of a dense bed of Myriophyllum heterophyllum, Nuphar variegatum (spatterdock), Scirpus subterminalis, and several species of Potamogeton (pondweed).

The major human disturbance within the wetland is the channel between

Lac La Belle and Lake Superior. These channel has probably had minimal impact upon the plant community, as the river joined the two water bodies prior to construction of the channel. The road, which runs across the edge of the wetland in part and upon upland beach ridges in part, does not appear to have greatly altered the wetland.

Known special plants from the marsh include Aster nemoralis (bog aster, state special concern) and Epilobium palustre (marsh willow-herb, state special concern). The wetland is worthy of protection because of its diverse flora, special plants, and lack of severe human disturbance.

The marsh along the eastern end of Lac La Belle is owned by the Lake Superior Land Company, with a parcel in Section 4 owned by Gene and Maryellen Arnsten.

DISCUSSION AND RECOMMENDATIONS

Response of Marsh Vegetation to High Water Levels

The importance of coastal marshes and their resiliency in response to high water levels was discussed in the 1987 Survey of Great Lakes Marshes in Michigan's Upper Peninsula (MNFI 1987). During the 1987 survey, it was noted that portions of the marshes which had suffered heavy erosion during the high water levels of 1986 were already beginning to be recolonized in the summer of 1987, when the water levels had just begun to drop. The 1988 surveys served to further demonstrate the resiliency of coastal marshes to high water levels. Signs of erosion resulting from high water levels were still evident in most of the marshes sampled in 1988, but recolonization, primarily by native vegetation, was occurring in all zones of the marsh. The greatest amount of erosion typically occurred at the high water beach line, where both beach ridges and thick organic deposits were eroded away by wave and current action. In both cases revegetation was swift as the water level dropped, indicating that the buried seeds of typical heavily-fruiting annual aquatics (Keddy and Reznicek, 1986) or densely rhizomatous perennial aquatics recolonized relatively rapidly after a drop in water level. The colonizers included Eleocharis acicularis (spike-rush), Eleocharis obtusa, Rorippa palustris (yellow cress), Juncus dudleyi (rush), Verbena hastata (vervain), Rumex maritima (dock), Bidens cernua (beggar-tick), Boehmeria cylindrica (false nettle), and many others.

Changes in the vegetation of the offshore portions of the Emergent Marsh zone also occurred due to high water levels. In 1988, species of the Emergent Marsh zone typically grew in water less than 90 cm (36 in) in

depth. In contrast, during 1987, when water levels were higher, the emergent species were typically growing in water as deep as 150 cm (60 in). It appears that during high water levels the emergent vegetation in deep water begins to die, both because of the reduced amount of available oxygen and because increased wave action breaks the stems and erodes the rhizomes. When water levels drop there is a lag time before the emergent vegetation expands outward into deeper water. By the summer of 1988, the emergent vegetation had not yet had time to recover from the high water years of 1986 and 1987, and was only found in up to 90 cm (36 in) of water. During 1989 sampling, emergent vegetation was found in deeper water (137 cm or 54 in deep in Kenyon Bay). Two species with limited vertical growth potential, Eleocharis smallii (Small's spike-rush) and Equisetum fluviatile (horsetail), were found in greater numbers during 1988 and 1989 than in 1987 due to shallower waters.

The location of muskrat houses, common within the Great Lakes marshes surveyed, also changed as a result of water level changes. In the marshes sampled in 1987, muskrat houses were located in 30-60 cm (12-24 in) deep water among emergent vegetation, typically cat-tails or bulrushes. Upon returning to sample two marshes in 1988, it was found that the houses, which were above the water level at the time of the revisit, had been abandoned and new houses had been constructed further from shore in shallow water. Thus, with changing lake levels, new openings are continually being made by muskrats in the Emergent Marsh beds.

Natural Community Composition

Major vegetational differences between the marshes in the Upper Peninsula and southern Lower Peninsula were evident in some of the natural

community zones. The Emergent Marshes in the southern Lower Peninsula were dominated by Scirpus validus and S. americanus, while S. acutus was much more common in northern Lower Michigan and Upper Michigan. Eleocharis smallii and Cladium mariscoides were also more common in the Upper Peninsula. Diversity of Potamogeton spp. appears to be higher in coastal marshes of the Upper Peninsula than those surveyed in the Lower Peninsula during 1988.

At the beach line, the muddy zone of the Emergent Marsh on Lake Erie supported Sagittaria montevidensis, a State Threatened plant. This species is restricted to Lake Erie shorelines in Michigan. Sagittaria graminea was commonly present in this same zone in some Upper Peninsula marshes following the drop in water level.

The Wet Meadow zones of both the northern and southern marshes are very similar. It appears that Bidens cernua, Polygonum lapathifolium, and Rumex maritimus establish commonly on the exposed organic material of the Wet Meadow zone in the southern Lower Peninsula, whereas they are not as common in Upper Michigan.

The estuaries of the two peninsulas differ greatly. Both have thick organic soils, but the vegetation of northern Lower Peninsula and Upper Peninsula estuaries contains many species characteristic of Bogs or Poor Fens. Those of the southern Lower Peninsula are often dominated by dense colonies of Peltandra virginica, a species restricted to southern Michigan. Cephalanthus occidentalis and Decodon verticillata are common shrubs in the southern Michigan estuaries which are absent in the northern Lower Peninsula and Upper Peninsula estuaries, where Alnus rugosa (speckled alder), Chamaedaphne calyculata (leatherleaf), and Myrica gale (sweet gale)

are common.

Human Disturbances

Dike and channel construction caused the greatest amount of marsh alteration in the southern half of Lower Michigan. A large amount of diking and channel construction has been done on State Game Areas, primarily to produce waterfowl habitat. The consequences of this alteration is the destruction of large expanses of natural plant communities. This probably also has severe long-term impacts for waterfowl, as at least two introduced plant species, purple loosestrife and Eurasian water-milfoil, often establish after dredging. Both species form dense monocultures which exclude native plant species. Unfortunately, neither species produces seeds or other edible parts of importance as food for waterfowl. Purple loosestrife, once established, is almost impossible to eradicate.

Dredging has occurred at the mouths of most of the large rivers entering the Great Lakes. The dredging allows the passage of either commercial or recreational ships and boats. The wakes generated by these vessels cause further erosion of both emergent and submergent vegetation. As a result, the best examples of high quality marshes are typically located where water depths are too shallow for pleasure boat or ship traffic.

Diking and dredging were not as common in most of the marshes of northern Lower Michigan and Upper Michigan sampled in 1989. A channel was dredged from Lake Superior to Lac La Belle across the existing river channel, but it did not appear to greatly alter the hydrology of the wetlands.

Dam construction had altered the hydrology of three marshes sampled in 1989, Lake Independence, Tobico, and Big Sable River marshes. Further investigation would be required to determine the full extent of marsh alteration by these dams.

Boat docks and slips were common sources of Emergent Marsh degradation. Single slips created narrow channels through the emergents, with little sign of active degradation along the edges of the channel, as long as boat traffic was restricted to the channel. Marshes sampled in 1989 which had been degraded by small boat slips included Squaw Bay, St. Martin Bay, Big Shoal Cove, Epoufette Bay, and Kenyon Bay. In the vicinity of marinas, or where there were several nearby slips, degradation was more severe, with the potential for complete destruction of the emergent beds.

Highway construction along the edges of Great Lakes' shorelines has also altered marsh hydrology. During highway construction it is common to fill in portions of the marsh, typically resulting in the flooding of portions of the Wet Meadow, Shrub Swamp, or Swamp Forest zones. This occurred at Hessel, St.Martin Bay, Squaw Bay, Cecil Bay, Arcadia Lake, and False Presque Isle.

Natural Area Recommendations

Several marshes sampled are of high natural quality and will be entered in MNFI's database as Natural Community occurrences (Table 1). Among the highest quality of these are El Cajon/Misery Bay, Cheboygan State Park, Carp/Pine Rivers, Voight Bay, Duck Bay, Bar Lake, Petobego Pond, Grand Island, and Lac La Belle. Waugoshance Point, also a high quality marsh, has been previously recognized as an occurrence.

Protection of the highest natural-quality marshes identified in this

survey is integral to conservation of Michigan's natural diversity. Marshes have long been recognized for the diversity of living organisms which they sustain. They also trap and utilize silt and nutrients, slowing the degradation of the Great Lakes. If the perpetuation of Michigan's natural heritage in all its diversity is to be ensured, the best representative marshes from each natural region of the state should be adequately protected. Other, more disturbed marshes are also of importance for their ecological functions and as wildlife habitat.

Protection of marshes as natural areas helps to ensure for future generations the opportunity to experience, appreciate, and learn about the natural landscape and the ecological processes which maintain it and its inhabitants. These marshes serve as scientific resources for study of system functions and for baseline data on relatively natural ecosystems and potentially as monitoring sites for detection and study of environmental degradation. The opportunities to protect high natural-quality marshes continue to decline yearly, especially in more urbanized and developed portions of the Lower Peninsula, making it imperative that we act now to protect this valuable natural resource for future generations.

ACKNOWLEDGEMENTS

Many thanks to Larry "Muck-walk" Brewer, Tim Garlock, Dr. Dan Wujek, and Dr. Ben Stark for their enthusiastic participation in the rigorous field surveys and plant identification. Thanks to the Remote Sensing Lab at Michigan State University for allowing us the use of photos from their photo archives. A final thanks to the landowners who so graciously allowed us to sample on their property or to cross their property to more easily reach the marshes.

LITERATURE CITED

Herdendorf, C. E., C. N. Raphael, and E. Jaworski. 1986. The ecology of Lake St. Clair Wetlands: a community profile. U.S. Fish Wildl. Serv. Biol. Rep. No. 85.

Keddy, P. A. and A. A. Reznicek. 1986. Great Lakes vegetation dynamics: The role of fluctuating water levels and buried seeds. J. of Great Lakes Res. 12(1):25-36. International Association of Great Lakes Research.

Liston, C. R. and C. D. McNabb. 1987. Limnological and fisheries studies of the St. Mary's River, Michigan, in relation to proposed extension of the navigation season, 1982 and 1983. Dept. of Fisheries and Wildlife, Michigan State University, East Lansing, MI.

Michigan Natural Features Inventory. 1986. Draft Description of Michigan Natural Community Types. (Unpublished manuscript, revised 6 March 1986).

Michigan Natural Features Inventory. 1987. Criteria for Determining Natural Quality/Condition Grades and Element Occurrence Size-Classes of Palustrine and Terrestrial Natural Communities in Michigan. (Unpublished manuscript, revised 11 February 1987).

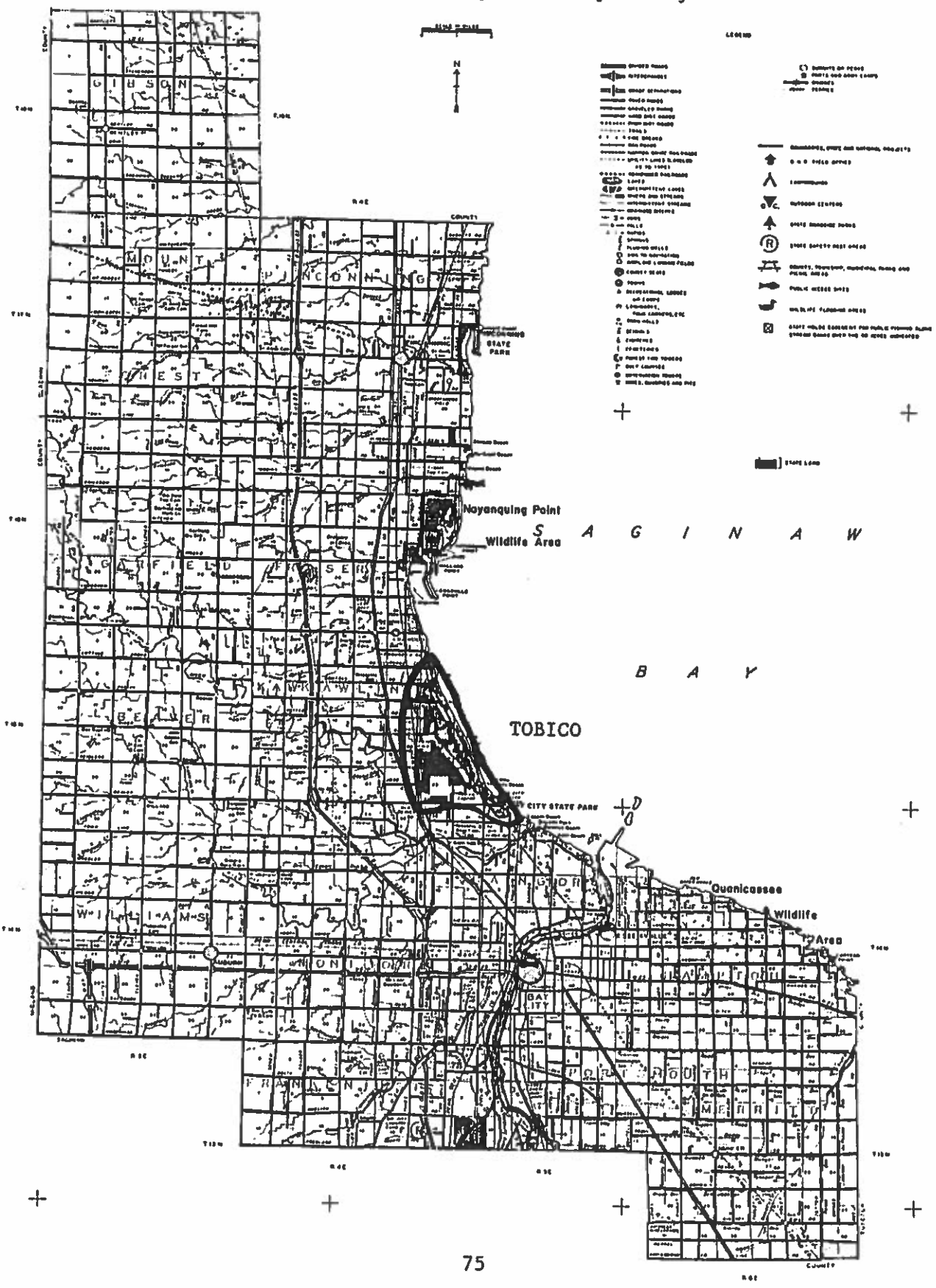
Michigan Natural Features Inventory. 1987. A Survey of Great Lakes Marshes in Michigan's Upper Peninsula. A report for Land and Water Management Division (CZM Grant 9C-10).

Michigan Natural Features Inventory. 1988. A Survey of Great Lakes Marshes in the Southern Half of Michigan's Lower Peninsula. A report for Land and Water Management Division (CZM Grant 9C-10).

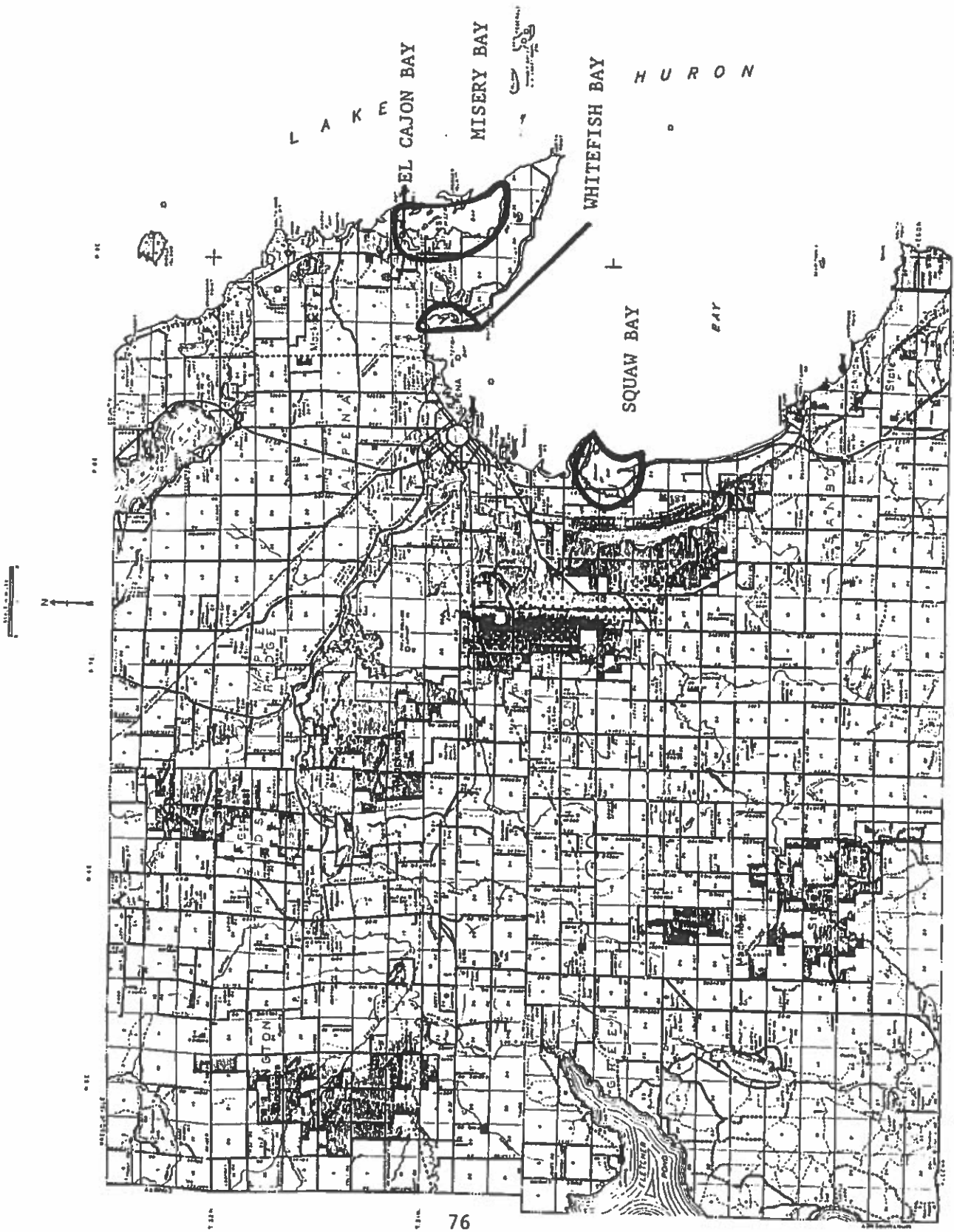
APPENDIX I

LOCATION OF MARSHES SAMPLED

APPENDIX I.1 Great Lakes Marshes sampled in Bay County

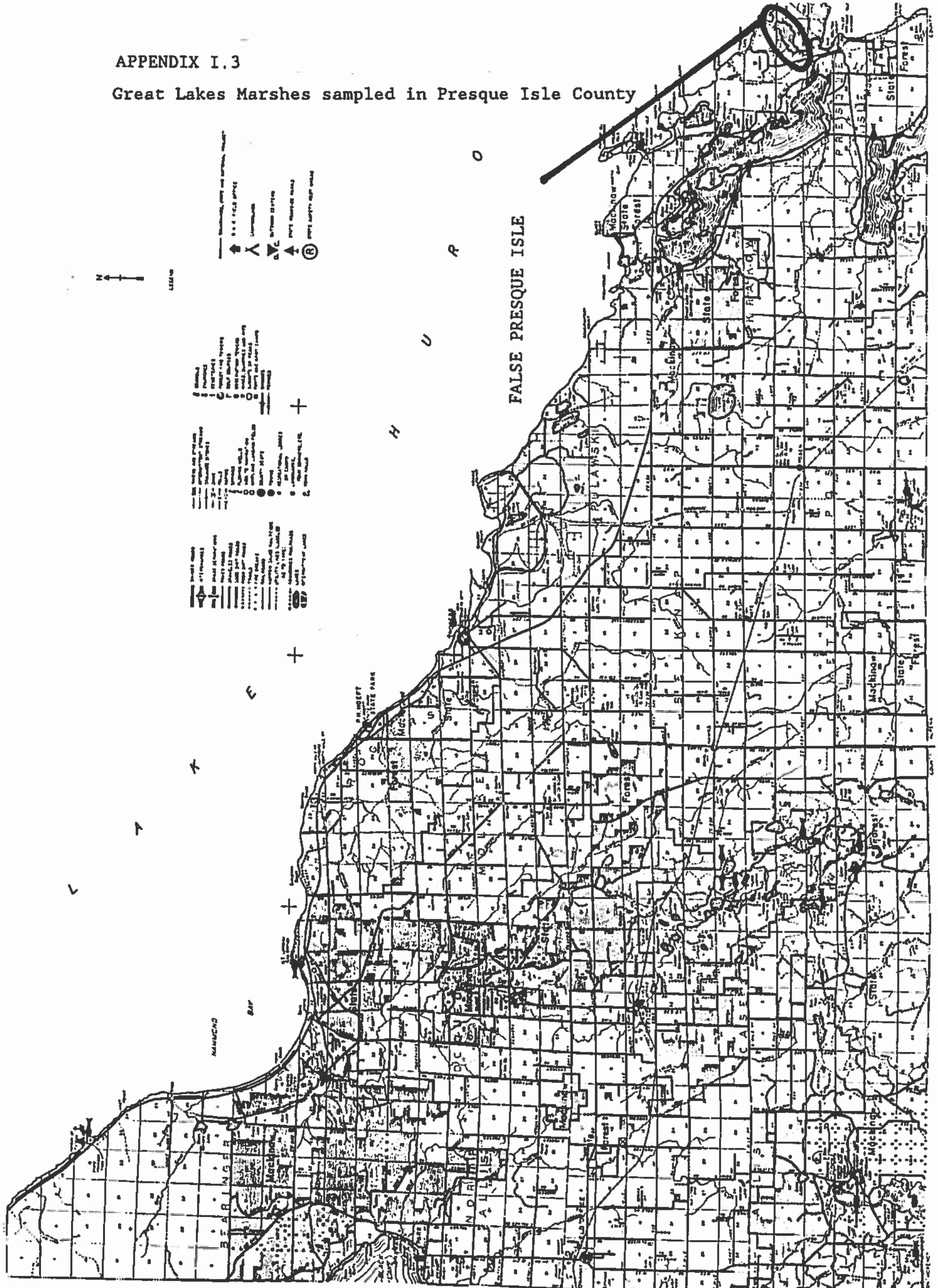


APPENDIX I.2 Great Lakes Marshes sampled in Alpena County

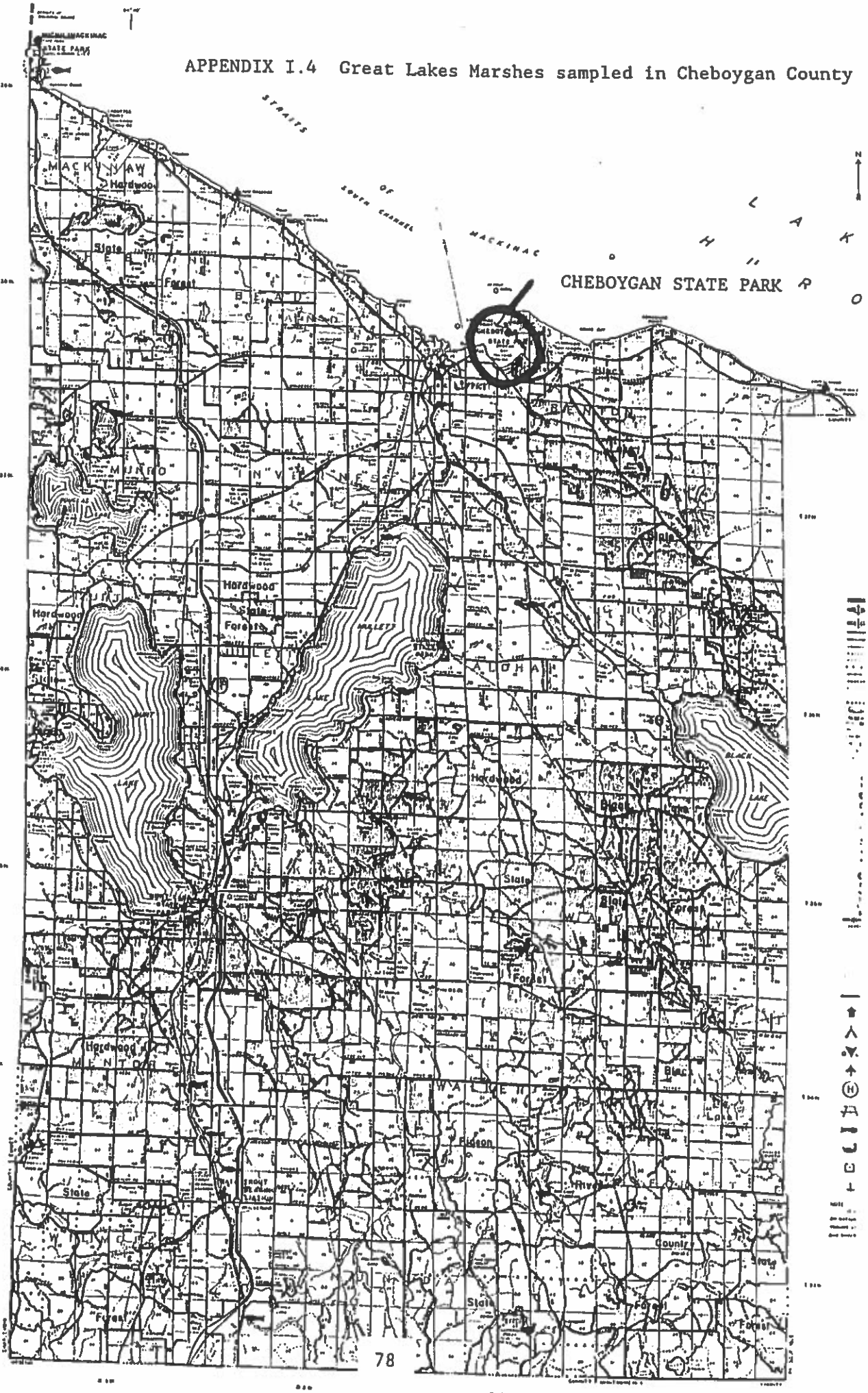


APPENDIX I.3

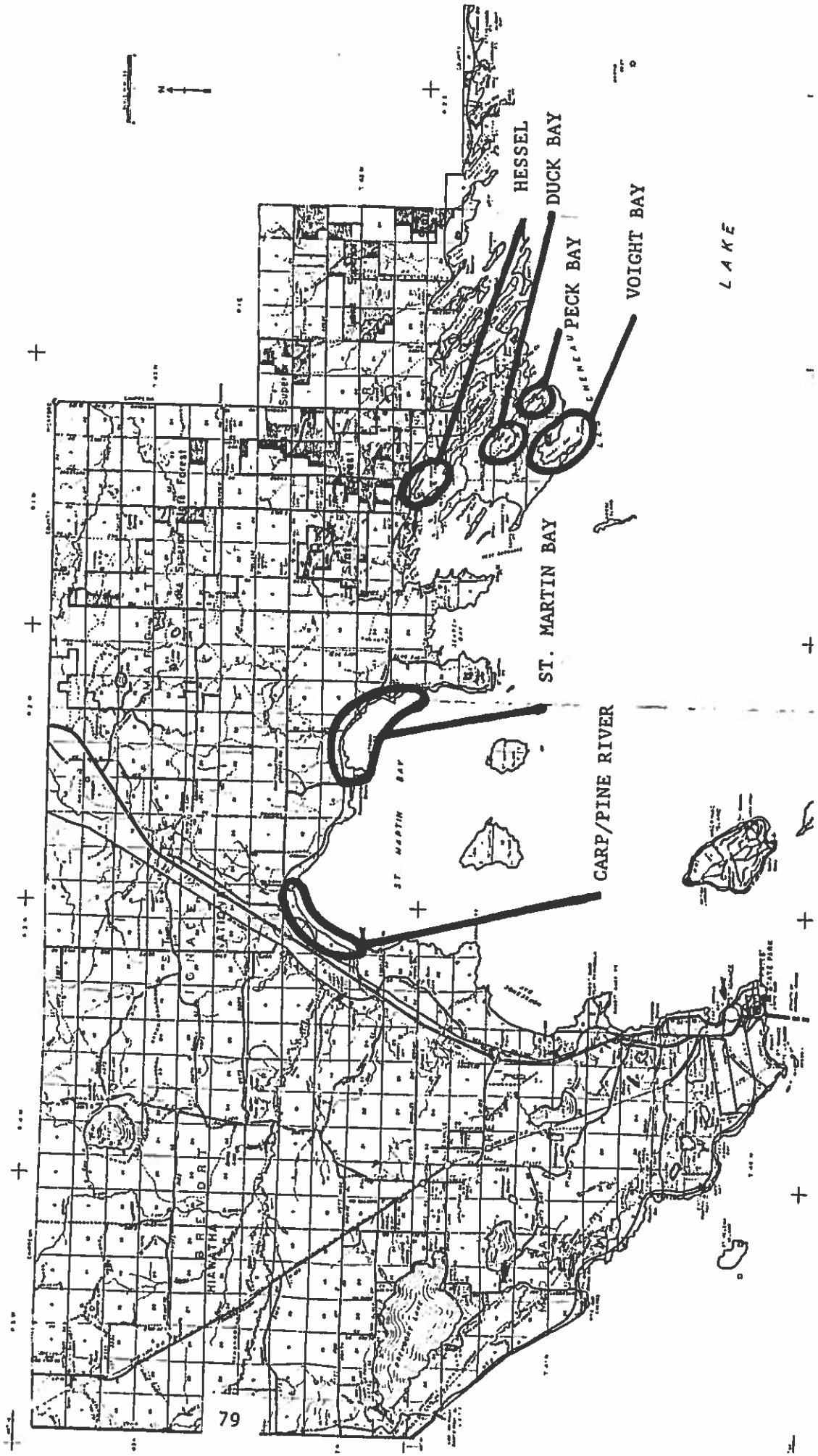
Great Lakes Marshes sampled in Presque Isle County



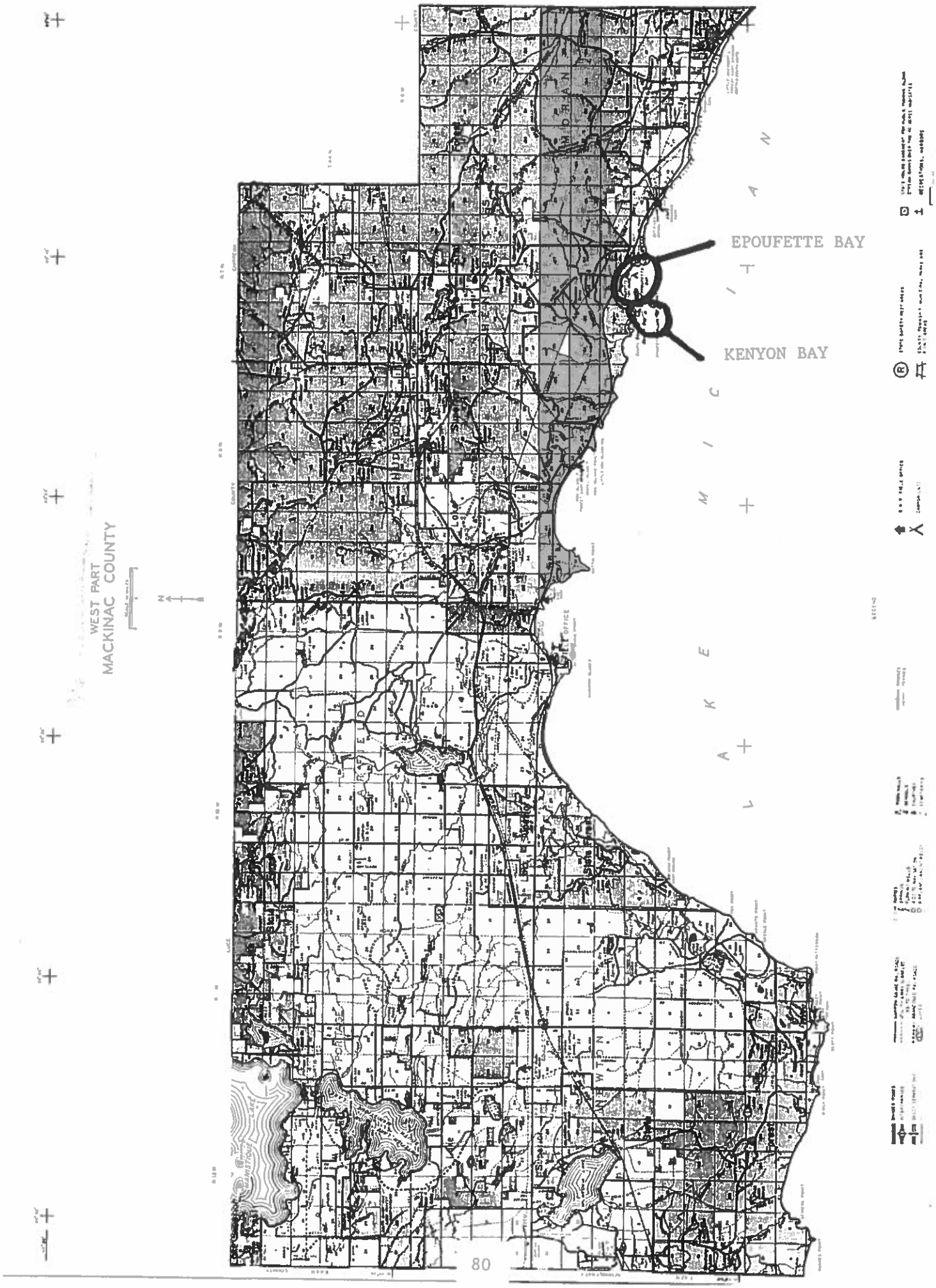
APPENDIX I.4 Great Lakes Marshes sampled in Cheboygan County



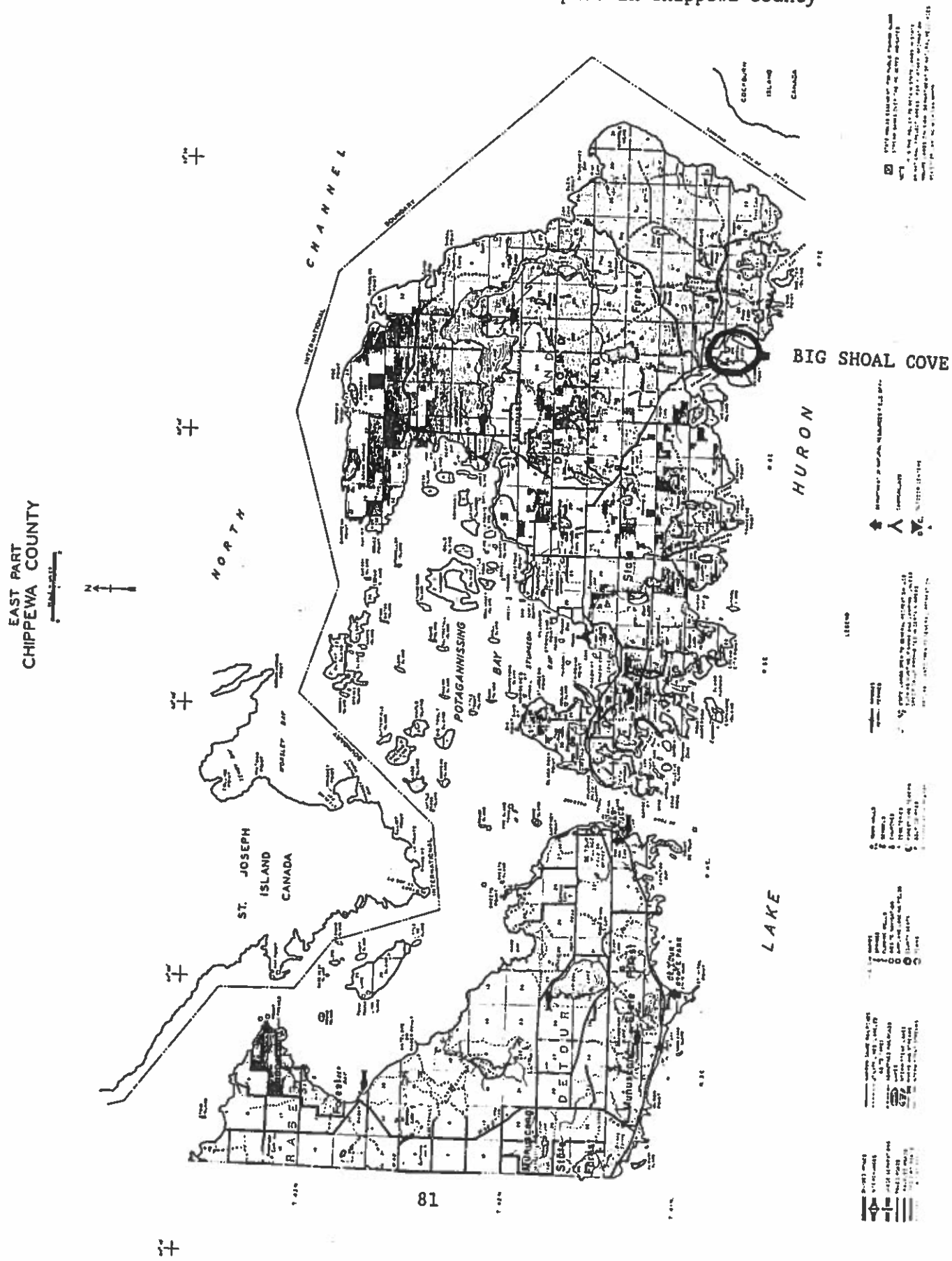
APPENDIX I.5 Great Lakes Marshes sampled in Mackinac County



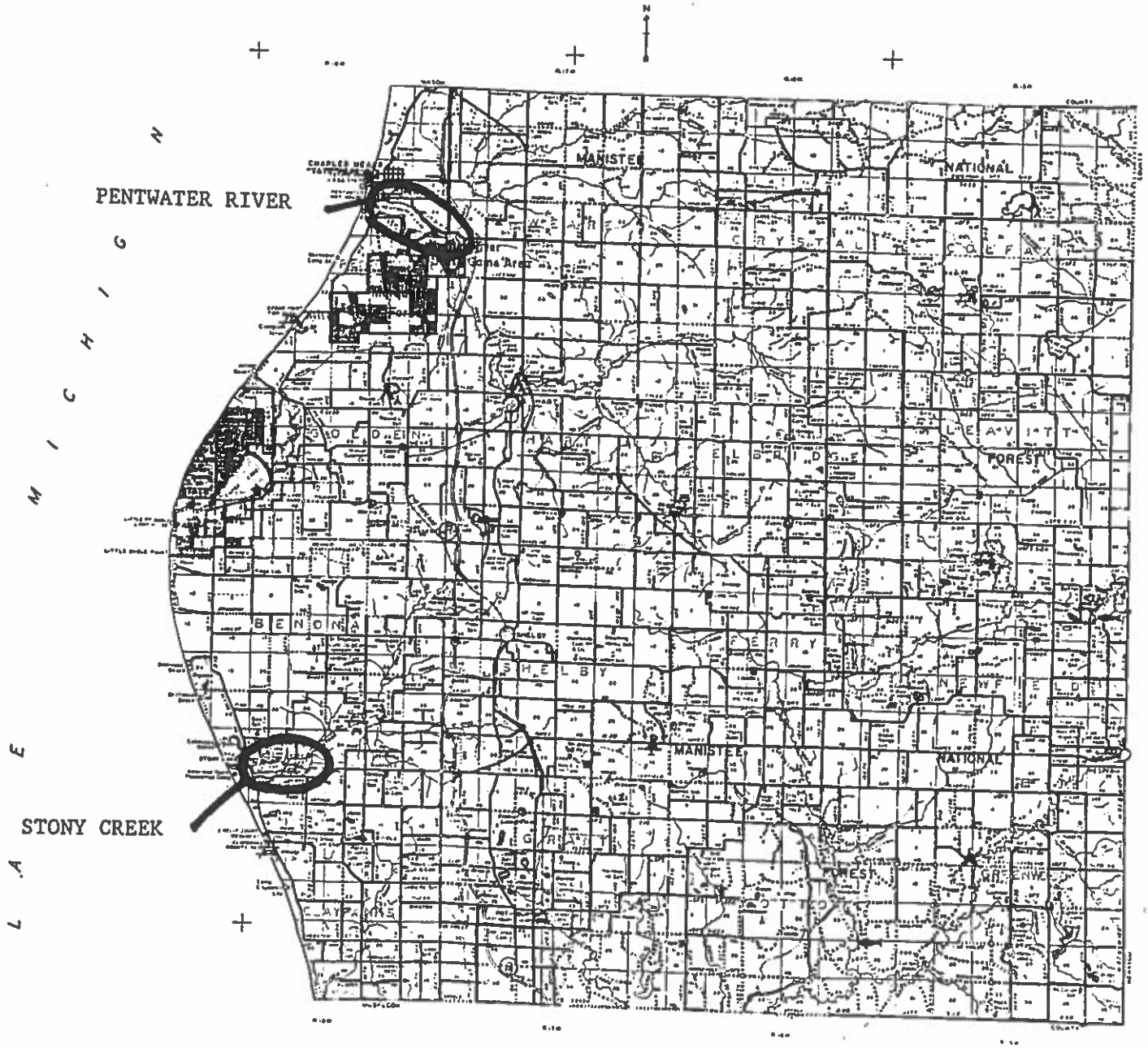
APPENDIX I.5 Great Lakes Marshes sampled in Mackinac County



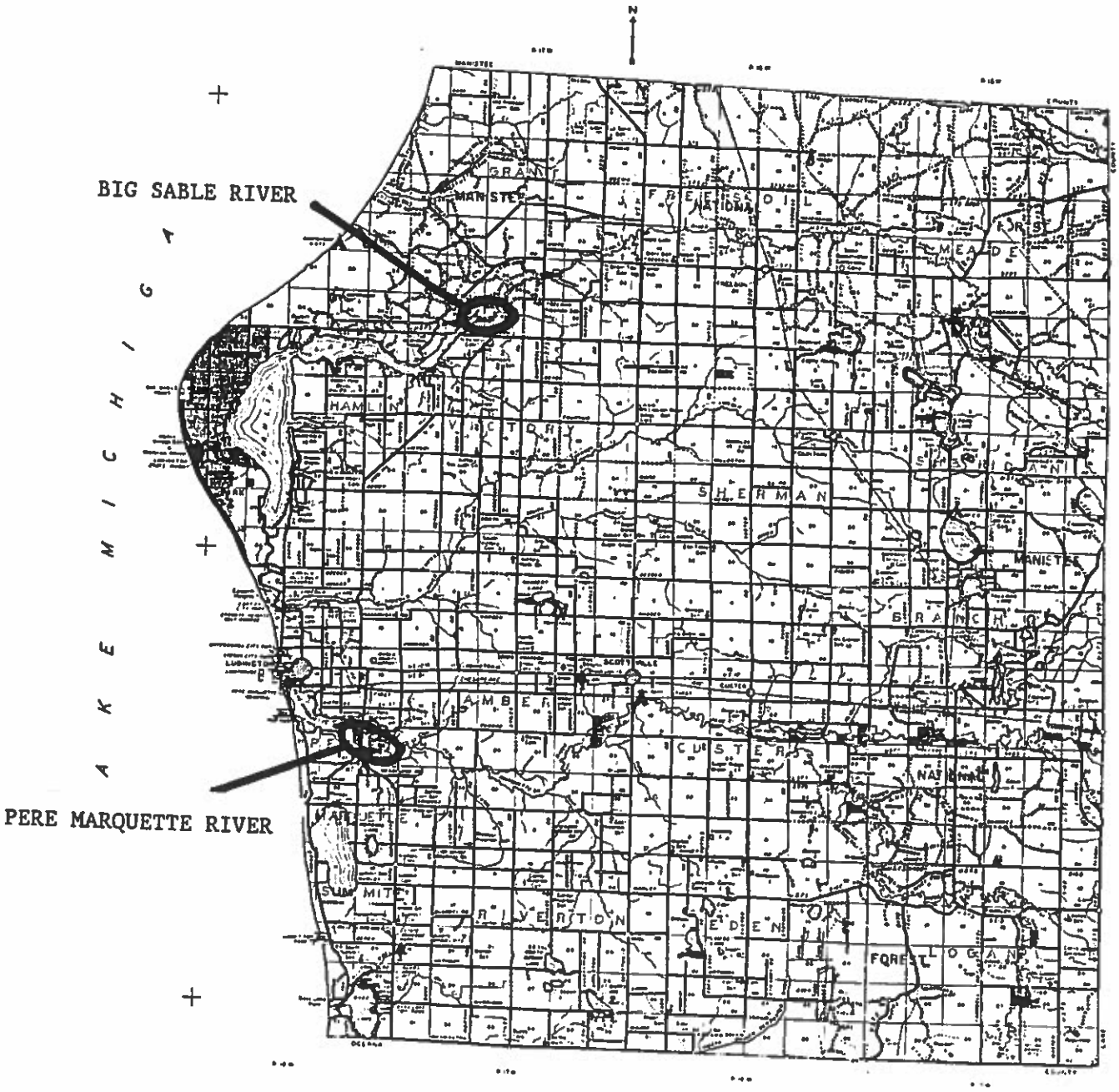
APPENDIX I.6 Great Lakes Marshes sampled in Chippewa County



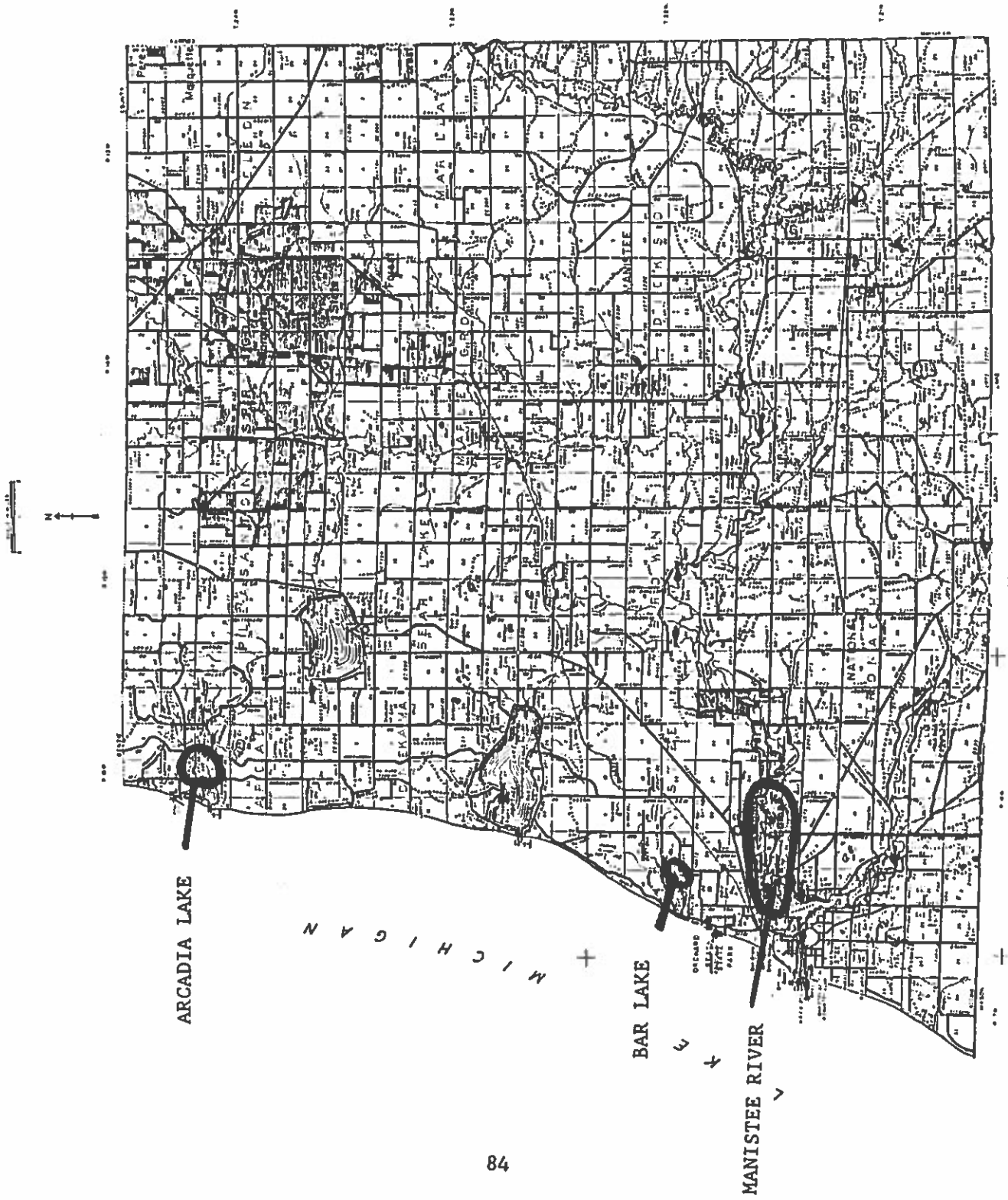
APPENDIX I.7 Great Lakes Marshes sampled in Oceana County



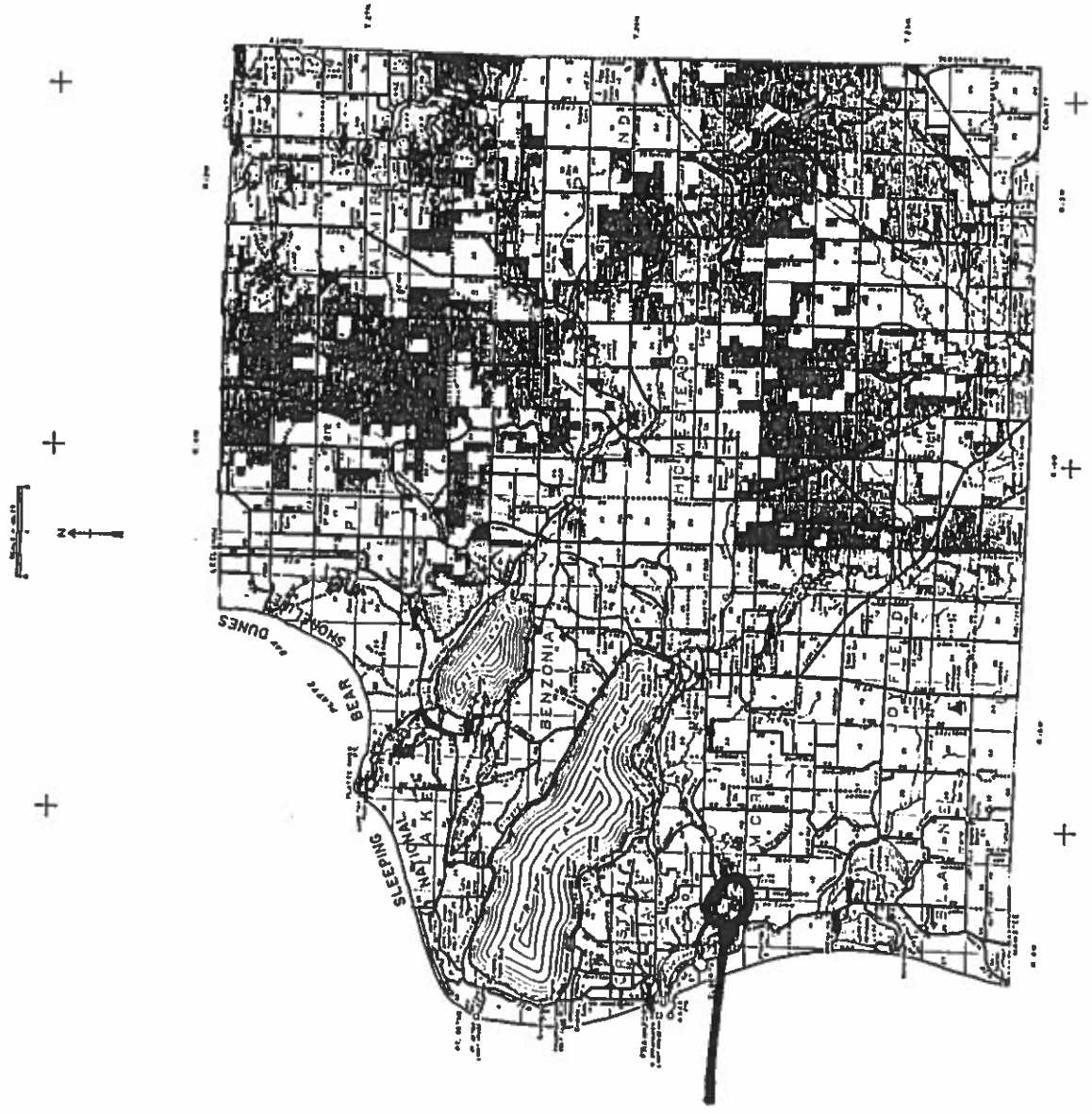
APPENDIX I.8 Great Lakes Marshes sampled in Mason County



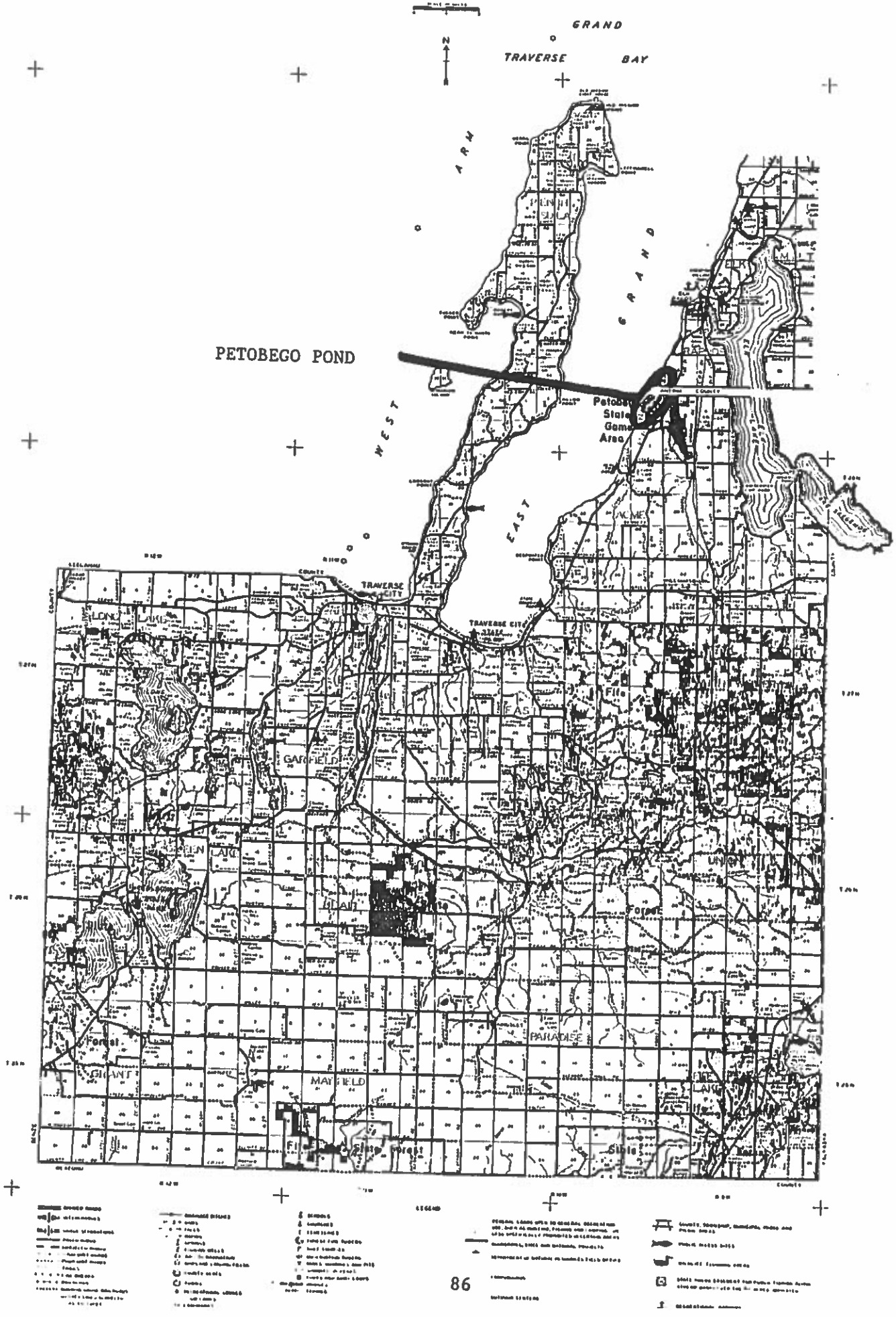
APPENDIX I.9 Great Lakes Marshes sampled in Manistee County



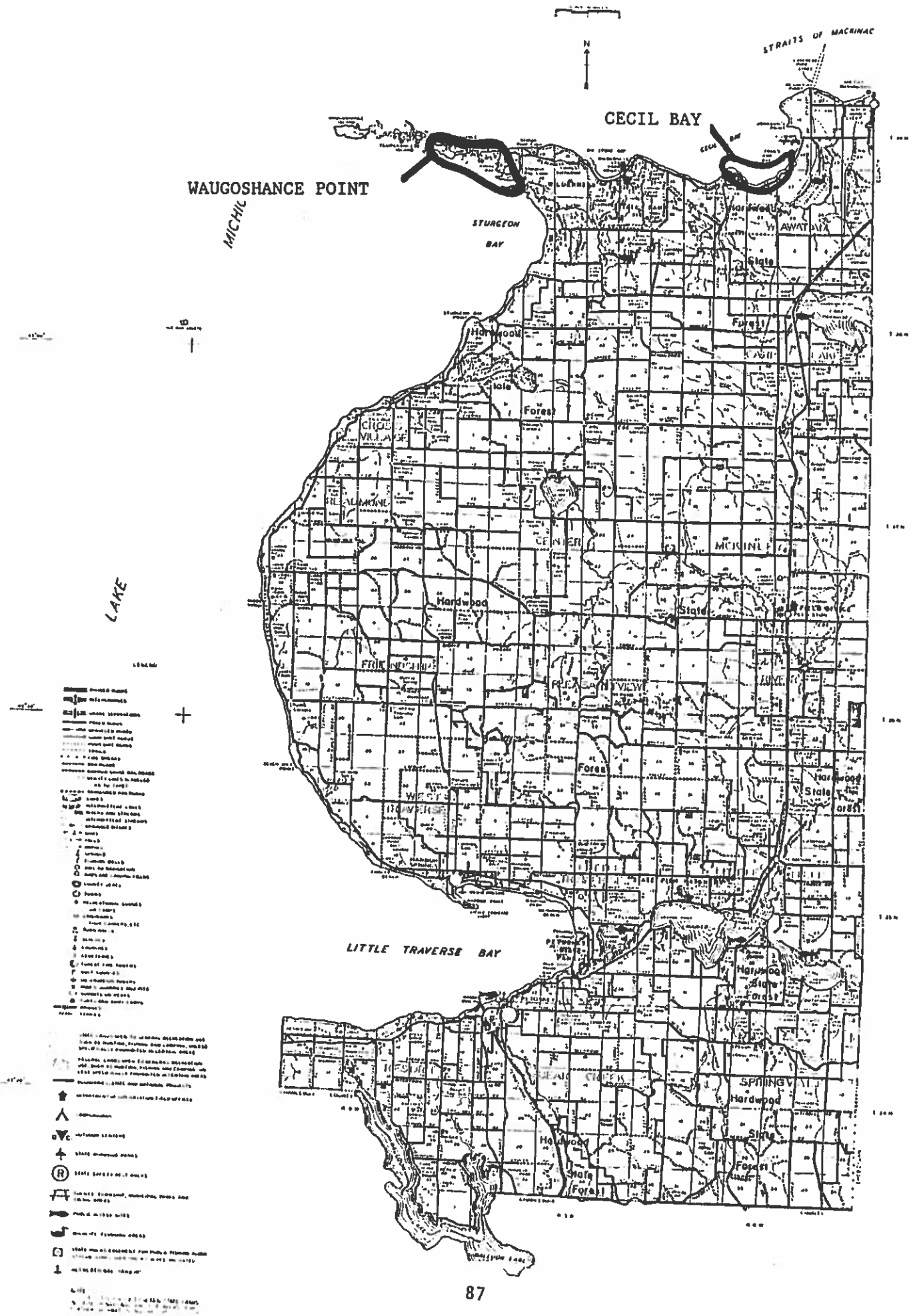
APPENDIX I.10 Great Lakes Marshes sampled in Benzie County



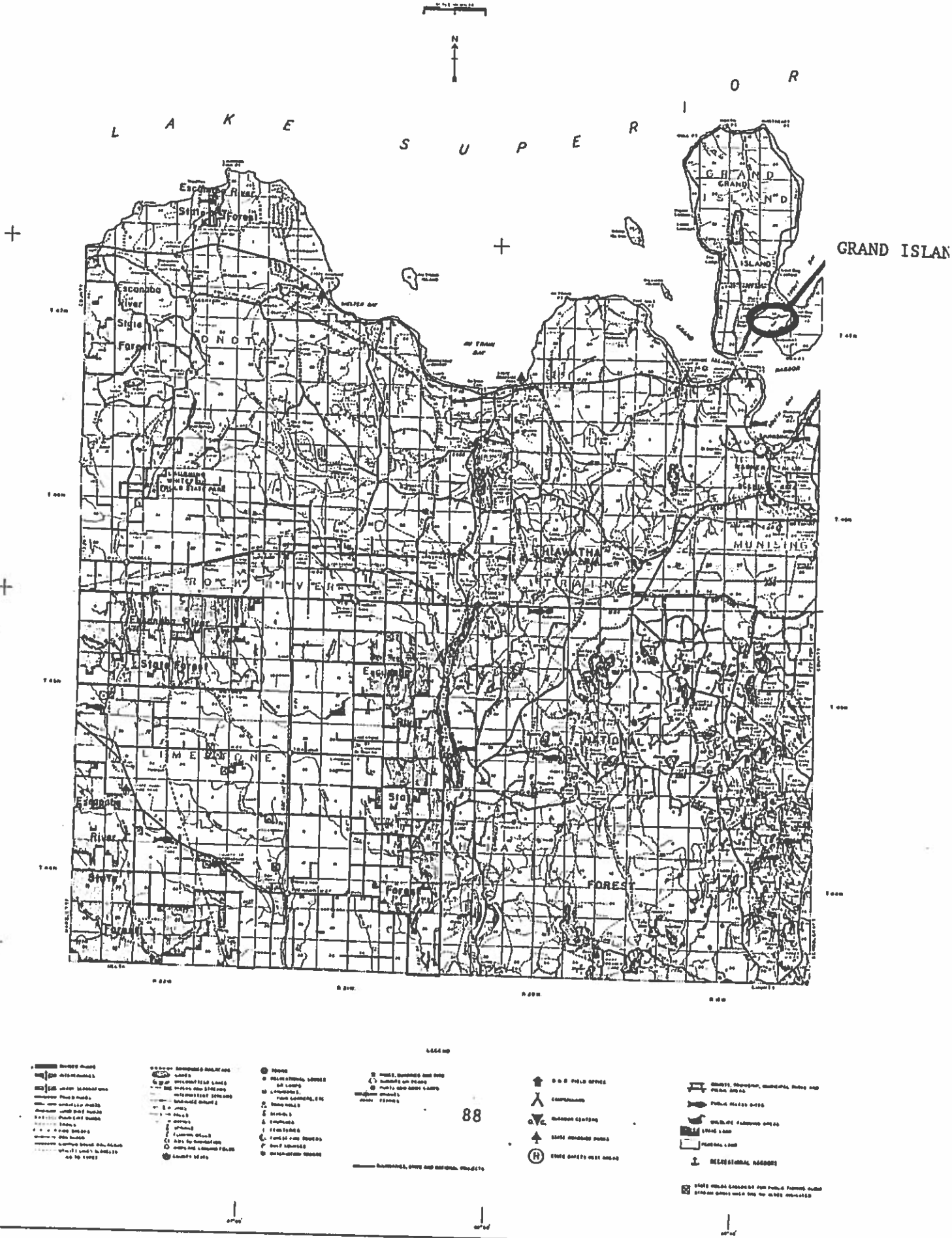
APPENDIX I.11 Great Lakes Marshes sampled in Grand Traverse and Antrim Counties



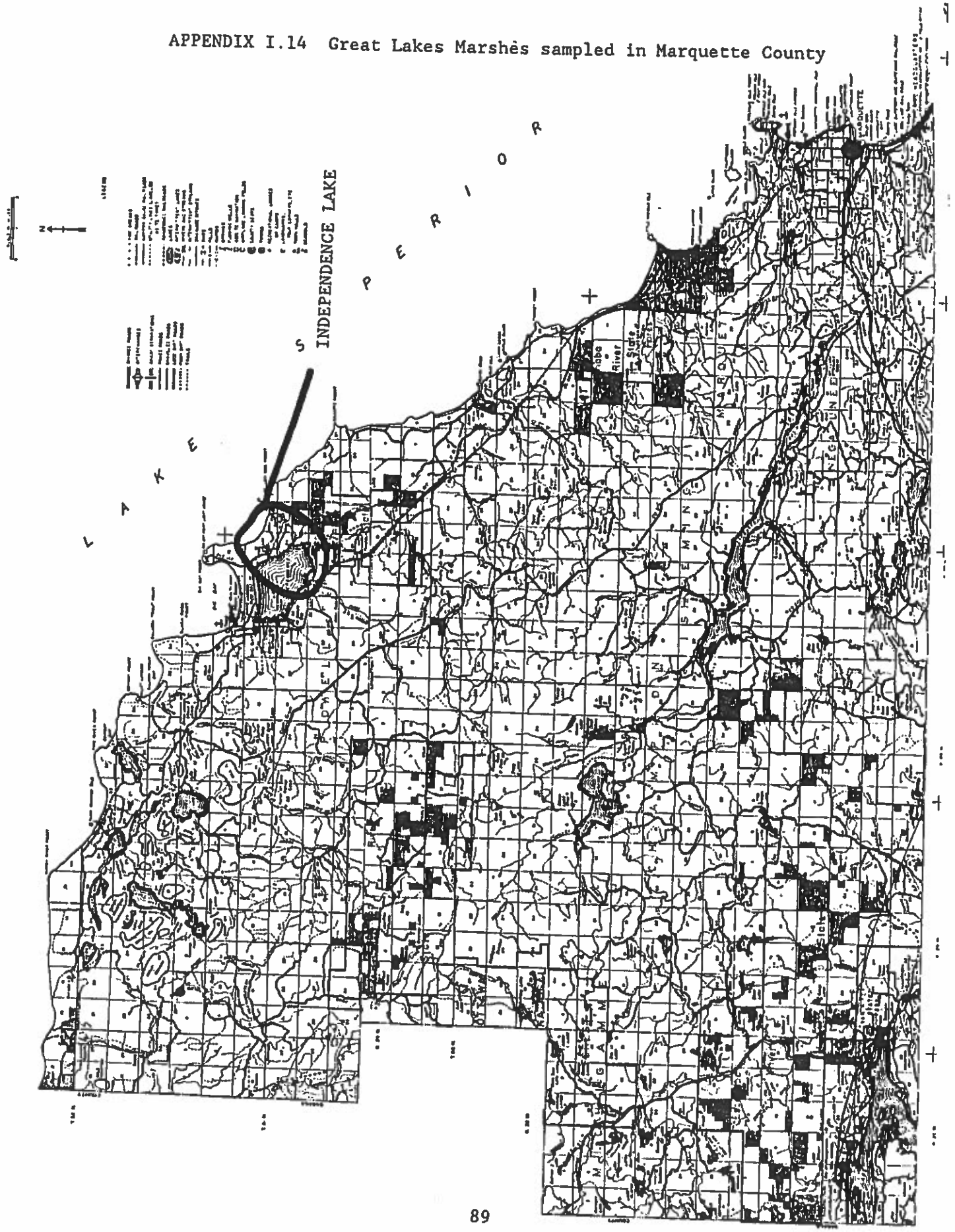
APPENDIX I.12 Great Lakes Marshes sampled in Emmet County



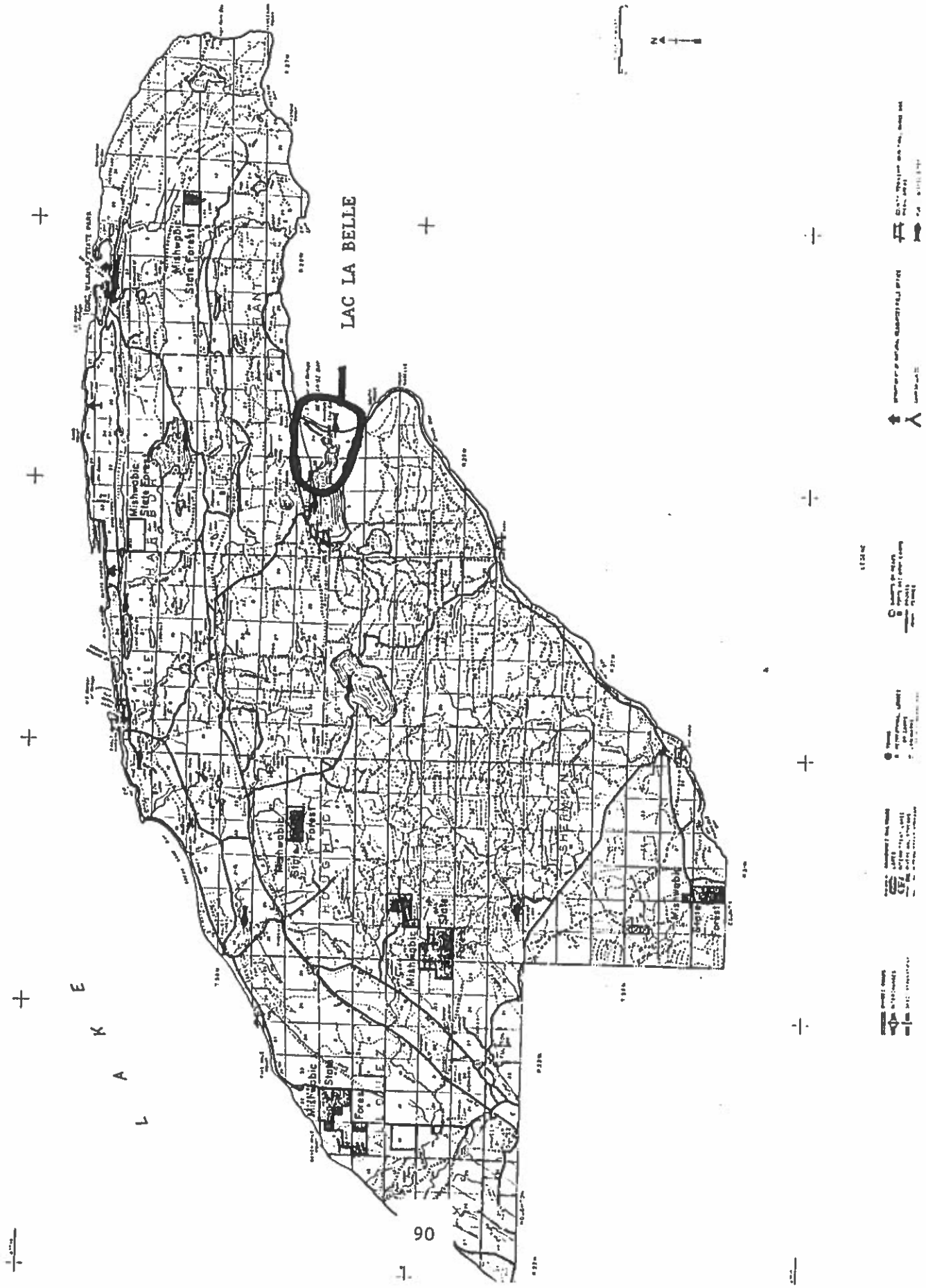
APPENDIX I.13 Great Lakes Marshes sampled in Alger County



APPENDIX I.14 Great Lakes Marshes sampled in Marquette County



APPENDIX I.15 Great Lakes Marshes sampled in Keweenaw County



APPENDIX II

GREAT LAKES MARSH SAMPLING FORM

GREAT LAKES MARSH SAMPLING FORM: PAGE 1

Communities:	Coverage Class:	Soil Texture:	Water Depth:
1=Herbaceous	1=1-20%	S=sand	D=dry
2=Shrub swamp	2=21-40%	L=loam	S=saturated
3=Tree swamp	3=41-60%	C=clay	Depth in inches
4=Emerg. marsh	4=61-80%		
5=	5=81-100%		

SITE NAME LOCATION: T R S. DATE: SURVEYORS:

COMMUNITY CODE																								
ACTUAL COMM.																								
% COVER-SUBMERG																								
% COVER-EMERG																								
ORGANIC DEPTH																								
SOIL TEXTURE																								
WATER DEPTH																								
SPECIES	OCCUR																							
Alisma plant.aq																								
Alnus rugosa																								
Aronia melano.																								
Asclepias incar																								
Bidens																								
Brasenia schreb																								
Bromus ciliatus																								
Calamagr. can.																								
Calla palustris																								
Campanula apar.																								
Carex aquatilis																								
C. bebbii																								
C. comosa																								
C. crinita																								
C. flava																								
C. hystericina																								
C. lacustris																								
C. lasiocarpa																								
C. retrorsa																								
C. stricta																								
C. viridula																								
Carex																								
Carex																								
Ceratophyllum d																								
Chara globular.																								
Chelone glabra																								
Cicuta bulbifer																								
C. maculata																								
Cirsium muticum																								
Cladium marisc.																								
Cornus amomum																								
C. stolonifera																								
Cyperus																								
Decodon vertic.																								
Deschamps. caes																								
Dulichium arund																								

NOTES:

GREAT LAKES MARSH SAMPLING FORM: PAGE 2

SITE NAME: LOCATION:T R S. DATE: SURVEYORS:

SPECIES	OCCUR
Eleochar. small	
E.	
Elodea canaden.	
Equisetum fluv.	
Eriocaulon sept	
Eupatorium mac.	
Eupatorium perf	
Fraxinus pennsy	
Galium trifidum	
Glyceria canad.	
Hypericum	
Ilex verticill.	
Impatiens bifl.	
Iris	
Isoetes	
Juncus balticus	
J. effusus	
J.	
Leersia oryzoid	
Lemna minor	
Lemna trisulca	
Lobelia dortman	
Lobelia kalmii	
Lycopus amer.	
L. uniflorus	
Lysimachia	
Lythrum salicar	
Mentha arvensis	
Muhlenber. glom	
Myrica gale	
Myriophyllum	
Najas flexilis	
Nitella flexil.	
Nuphar	
Nymphaea odorat	
Phalaris arund.	
Phragmites aust	
Polygonum amphi	
Polygonum	
Pontederia cord	
Potamogemon gra	
P. richardsonii	
P. robbinsii	
P.	
P.	
Potentilla palu	
Ranunculus	
Rhynchospora	

GREAT LAKES MARSH SAMPLING FORM: PAGE 3

SITE NAME: LOCATION: T R S. DATE: SURVEYORS:

SPECIES	OCCUR
Rorippa islandi	
Rosa	
Rumex	
Sagittaria	
Salix bebbiana	
S. candida	
S. cordata	
S. glaucophyll.	
S. lucida	
Salix	
Scirpus acutus	
S. americanus	
S. validus	
Scirpus	
Scutellaria	
Sium suave	
Solidago	
Sparganium	
Sparganium	
Spartina pectin	
Spiraea alba	
S. tomentosa	
Spiranthes rom.	
Spirodela polyr	
Subularia aquat	
Thalictrum dasy	
Thelypteris pal	
Tofieldia glut.	
Triadenum fras.	
T. virginicum	
Triglochin mari	
T. palustris	
Typha angusti.	
T. latifolia	
Utricularia	
Utricularia	
Vallisneria am.	
Viburnum lent.	

APPENDIX III

EXPLANATION OF NATURAL QUALITY AND CONDITION RANKS

Great Lakes Marsh Must be big enough to sustain breeding waterfowl, shorebirds, fish spawning grounds, and some medium-sized mammals (e.g. muskrat, fox). Must exhibit typical zonation, preferably with natural vegetation at upland edge. Increase quality-grade for marshes with several cover types and many native vascular plant species (40+). Decrease quality-grade for presence of exotics, especially if major vegetative composition changes result. Water control structures are a major disturbance and lower condition-grade relative to severity of hydrological change. Boat slips, jetties, etc. are minor disturbances unless associated with heavy human use, which disturbs animals and destroys submergent vegetation. [See also: Submergent Marsh, Emergent Marsh, Northern Wet Meadow, Southern Wet Meadow, Northern Shrub Thicket, Southern Shrub-Carr, and Inundated Shrub Swamp criteria.]

Benchmark Quality Standard: High native plant species density and diversity (equitability and richness) relative to environmental conditions; heterogenous plant community zonation; presence of full range of natural communities expected for site; well developed natural vegetative buffer if exposed to open water; good buffer of associated natural communities on upland side; and unaltered natural disturbance regime.

Minimum Element Occurrence Specifications: Exceptional significance: EO Rank B and 100 acres. Notable significance: EO Rank B and 30 acres.

Element Occurrence Size-Classes: Large: 300 or more acres; Moderate: 100-299 acres; Small: 30-99 acres; Very Small: under 30 acres.

Boundary Mapping: Wetlands associated with a single coastal feature (a bay, a delta) constitute one occurrence even if interrupted by fields, forest, fill, or channels. Highly managed portions of marshes, even if they sustain animals, should be excluded.

Exemplary Occurrences: St. Clair River Delta, St. Clair Co. (southern type); Munuscong River Delta, Chippewa Co. (northern type); Pottawattomie Bayou, Ottawa Co. (estuary).

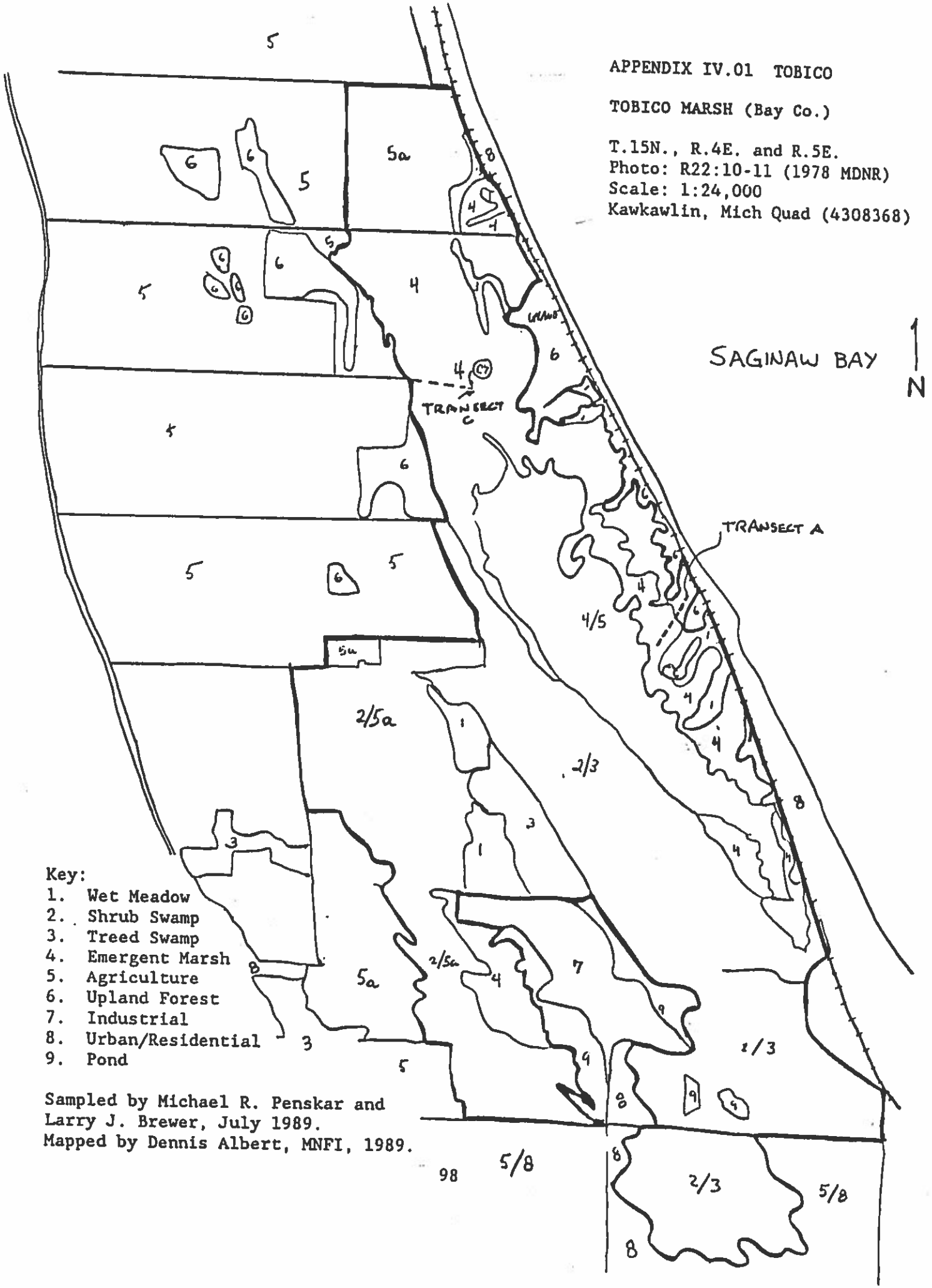
APPENDIX IV

NATURAL COMMUNITY MAPS OF MARSHES SAMPLED

APPENDIX IV.01 TOBICO

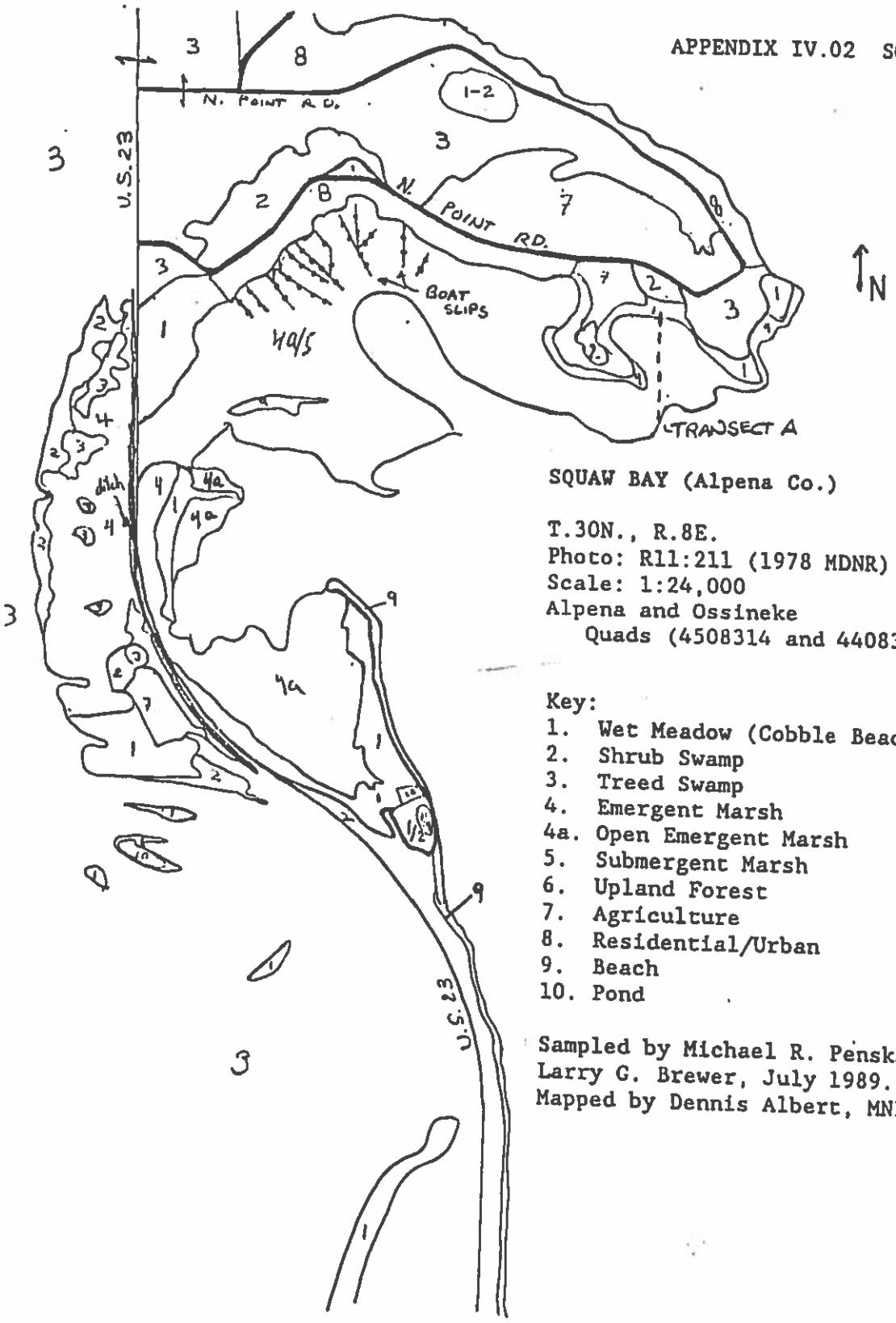
TOBICO MARSH (Bay Co.)

T.15N., R.4E. and R.5E.
Photo: R22:10-11 (1978 MDNR)
Scale: 1:24,000
Kawkawlin, Mich Quad (4308368)



Key:
1. Wet Meadow
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
5. Agriculture
6. Upland Forest
7. Industrial
8. Urban/Residential
9. Pond

Sampled by Michael R. Penskar and
Larry J. Brewer, July 1989.
Mapped by Dennis Albert, MNFI, 1989.

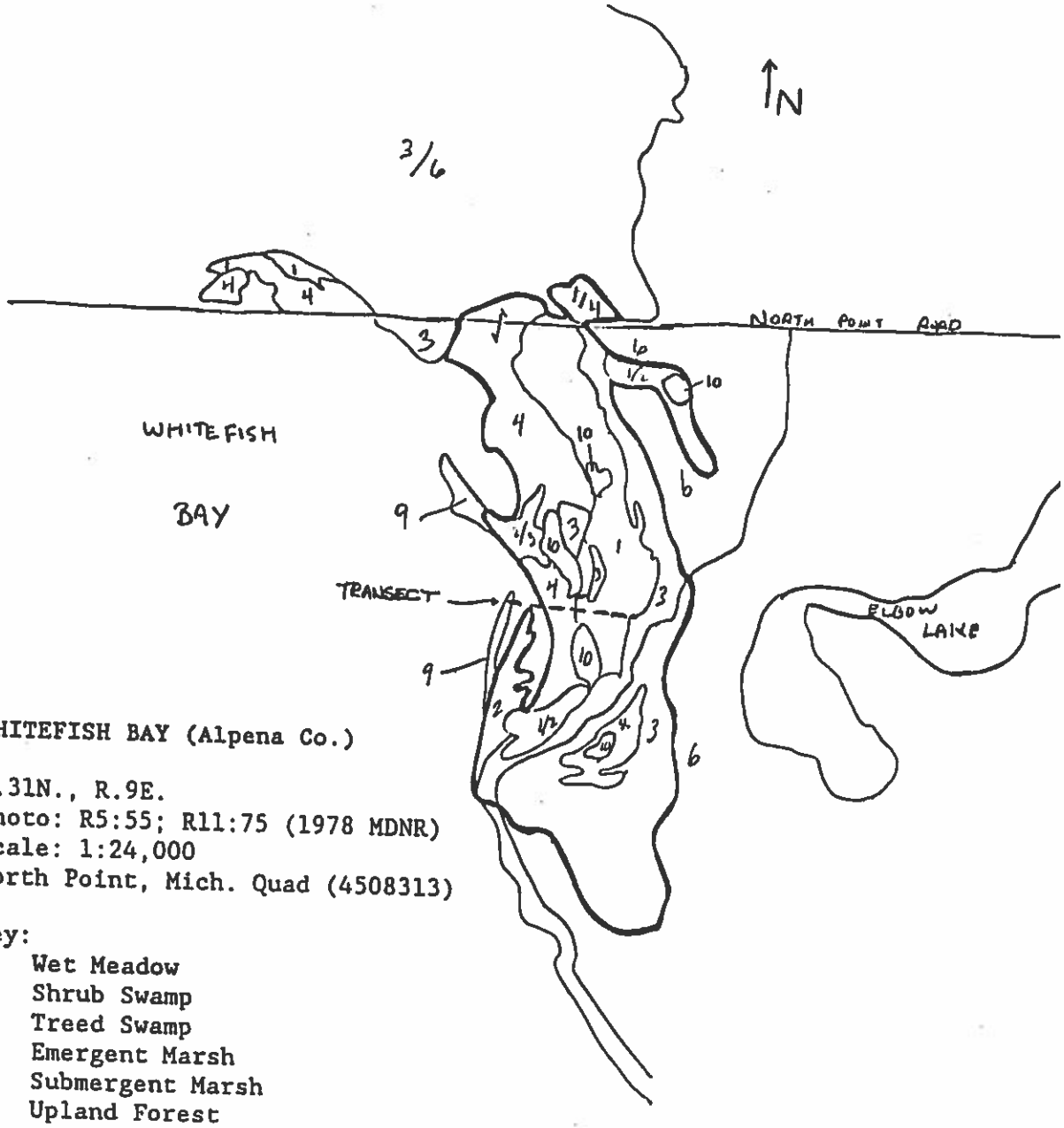


SQUAW BAY (Alpena Co.)

T.30N., R.8E.
Photo: R11:211 (1978 MDNR)
Scale: 1:24,000
Alpena and Ossineke
Quads (4508314 and 4408344)

Key:
1. Wet Meadow (Cobble Beach)
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
4a. Open Emergent Marsh
5. Submergent Marsh
6. Upland Forest
7. Agriculture
8. Residential/Urban
9. Beach
10. Pond

Sampled by Michael R. Penskar and
Larry G. Brewer, July 1989.
Mapped by Dennis Albert, MNFI, 198



WHITEFISH BAY (Alpena Co.)

T.31N., R.9E.
Photo: R5:55; R11:75 (1978 MDNR)
Scale: 1:24,000
North Point, Mich. Quad (4508313)

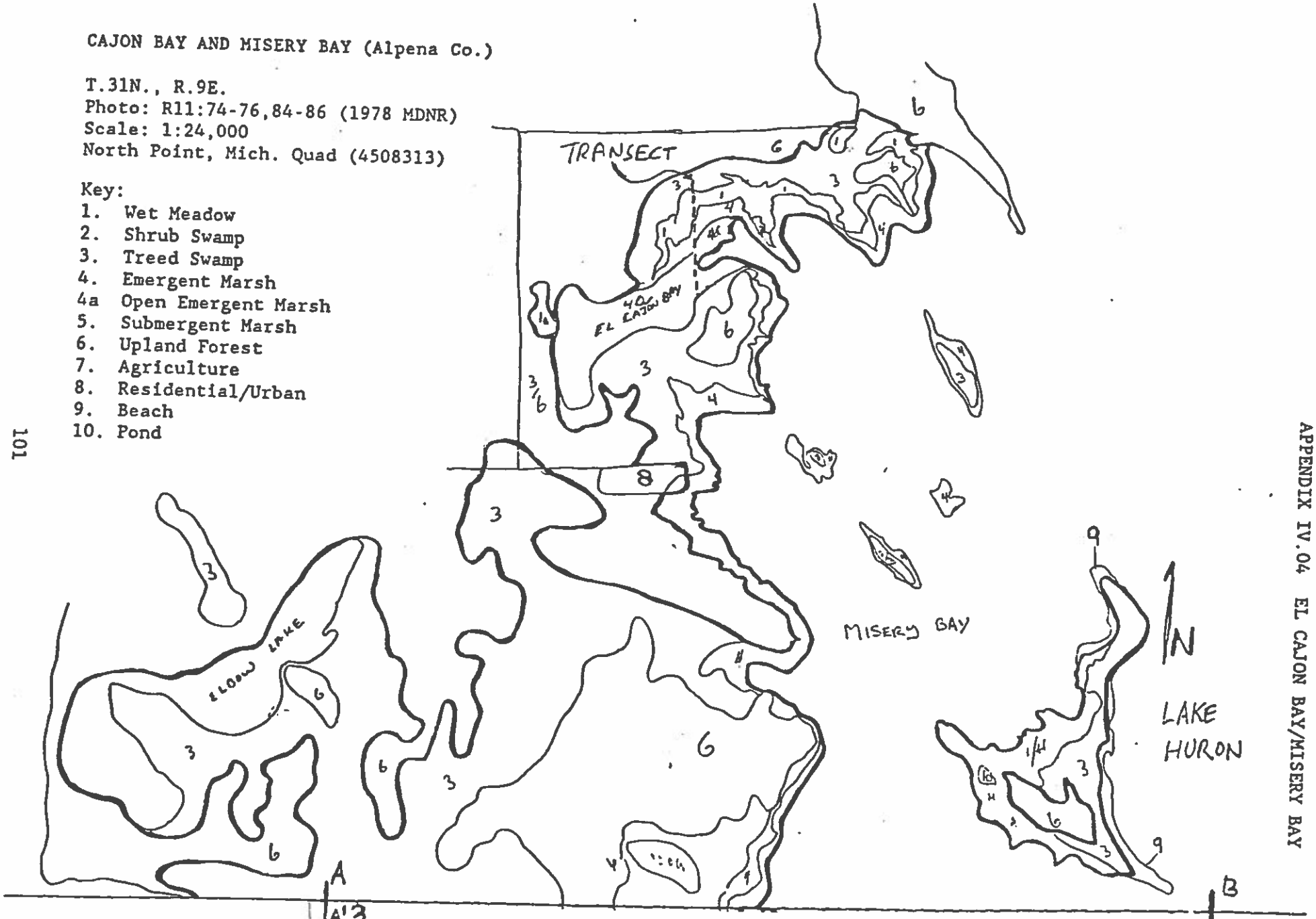
Key:
1. Wet Meadow
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
5. Submergent Marsh
6. Upland Forest
7. Agriculture
8. Residential/Urban
9. Beach
10. Pond

Sampled by Dennis Albert and Tim Garlock, August 1989.
Mapped by Dennis Albert, MNFI, 1989.

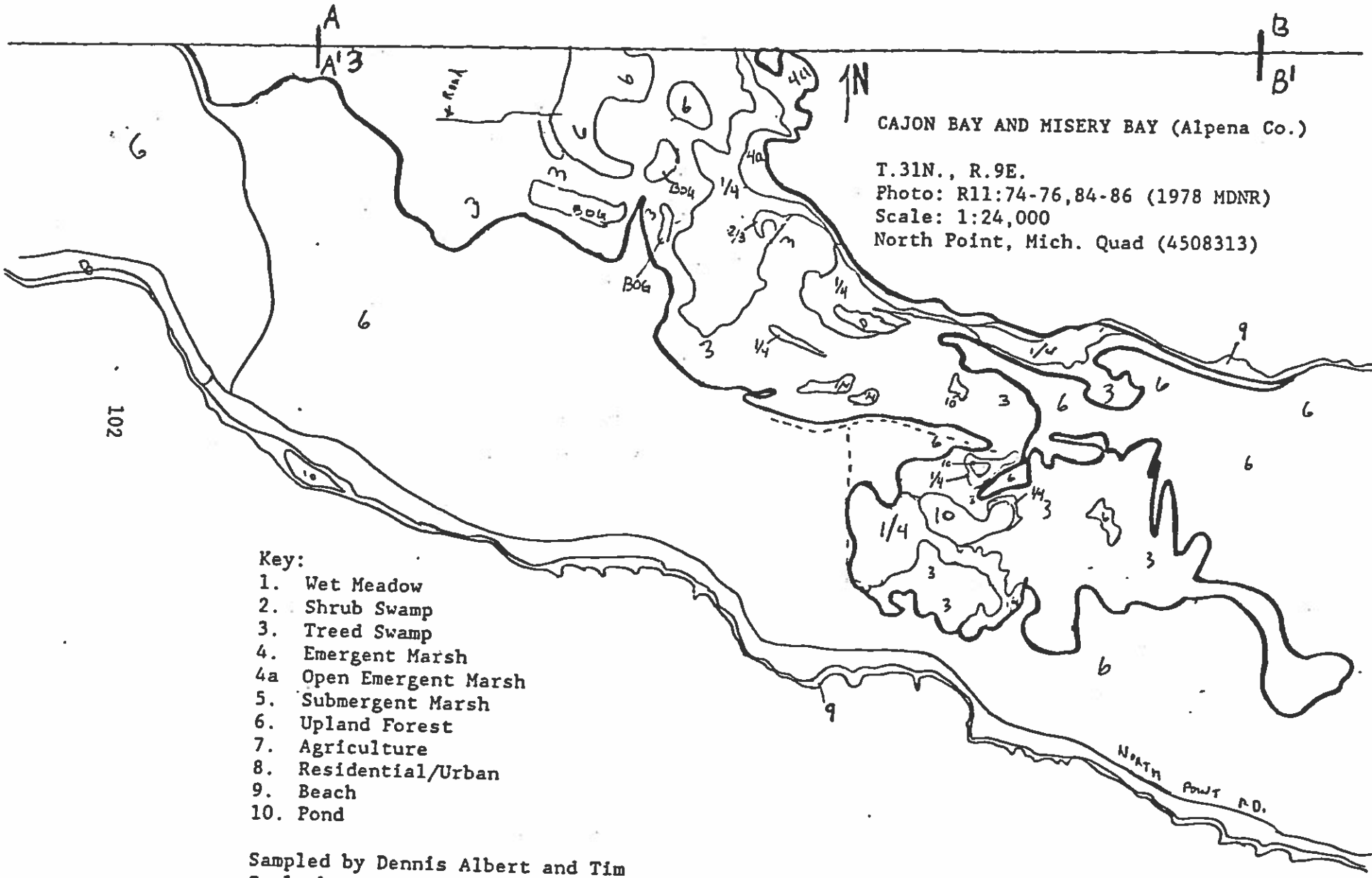
CAJON BAY AND MISERY BAY (Alpena Co.)

T.31N., R.9E.
Photo: R11:74-76,84-86 (1978 MDNR)
Scale: 1:24,000
North Point, Mich. Quad (4508313)

Key:
1. Wet Meadow
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
4a Open Emergent Marsh
5. Submergent Marsh
6. Upland Forest
7. Agriculture
8. Residential/Urban
9. Beach
10. Pond



Sampled by Dennis Albert and Tim Garlock, August 1989.



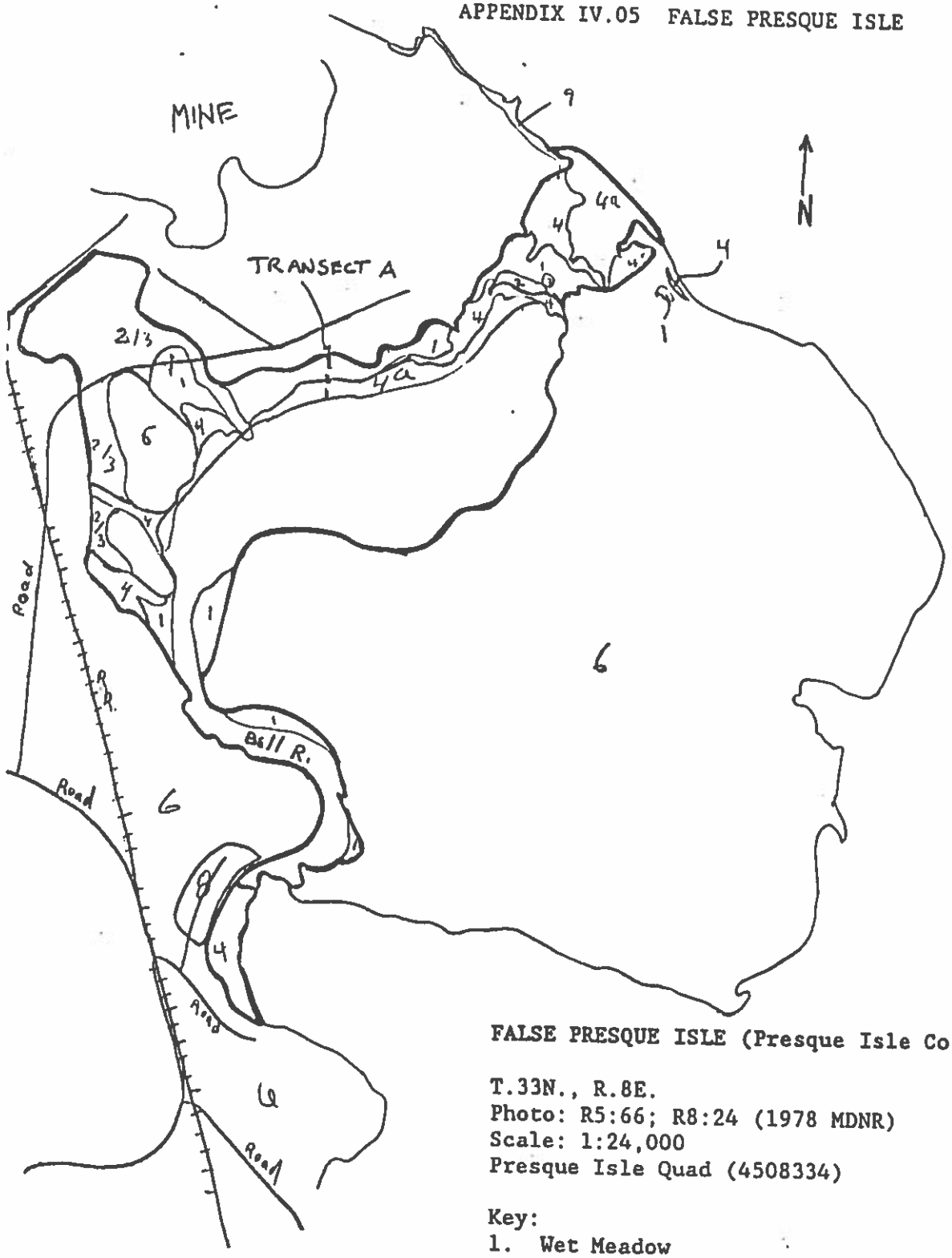
CAJON BAY AND MISERY BAY (Alpena Co.)

T.31N., R.9E.
Photo: R11:74-76,84-86 (1978 MDNR)
Scale: 1:24,000
North Point, Mich. Quad (4508313)

Key:
1. Wet Meadow
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
4a Open Emergent Marsh
5. Submergent Marsh
6. Upland Forest
7. Agriculture
8. Residential/Urban
9. Beach
10. Pond

Sampled by Dennis Albert and Tim Garlock, August 1989.
Mapped by Dennis Albert, MNFI, 1989.

APPENDIX IV.04 EL CAJON BAY/MISERY BAY



Sampled by Michael R. Penskar and
Larry J. Brewer, July 1989.
Mapped by Dennis Albert, MNFI, 1989.

FALSE PRESQUE ISLE (Presque Isle Co.)

T.33N., R.8E.
Photo: R5:66; R8:24 (1978 MDNR)
Scale: 1:24,000
Presque Isle Quad (4508334)

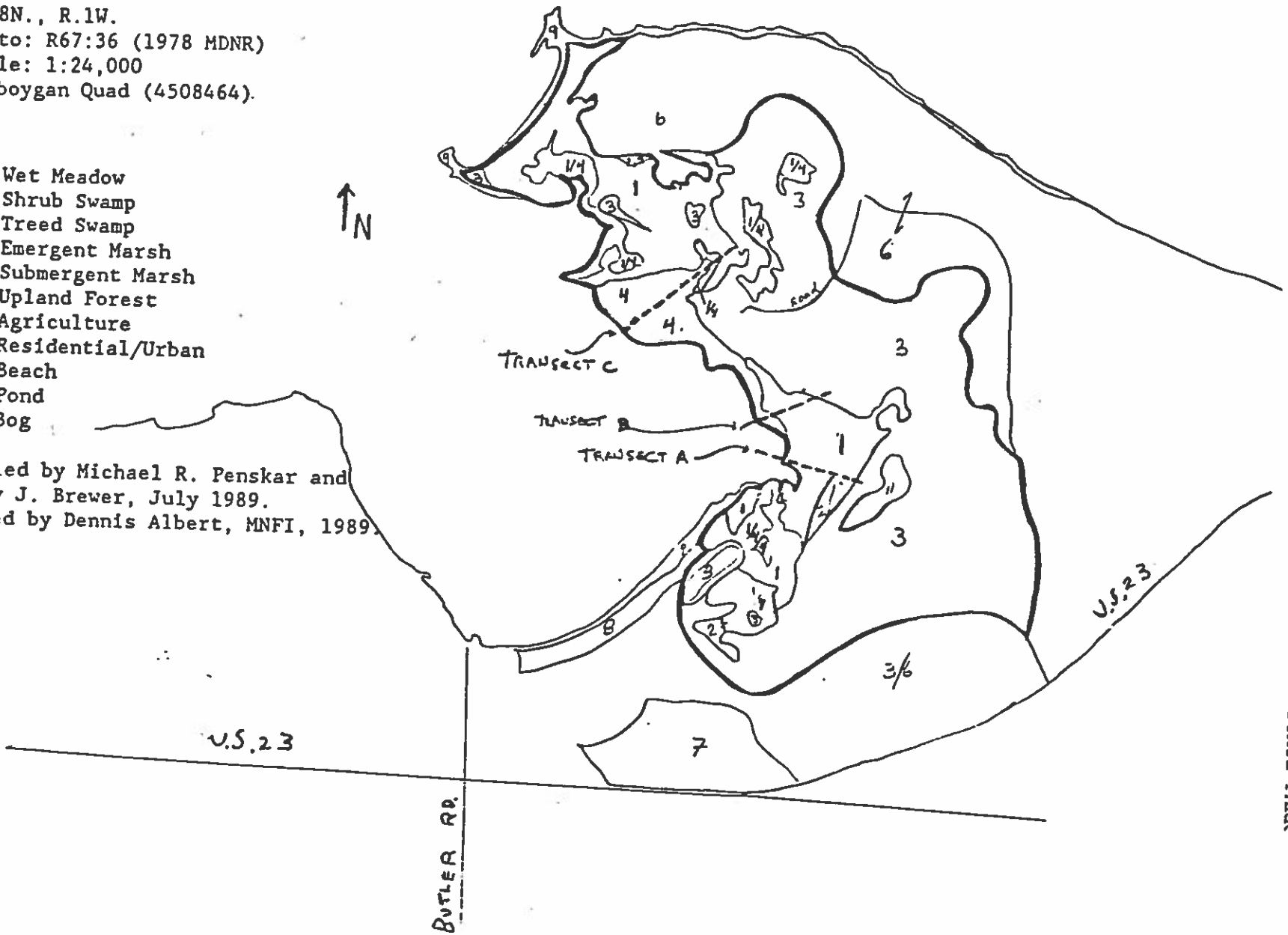
Key:
1. Wet Meadow
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
4a Open Emergent Marsh
5. Submergent Marsh
6. Upland Forest
7. Agriculture
8. Residential/Urban
9. Beach
10. Pond

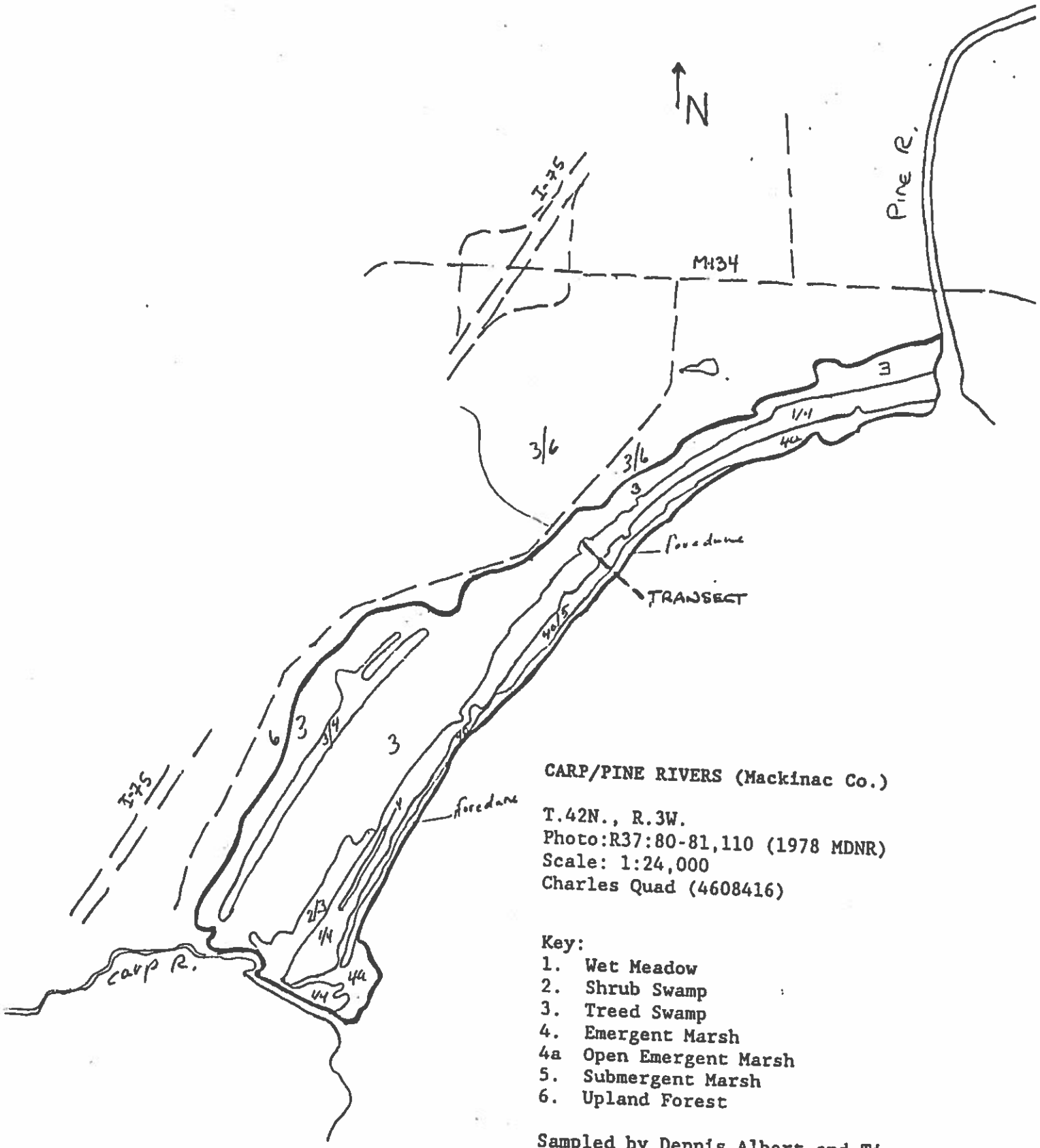
CHEBOYGAN STATE PARK (Cheboygan Co.)

T.38N., R.1W.
Photo: R67:36 (1978 MDNR)
Scale: 1:24,000
Cheboygan Quad (4508464).

Key:
1. Wet Meadow
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
5. Submergent Marsh
6. Upland Forest
7. Agriculture
8. Residential/Urban
9. Beach
10. Pond
11. Bog

Sampled by Michael R. Penskar and Larry J. Brewer, July 1989.
Mapped by Dennis Albert, MNFI, 1989.



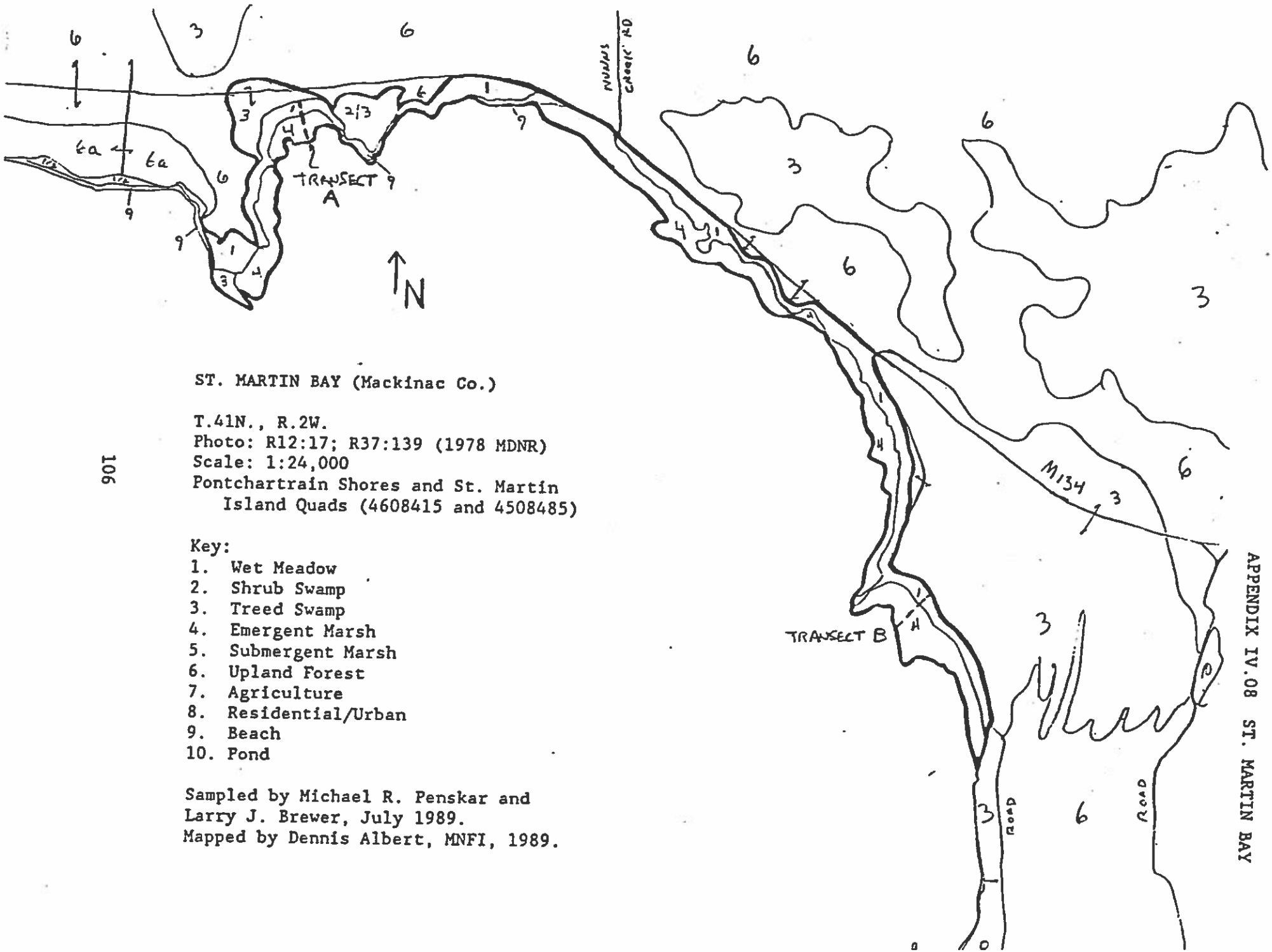


CARP/PINE RIVERS (Mackinac Co.)

T.42N., R.3W.
Photo:R37:80-81,110 (1978 MDNR)
Scale: 1:24,000
Charles Quad (4608416)

Key:
1. Wet Meadow
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
4a Open Emergent Marsh
5. Submergent Marsh
6. Upland Forest

Sampled by Dennis Albert and Tim Garlock, August 1989.
Mapped by Dennis Albert, MNFI, 1989.

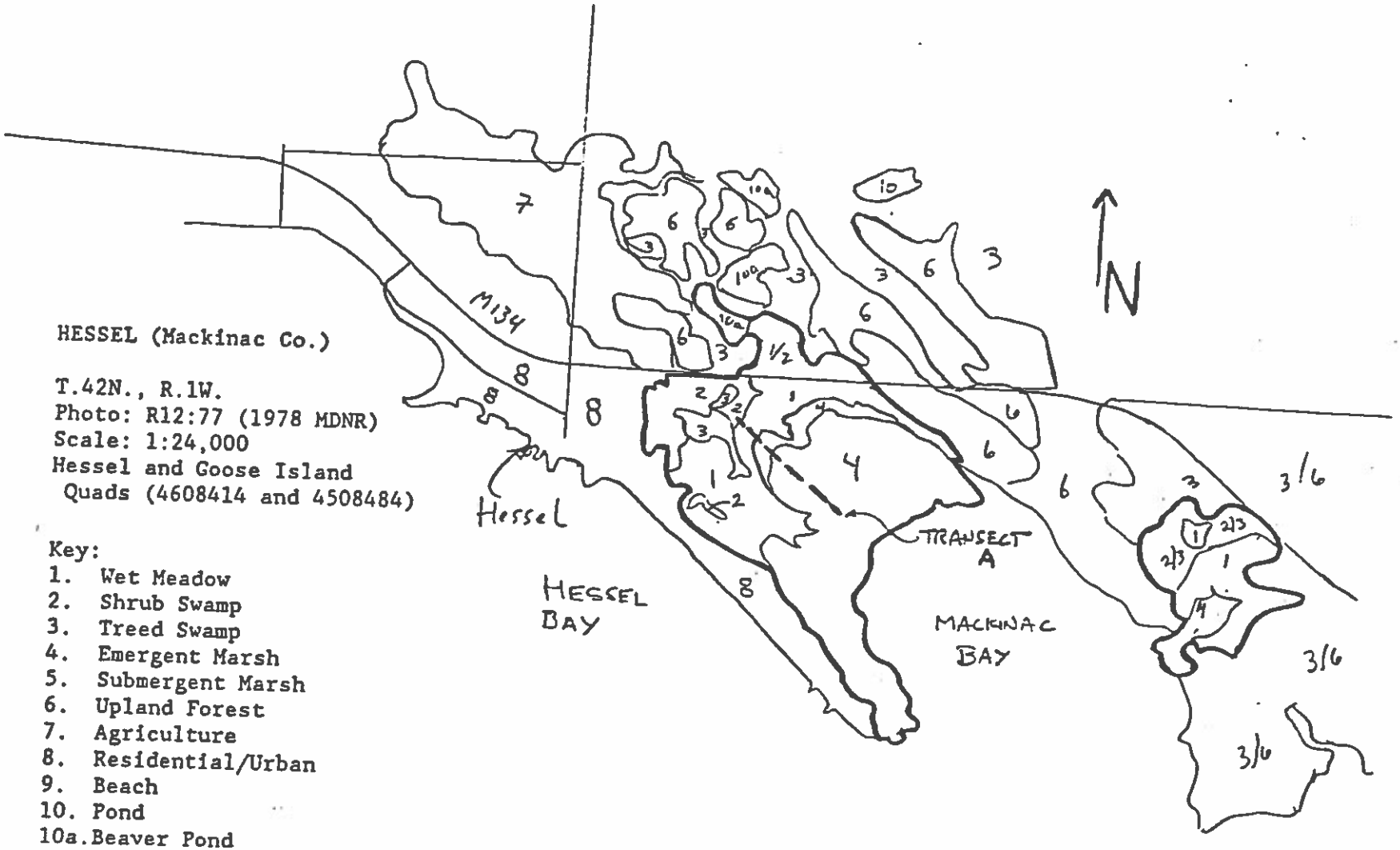


ST. MARTIN BAY (Mackinac Co.)

T.41N., R.2W.
Photo: R12:17; R37:139 (1978 MDNR)
Scale: 1:24,000
Pontchartrain Shores and St. Martin Island Quads (4608415 and 4508485)

Key:
1. Wet Meadow
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
5. Submergent Marsh
6. Upland Forest
7. Agriculture
8. Residential/Urban
9. Beach
10. Pond

Sampled by Michael R. Penskar and Larry J. Brewer, July 1989.
Mapped by Dennis Albert, MNFI, 1989.

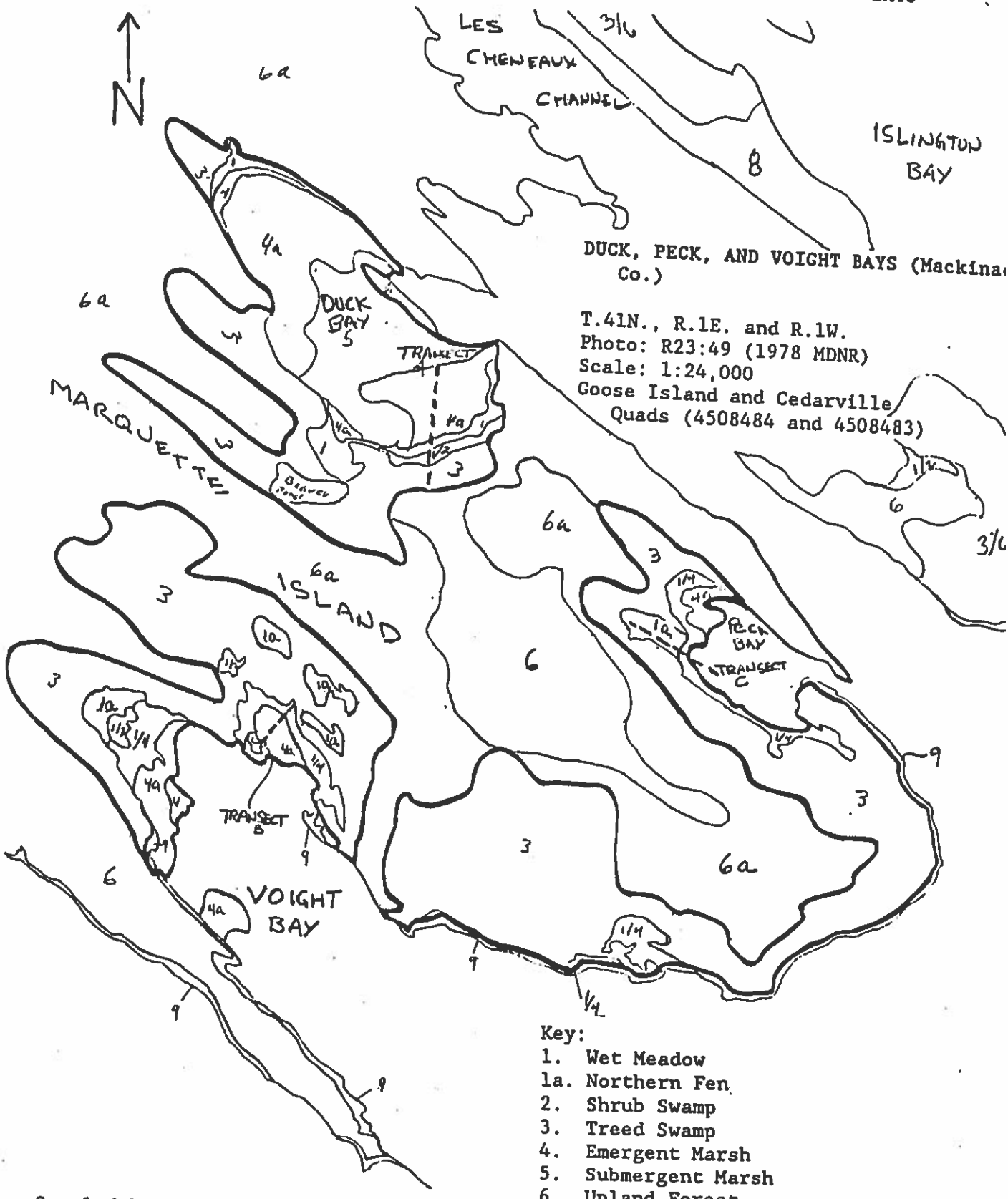


HESSEL (Mackinac Co.)

T.42N., R.1W.
Photo: R12:77 (1978 MDNR)
Scale: 1:24,000
Hessel and Goose Island
Quads (4608414 and 4508484)

Key:
1. Wet Meadow
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
5. Submergent Marsh
6. Upland Forest
7. Agriculture
8. Residential/Urban
9. Beach
10. Pond
10a. Beaver Pond
11. Bog

Sampled by Michael R. Penskar and
Larry J. Brewer, July 1989.
Mapped by Dennis Albert, MNFI, 1989.



DUCK, PECK, AND VOIGHT BAYS (Mackinac Co.)

T.41N., R.1E. and R.1W.
Photo: R23:49 (1978 MDNR)
Scale: 1:24,000
Goose Island and Cedarville Quads (4508484 and 4508483)

Sampled by Dennis Albert and Tim Garlock, August 1989.
Mapped by Dennis Albert, MNFI, 1989.

Key:
1. Wet Meadow
1a. Northern Fen
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
5. Submergent Marsh
6. Upland Forest
6a. Upland Conifer Forest
7. Agriculture
8. Residential/Urban
9. Beach
10. Pond

BIG SHOAL COVE (Chippewa Co.)

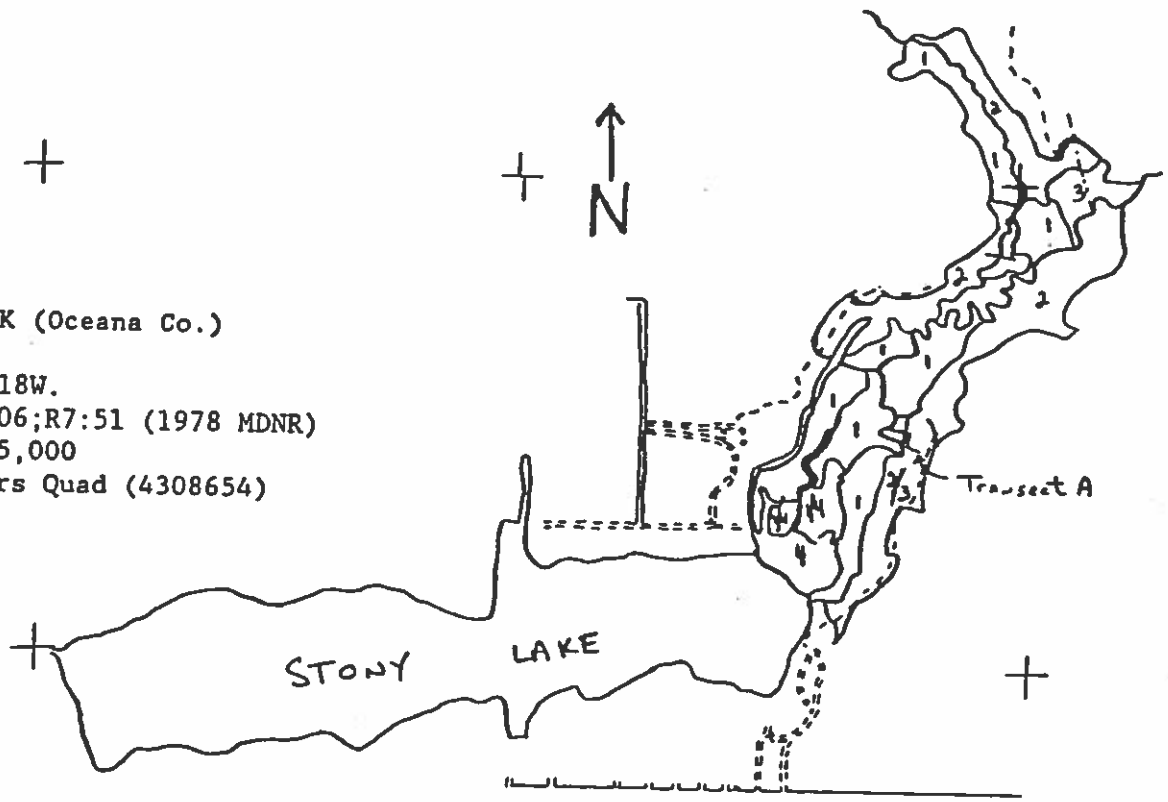
T.41N., R.6E. and R.7E.
Photo: R5:112 (1978 MDNR)
Scale: 1:24,000
Marble Head Quad (4508385)

Key:
1. Wet Meadow
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
5. Submergent Marsh
6. Upland Forest
7. Agriculture
8. Residential/Urban
9. Beach
10. Pond

Sampled by Michael R. Penskar and Larry J. Brewer, July 1989.
Mapped by Dennis Albert, MNFI, 1989.

STONY CREEK (Oceana Co.)

T.14N., R.18W.
Photo: R6:06;R7:51 (1978 MDNR)
Scale: 1:25,000
Town Corners Quad (4308654)



Key:
1. Emergent Marsh
2. Shrub Swamp
3. Wet Meadow
4. Submergent Marsh

Sampled by Gary Reese, Dan Wujek,
and Ben Stark, August 1989.
Mapped by Gary Reese, MNFI, 1989.

PENTWATER MARSH (Oceana Co.)

T.16N., R.18W.
Photo: R7:99 (1977 MDNR)
Scale: 1:24,000 (approx.)
Pentwater and Mears Quads
(4308674 and 4308664)

Key:
1. Shrub Swamp
2. Water
3. Wet Meadow
4. Emergent Marsh
5. Submergent Marsh

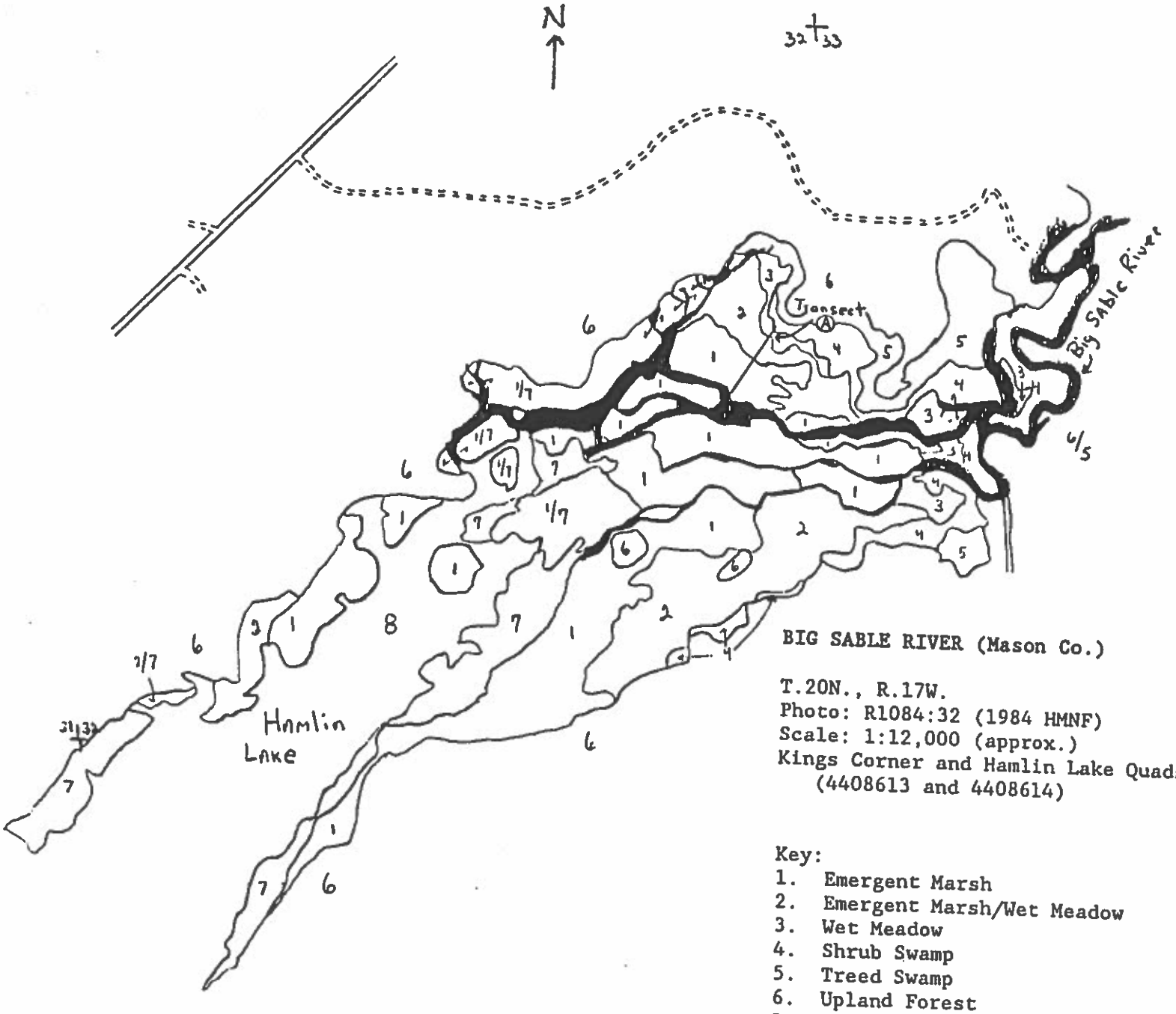
Sampled by Gary Reese and Michael Penskar, July 1989.
Mapped by Gary Reese, MNFI, 1989.

PERE MARQUETTE (Mason Co.)

T.18N., R.18W.
Photos: R7:69;R25:107 (1977 MDNR)
Scale: 1:25,000
Ludington Quad (4308684)

Key:
1. Wet Meadow
2. Shrub Swamp
3. Emergent Marsh
4. Treed Swamp
5. Submergent Marsh

Sampled by Gary Reese, Dan Wujek, and Ben Stark, August 1989.
Mapped by Gary Reese, MNFI, 1989.

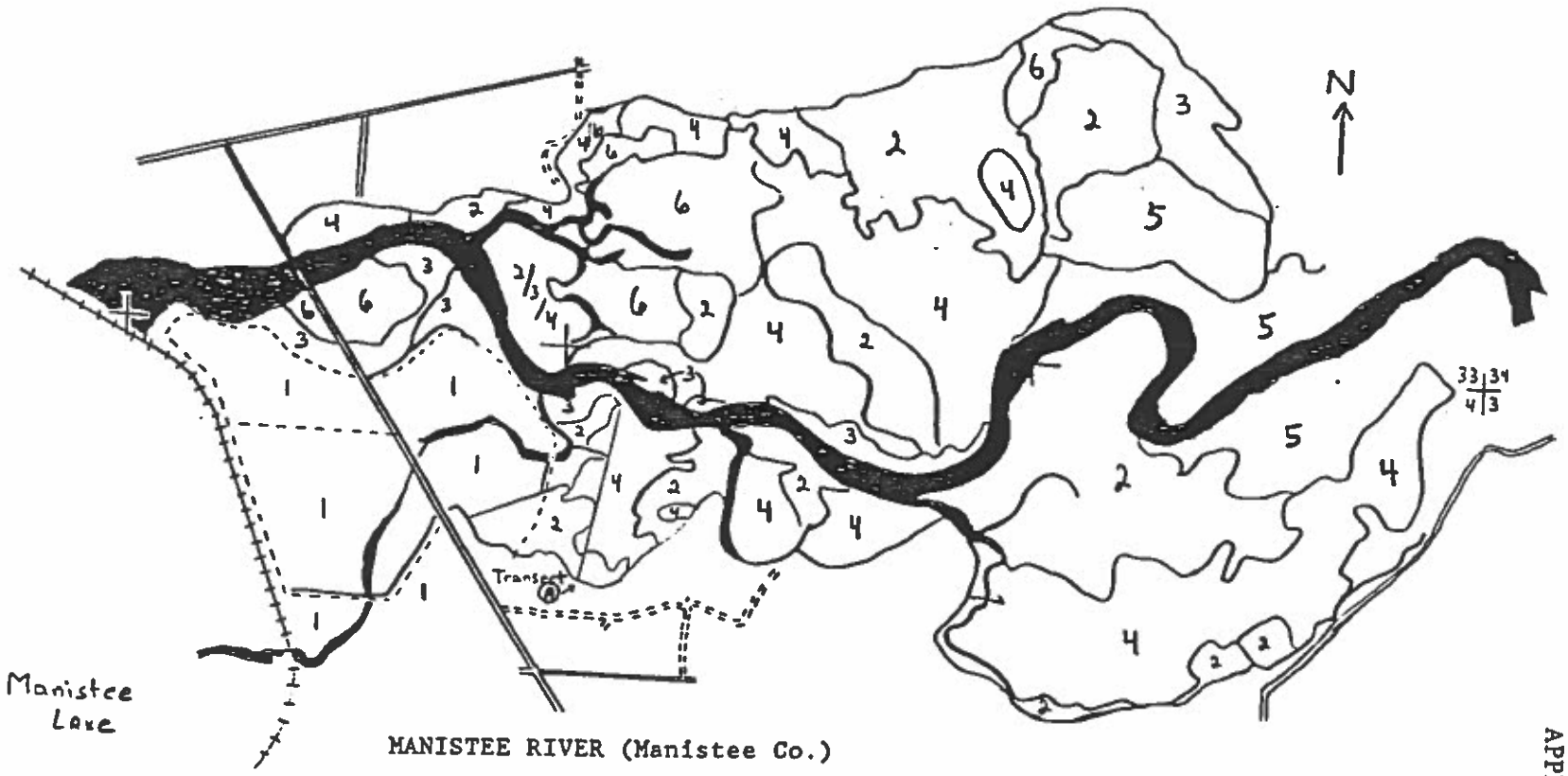


BIG SABLE RIVER (Mason Co.)

T.20N., R.17W.
Photo: R1084:32 (1984 HMNF)
Scale: 1:12,000 (approx.)
Kings Corner and Hamlin Lake Quads
(4408613 and 4408614)

Key:
1. Emergent Marsh
2. Emergent Marsh/Wet Meadow
3. Wet Meadow
4. Shrub Swamp
5. Treed Swamp
6. Upland Forest
7. Submergent Marsh
8. Open Water

Sampled by Gary Reese, Dan Wujek, and Ben Stark, August 1989.
Mapped by Gary Reese, MNFI, 1989.

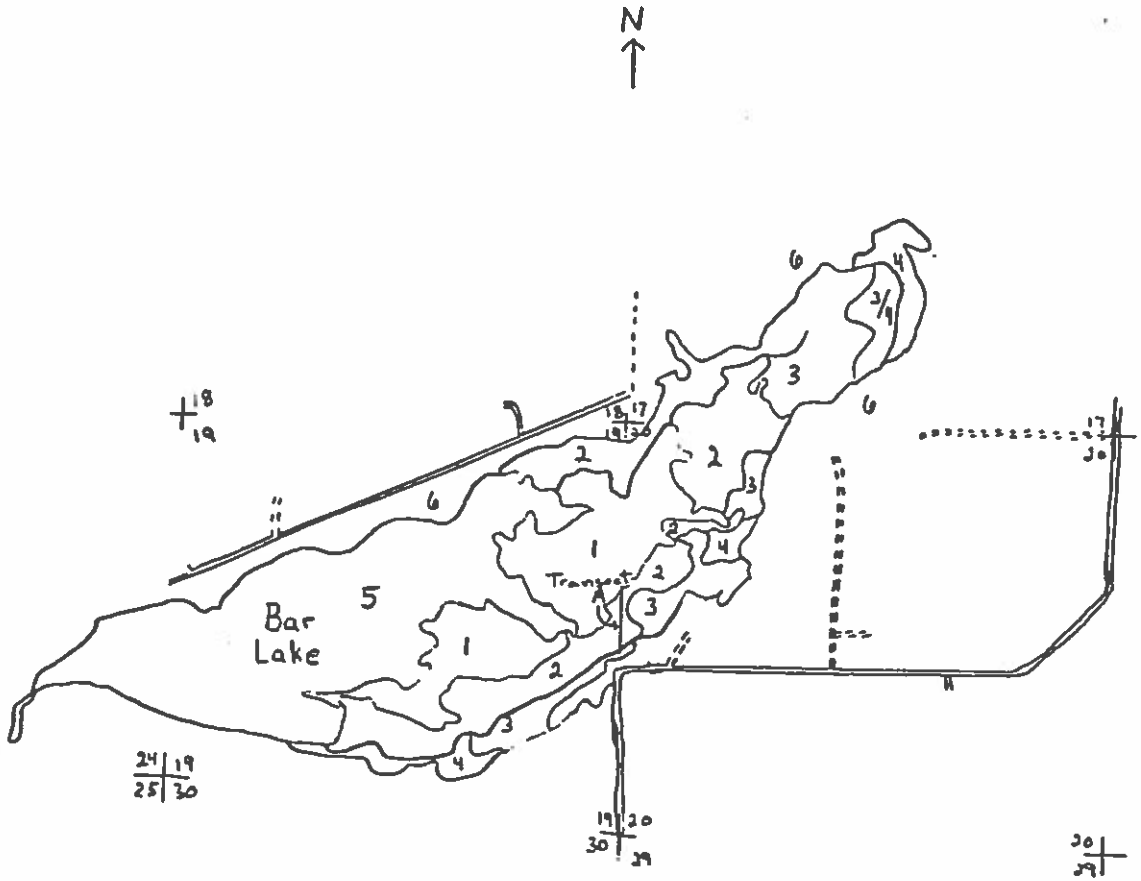


MANISTEE RIVER (Manistee Co.)

T.21N. and T.22N, R.16W.
Photo: R22:132 (1978 MDNR)
Scale 1:25,000
Parkdale and Onekama Quads
(4408633 and 4408632)

Key:
1. Old field
2. Shrub Swamp
3. Treed Swamp
4. Wet Meadow
5. Floodplain Forest
6. Emergent Marsh

Sampled by Gary Reese, Dan Wujek,
and Ben Stark, August 1989.
Mapped by Gary Reese, MNFI, 1989.

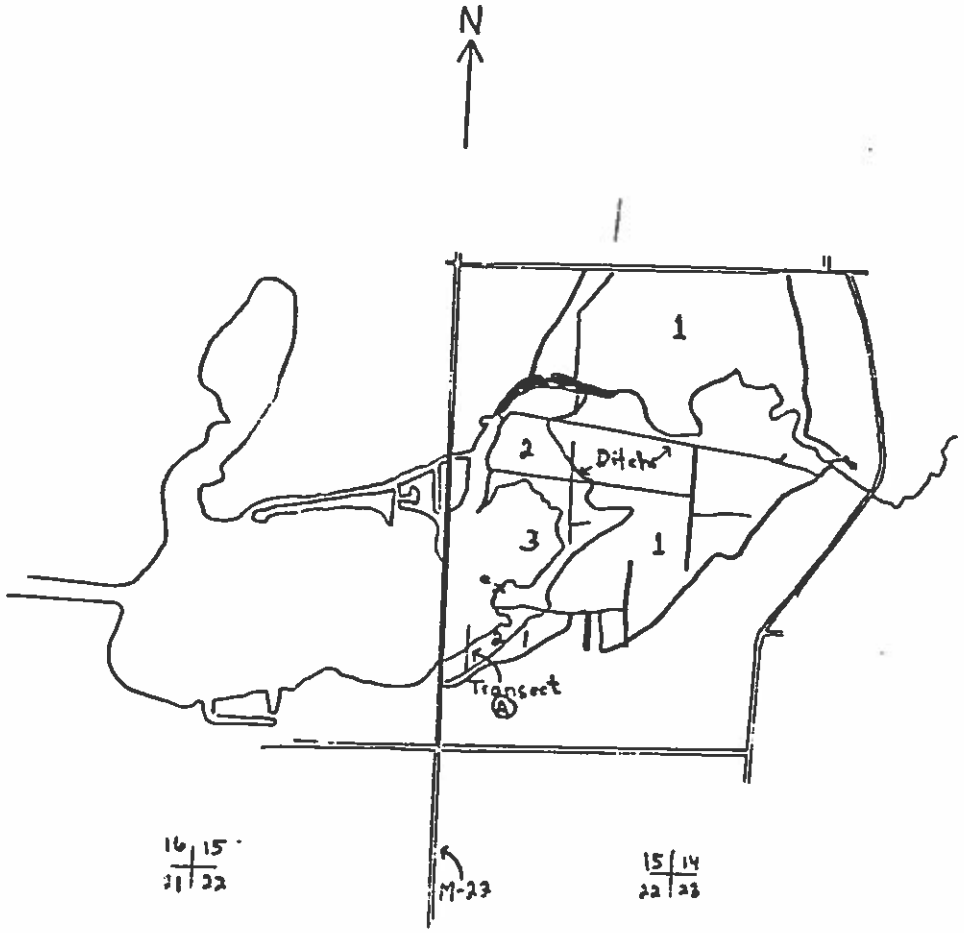


BAR LAKE (Manistee Co.)

T.22N., R.16W.
Photo: R22:134 (1978 MDNR)
Scale: 1:25,000
Parkdale Quad (4408633)

Key:
1. Submergent Marsh
2. Emergent Marsh
3. Shrub Swamp
4. Treed Swamp
5. Open water
6. Upland Forest

Sampled by Gary Reese, Dan Wujek,
and Ben Stark, August 1989.
Mapped by Gary Reese, MNFI, 1989.

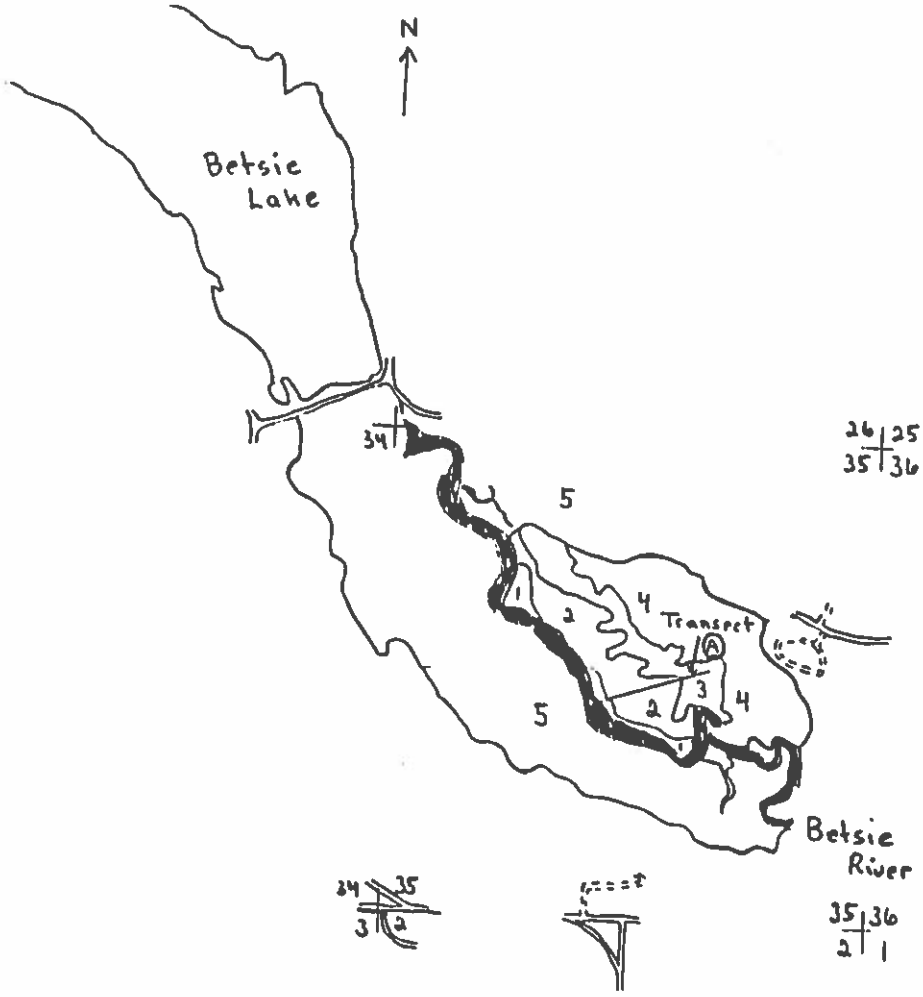


ARCADIA LAKE (Manistee Co.)

T.24N., R. 16W.
Photo: R22:76 (1978 MDNR)
Scale: 1:25,000
Bear Lake Quad (4408642)

Key:
1. Wet Meadow
2. Emergent Marsh
3. Submergent Marsh and open water

Sampled by Gary Reese, Dan Wujek, and Ben Stark, August 1989.
Mapped by Gary Reese, MNFI, 1989.

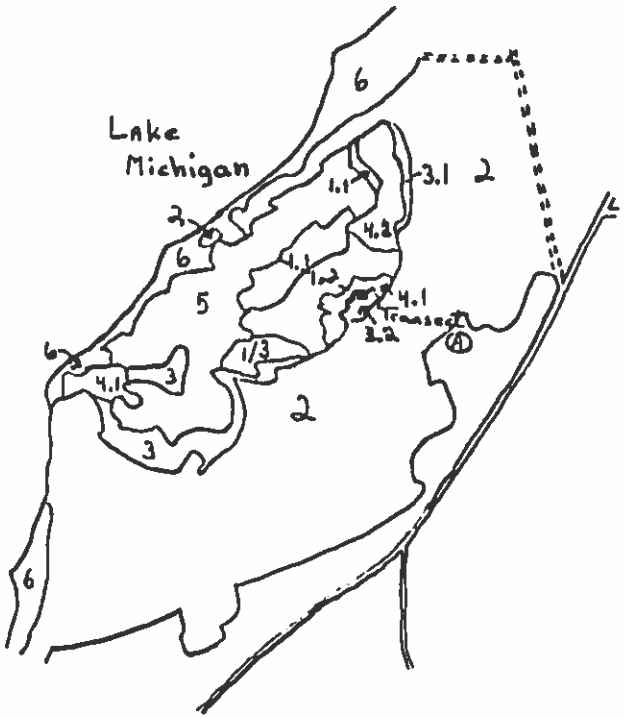


BETSIE RIVER (Benzie Co.)

T.26N., R.16W.
Photos: R22:83; R14:191 (1978 MDNR)
Scale: 1:25,000
Benzonia Quad (4408651)

Key:
1. Emergent Marsh
2. Wet Meadow
3. Shrub Swamp
4. Treed Swamp
5. Old field

Sampled by Gary Reese, Dan Wujek, and Ben Stark, August 1989.
Mapped by Gary Reese, MNFI, 1989.



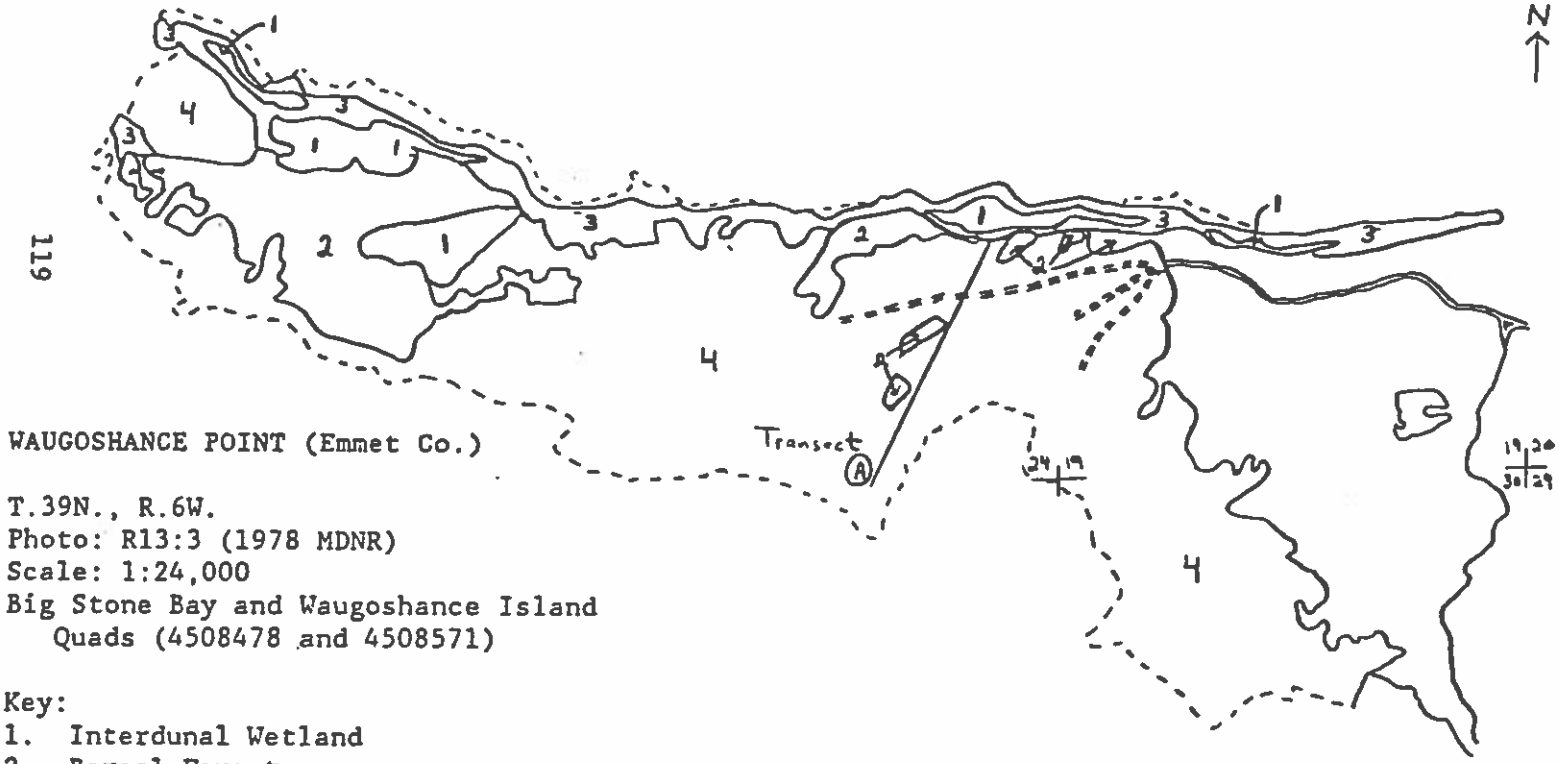
PETOBEGO POND (Grand Traverse and Antrim Co.'s)

T.28N., R.9W.
Photo: R32:194 (1987 MDNR)
Scale: 1:25,000
Williamsburg Quad (4408574)

Key:

1.1 Submergent Marsh: Scirpus acutus dominated
1.2 Submergent Marsh: Nuphar variegata dominated
2. Forest
3.1 Northern Fen
3.2 Wet Meadow
4.1 Emergent Marsh: Typha dominated
4.2 Emergent Marsh: Scirpus acutus dominated
5. Open water
6. Sand/Gravel Beach and Open Dunes

Sampled by Gary Reese and Michael Penskar, July 1989.
Mapped by Gary Reese, MNFI, 1989.



WAUGOSHANCE POINT (Emmet Co.)

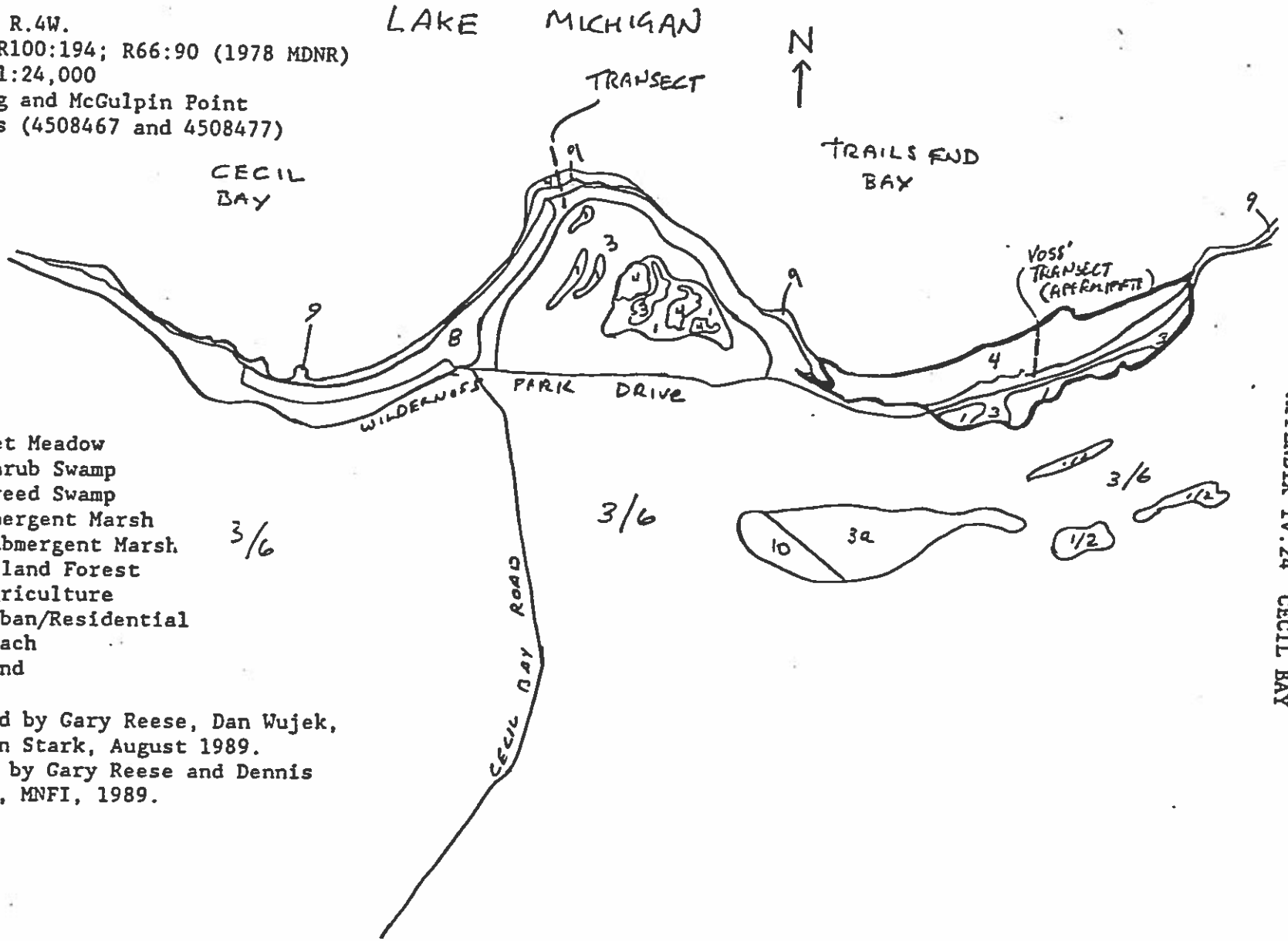
T.39N., R.6W.
Photo: R13:3 (1978 MDNR)
Scale: 1:24,000
Big Stone Bay and Waugoshance Island
Quads (4508478 and 4508571)

Key:
1. Interdunal Wetland
2. Boreal Forest
3. Open Dunes and Sand/Gravel Beach
4. Cobble Beach, Emergent Marsh, and Submergent Marsh
--- extent of vegetation in 1938

Sampled by Gary Reese and Michael Penskar, August 1989.

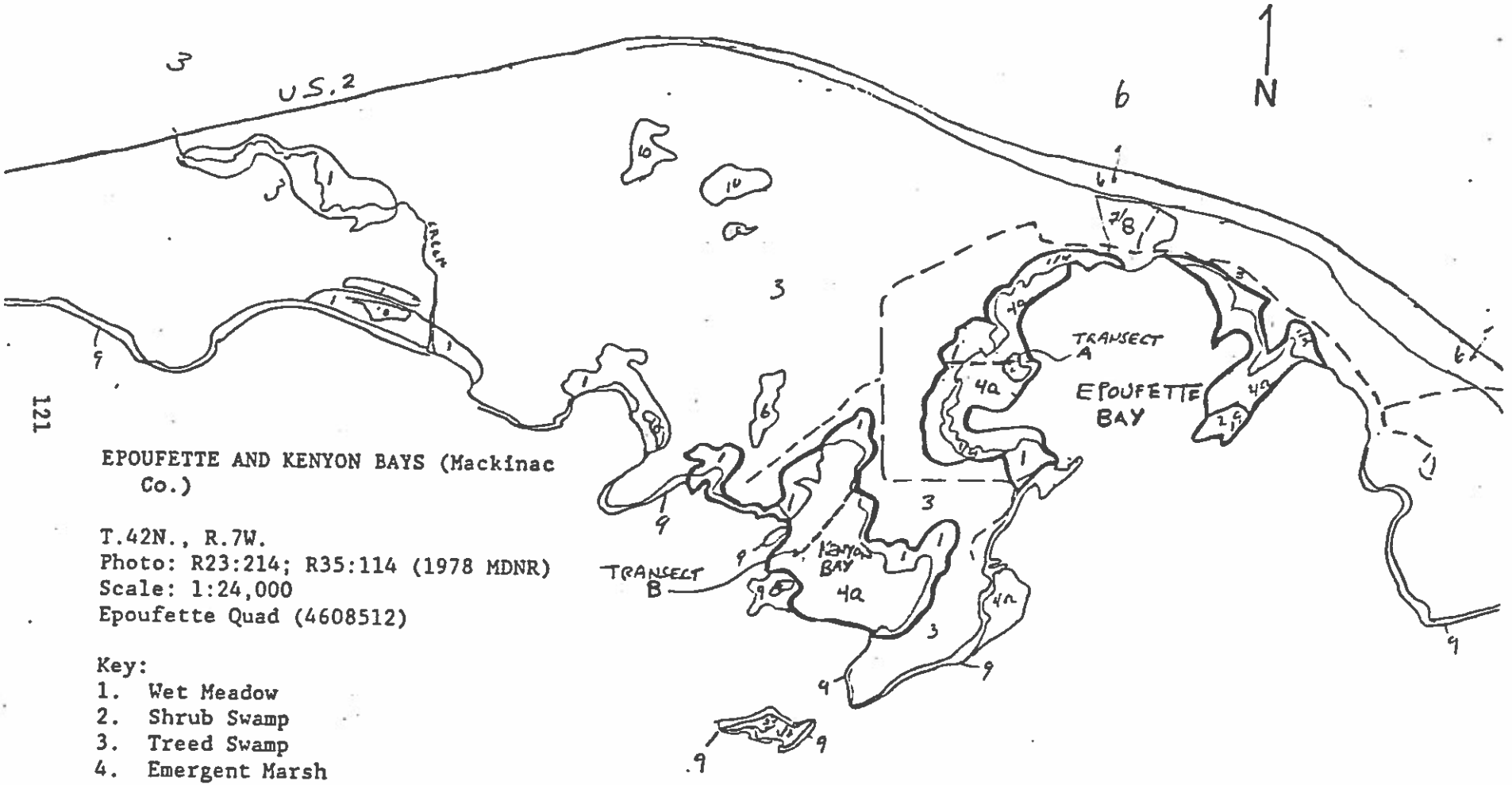
CECIL BAY (Emmet Co.)

T.39N., R.4W.
Photo: R100:194; R66:90 (1978 MDNR)
Scale: 1:24,000
Levering and McGulpin Point
Quads (4508467 and 4508477)



Key:
1. Wet Meadow
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
5. Submergent Marsh
6. Upland Forest
7. Agriculture
8. Urban/Residential
9. Beach
10. Pond

Sampled by Gary Reese, Dan Wujek, and Ben Stark, August 1989.
Mapped by Gary Reese and Dennis Albert, MNFI, 1989.

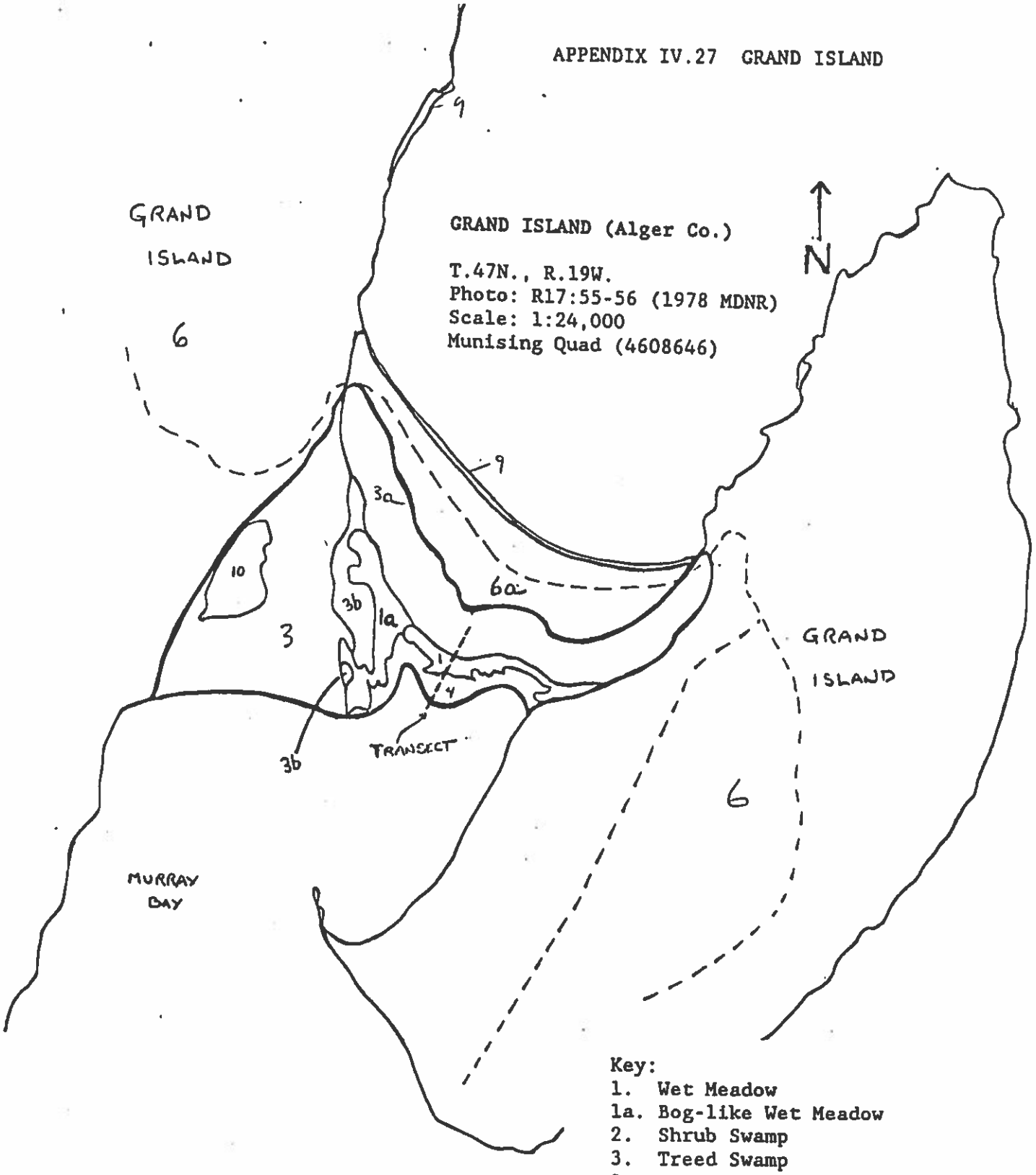


EPOUFETTE AND KENYON BAYS (Mackinac Co.)

T.42N., R.7W.
Photo: R23:214; R35:114 (1978 MDNR)
Scale: 1:24,000
Epoufette Quad (4608512)

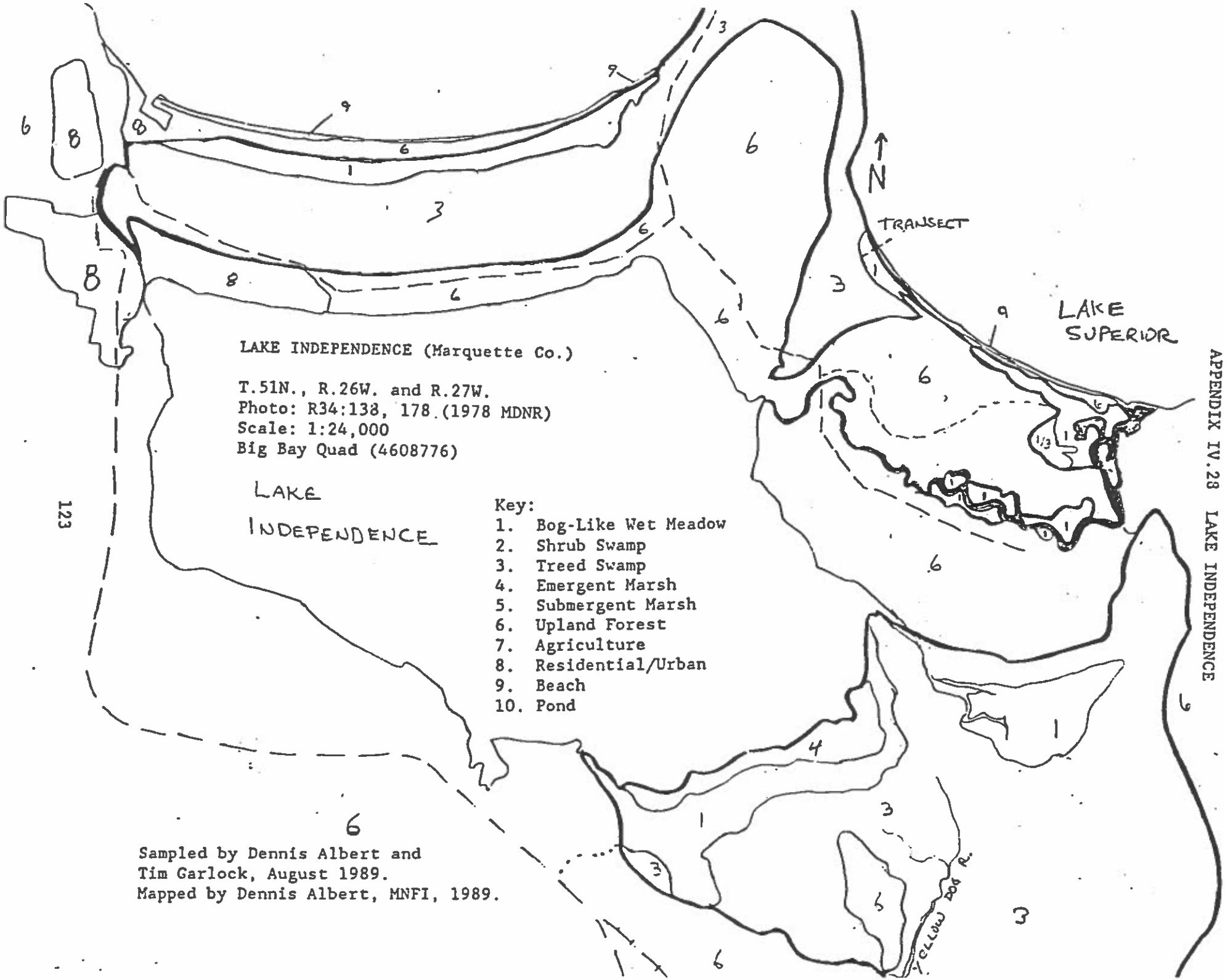
Key:
1. Wet Meadow
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
4a. Open Emergent Marsh
5. Submergent Marsh
6. Upland Forest
7. Agriculture
8. Residential/Urban
9. Beach
10. Pond

Sampled by Dennis Albert and Tim Garlock, August 1989.
Mapped by Dennis Albert, MNFI, 1989.



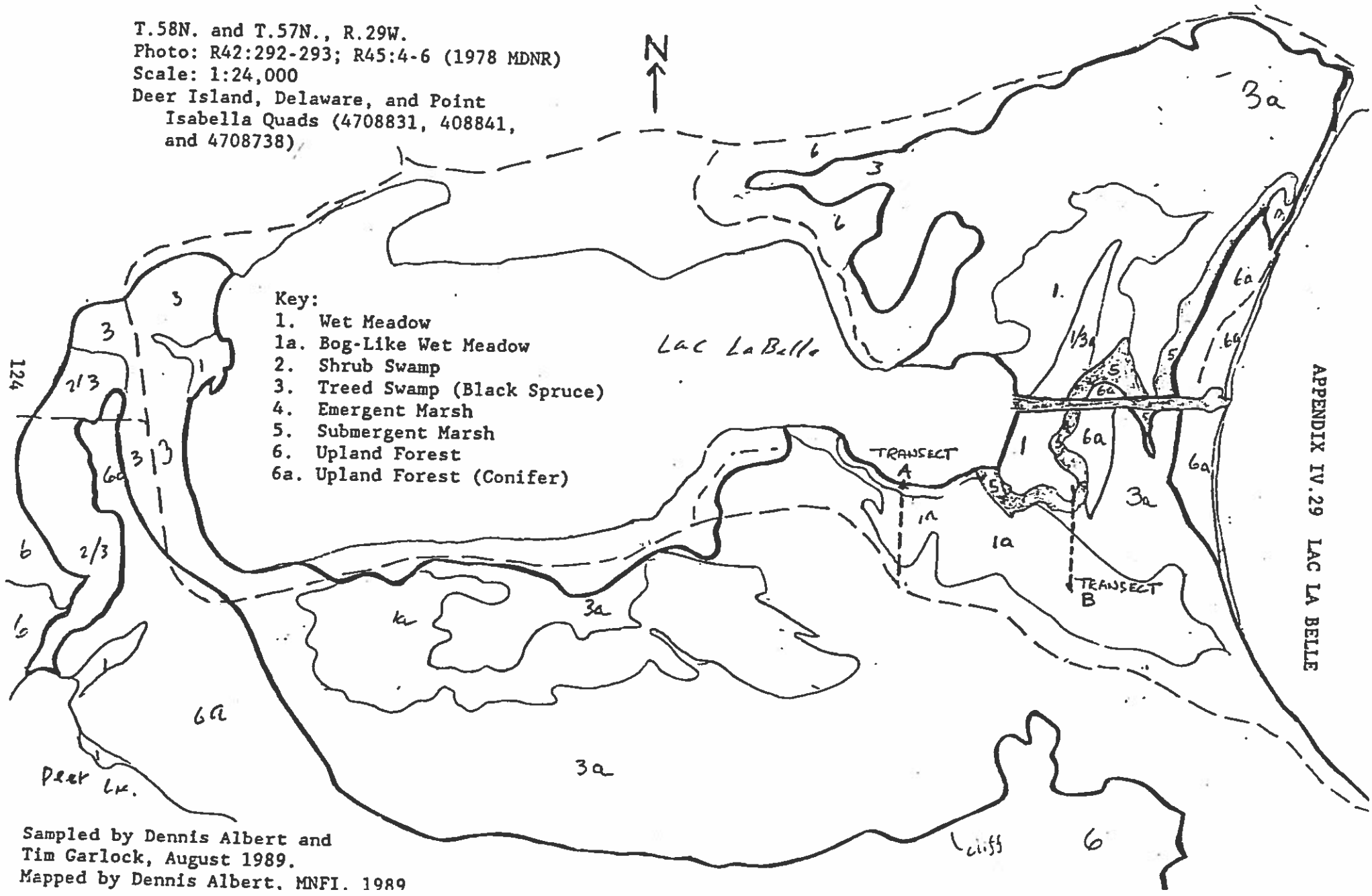
Key:
1. Wet Meadow
1a. Bog-like Wet Meadow
2. Shrub Swamp
3. Treed Swamp
3a. Treed Swamp on Beach Ridge/Swale
3b. Treed Swamp on Bog Mat
4. Emergent Marsh
5. Submergent Marsh
6. Upland Forest (Hardwood)
6a. Upland Forest (Conifer)
7. Agriculture
8. Residential/Urban
9. Beach
10. Pond

Sampled by Dennis Albert and
Tim Garlock, August 1989.
Mapped by Dennis Albert, MNFI, 1989.


LAKE INDEPENDENCE (Marquette Co.)
T.51N., R.26W. and R.27W.
Photo: R34:138, 178 (1978 MDNR)
Scale: 1:24,000
Big Bay Quad (4608776)
LAKE INDEPENDENCE
Key:
1. Bog-Like Wet Meadow
2. Shrub Swamp
3. Treed Swamp
4. Emergent Marsh
5. Submergent Marsh
6. Upland Forest
7. Agriculture
8. Residential/Urban
9. Beach
10. Pond
N
TRANSECT
LAKE SUPERIOR
YELLOW DOG R.
123
Sampled by Dennis Albert and
Tim Garlock, August 1989.
Mapped by Dennis Albert, MNFI, 1989.

LAC LA BELLE (Keweenaw Co.)

T.58N. and T.57N., R.29W.
Photo: R42:292-293; R45:4-6 (1978 MDNR)
Scale: 1:24,000
Deer Island, Delaware, and Point Isabella Quads (4708831, 408841, and 4708738)



Sampled by Dennis Albert and Tim Garlock, August 1989.
Mapped by Dennis Albert, MNFI, 1989

APPENDIX IV.29 LAC LA BELLE