HISTORICAL WETLANDS OF MICHIGAN'S COASTAL ZONE AND SOUTHEASTERN LAKEPLAIN

prepared by

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ABSTRACT

In 1992, a one year project to map the historical wetlands of Michigan's coastal townships was initiated by the Michigan Natural Features Inventory (MNFI) and funded through a Michigan Coastal Zone Management grant. The southeast Michigan lakeplain, extending up to 35 miles inland (in St. Clair, Macomb, Wayne, Monroe, Washtenaw, and Lenawee counties) was also included. Information from the transcribed field notes and township plat maps of the General Land Office surveys conducted between 1816 and 1856 was used to locate and identify historical wetlands and surrounding upland vegetation types along section lines as they existed prior to wide-spread European settlement. This information was placed on mylar overlays of USGS topographic maps. Great Lakes shoreline boundaries, natural disturbances, and cultural features were also noted on the mylars. Wetland/vegetation type boundaries were interpolated between section lines using elevation lines, surface geology maps, soil type maps, MNFI field survey maps, and other vegetation maps where available. All mapped information was coded using an expanded version of the Michigan Resource Inventory System (MIRIS) cover type code system currently used by the Michigan Department of Natural Resources. Interpreted maps were then digitized for inclusion in the MIRIS database. This report will detail the methods used in map production, focus on the potential uses of this information in Monroe County, and along the Saginaw Bay shoreline, then provide an overview of Michigan's coastal wetlands from a regional perspective.

INTRODUCTION AND OVERVIEW

With the loss of an estimated 50% of the state's wetlands, and ever increasing pressure on those that remain, the need for identifying strategies for wetland protection and restoration is greater than ever. Nowhere in Michigan is this more urgent than in the Great Lakes coastal zone and southeastern lakeplain, where both historical wetland losses and current land use pressures reach some of their highest levels. The resulting wildlife habitat degradation and implications for Great Lakes water quality demand investment in wetland protection and restoration.

An understanding of the type, location, and ecological context of Michigan's historical wetlands is critical to the development of ecologically meaningful wetland mitigation and restoration. Estimates of the loss of different wetland types in different ecological regions of the state may be determined by comparing historical and current data. And very importantly, an historical database could be used as a reference point for addressing the immediate problem of cumulative impacts to wetlands due to fragmentation, degradation, and conversion. Patterns we see today in wetland hydrology, biodiversity, and ecosystem function will undoubtedly be more meaningful when placed in a historical context.

The only state-wide attempt at mapping Michigan's presettlement vegetation was completed by J.O. Veatch (1959). Veatch utilized soils maps as a primary reference for determining presettlement vegetation. He utilized various other sources as well, including local histories, botanical publications, and

writings from the early explorers. These maps (scale 1:500,000) do not identify specific wetlands, but provides an overall sense of tree species expected within a given township. Comparison of these maps with General Land Office surveys have indicated high levels of inaccuracy in portions of the state.

The township sketch maps and transcribed field notes of the original land surveys conducted between 1816 and 1855 by the General Land Office provide the best available record on the pre-European-settlement landscape of Michigan (Bourdo 1956). This square mile grid of the state surveyed during the establishment of 36 square mile townships provides a framework for this database. The township sketch maps vary considerably in their quality. They were produced at the time of the surveys without the benefit of a topographic map. Maps produced in early years of the surveys (southern, Lower Michigan) contain little information, often limited to lakes and streams. As the surveys progressed, increasingly more information was included. Those produced in the upper peninsula (Figure 1) include much information on wetland location and dominant tree species. Trygg (1964) produced composite maps for the Upper Midwest using these township sketch maps. His maps differentiate between prairie, marsh, bottom lands, and swamp. But, they do not indicate the dominant tree species of the swamps. He completed no maps for southern, Lower Michigan, due to the lack of information included.

Although survey methods saw minor modifications during the course of the Michigan surveys, the transcribed surveyors notes are

Figure 1: Township sketch map of the General Land Office surveys in Keweenaw County, Michigan.

much more consistent in quality throughout the state. Surveyors were instructed to note the occurrence of wetlands, comment on the agricultural potential of soils, and note the quantity and quality of timber resources as they were encountered along each section line (Caldwell 1990). Surveyors used trees at each section corner and half-mile post as "witness trees". Wherever trees were noted, their species and diameters were included. Tree species and diameters were also noted when they occurred along the section lines. At corner and half-mile posts, witness trees were selected from the closest tree to the northeast, northwest, southeast, and southwest quadrants. Often just two trees were marked and noted at each section corner. The exact bearing and distance between each witness tree at the corner and half-mile posts were also recorded. Natural disturbances, such as recent fires, windthrows, and beaver floodings were also recorded along the section lines, as were various cultural features, either of Native American origin, or early European settlers.

These detailed records formed the basis for the development of these historical wetland maps. The maps were compiled by plant ecologists familiar with the tree species, surface geology, and soils of Michigan's natural communities.

This report will discuss the methods used in map production and explore ways they can be utilized as tools for wetland protection and restoration. The final section will provide a regional overview of presettlement vegetation types and related natural processes in Michigan's coastal zone.

METHODS

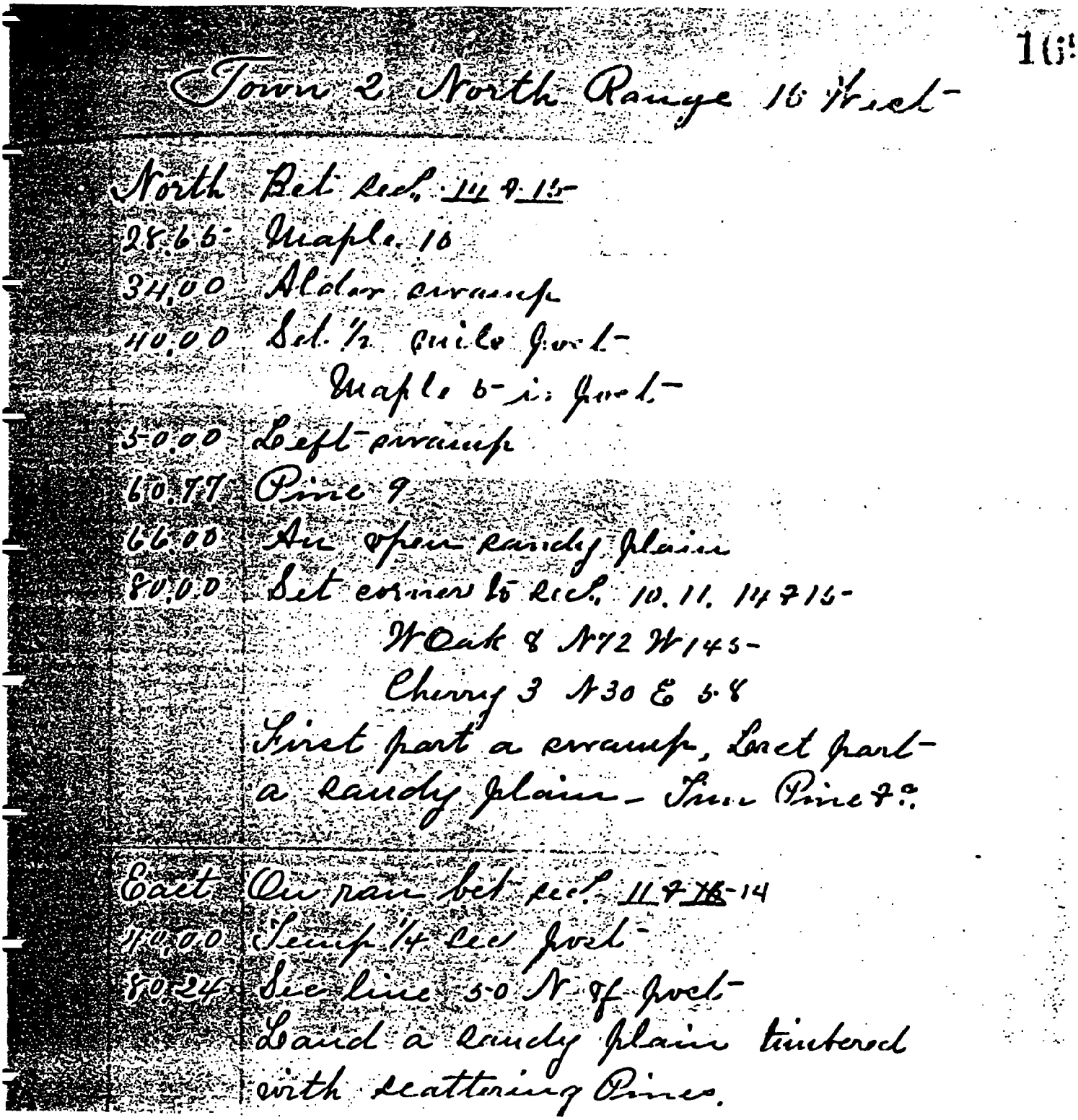
MAP PRODUCTION

The transcribed field notes of the General Land Office (GLO) surveys were made available to our mapping team by the State Archives of Michigan. Township sketch maps produced by surveyors were copied from microfilm available from the MDNR Real Estate Division. Matte mylar (18"x 24") was attached to 7.5 minute USGS topographic maps, which for Michigan, are available in 1:24,000 and 1:25,000 scales. A scale indicating chains (1 chain = 20 meters; 80 chains per mile) was used for precise measurements along each section line.

All information extracted from the GLO survey notes and maps appear on the mylar overlays and map borders. Information in the GLO notes are organized in a systematic pattern reflecting the measurement of each section line in the township (Figure 2). From a given corner point, comments are made along the next mile as it is measured out. Usually, wherever a feature is mentioned, the distance (in chains) along the line is noted as well.

Common names of tree species were abbreviated to 3-4 letter combinations (Table 1). Several species were noted more generically than others. For example "elm", "ash", and "maple" were commonly used without distinguishing the two or three native species that could have been encountered. Published floras and several other sources (Hutchinson 1988) were reviewed to determine which old common names referred to which tree species; (e.g. "spruce pine" = jack pine, "yellow pine" = red pine). Tree

FIGURE 2: Sample page of transcribed GLO field notes from Southwest Michigan.



Town 2 North Range 16 West

North Bet Sec. 11 & 15-

28.65 Maple 16

34.00 Alder swamp

40.00 Set ½ Mile Post-

Maple 6-12 Post-

53.00 Left swamp

60.77 Pine 9

66.00 Ar open sandy plain

80.00 Set corner to Sec. 10. 11. 14 & 15-

W Oak & N72 W14 S-

Cherry 3 N30 E 5.8

First part a swamp, Last part-

a sandy plain - Some Pine &c.

East On run bet Sec. 11 & 14-14

40.00 Temp ¼ Sec Post-

80.24 See line 53.00 N of Post-

Land a sandy plain timbered

with scattering Pines.

TABLE 1: TREE SPECIES ABBREVIATION, ALIAS, COMMENTS, AND SCIENTIFIC NAME

ABBREV	SPECIES	ALIAS	COMMENTS	SCIENTIFIC NAME
ALD	SPECKLED ALDER			Alnus rugosa
APPLE	APPLE			Malus spp.
ASH	ASH		WHITE, BLACK, OR RED	Fraxinus spp.
ASP	ASPEN		QUAKING OR BIG TOOTH	Populus spp.
B ASH	BLACK ASH			Fraxinus nigra
B POP	BALSAM POPLAR	BALM OF GILEAD		Populus balsamifera
B WALN	BLACK WALNUT			Juglans nigra
BCH	BEECH			Fagus grandifolia
BL ASH	BLUE ASH			Fraxinus quadrangulata
BL BCH	BLUE BEECH	MUSCLE WOOD		Carpinus caroliniana
BO	BLACK OAK	SOMETIMES YELLOW OAK	PROB. INCLUDES PIN OAK ON LAKEPLAIN	Quercus velutina
BRCH	BIRCH			Betula spp.
CED	CEDAR			Thuja occidentalis
CHER	CHERRY			Prunus serotina
COTN	COTTONWOOD			Populus deltoides
ELM	ELM	AMERICAN OR SLIPPERY		Ulmus spp.
FIR	BALSAM FIR			Abies balsamea
G HEM	CANADA YEW	GROUND HEMLOCK		Taxus canadensis
GRAPE	GRAPEVINE			Vitis spp.
GUM	BLACK GUM	PEPPERIDGE		Nyssa sylvatica
HACK	HACKBERRY			Celtis occidentalis
HAZL	WITCH HAZEL			Hamamelis virginiana
HCK	HICKORY			Carya spp.
HEM	HEMLOCK			Tsuga canadensis
IRON	IRONWOOD	HORNBEAM		Ostrya virginiana
LYN	BASSWOOD			Tilia americana
PIN	PIN OAK	JACK OAK	CONSISTANT USE UNCERTAIN	Quercus palustris
POPL	BIG TOOTH ASPEN POPLAR			Populus grandidentata
PR ASH	PRICKLY ASH			Zanthoxylum americanum
Q ASP	QUAKING ASPEN			Populus tremuloides
R BUD	RED BUD			Cercis canadensis
RO	RED OAK		N.PIN OAK ALSO IN U.P.	Quercus rubra
S MAPL	SOFT MAPLE	RED MAPLE OR SILVER MAPLE		Acer spp.
SAS	SASSAFRAS			Sassafras albidum
SM	SUGAR MAPLE	SUGAR, HARD MAPLE		Acer saccharum
SP	JACK PINE	SPRUCE PINE		Pinus banksiana
SPICE	SPICEBUSH			Lindera benzoin
SPR	SPRUCE			Picea spp.
SWO	SWAMP WHITE OAK	SWAMP OAK		Quercus bicolor
SYC	SYCAMORE			Platanus occidentalis
TAM	TAMARACK	TAMARACH		Larix laricina
THORN	HAWTHORN	THORN		Crayaegus spp.
WBRCH	WHITE BIRCH			Betula papyrifera
WMAPL	SILVER MAPLE		USE NOT CONSISTANT	Acer saccharinum
WSPR	WHITE SPRUCE			Picea glauca
WIL	WILLOW			Salix spp.
WO	WHITE OAK			Quercus alba
WP	WHITE PINE	PINE		Pinus strobus
WTWD	TULIP TREE	WHITEWOOD, BUTTONWOOD (?)		Liriodendron tulipifera
W WALN	BUTTERNUT	WHITE WALNUT		Juglans cinerea
Y BRCH	YELLOW BIRCH			Betula alleghaniensis
YO	CHINQUAPIN OAK	YELLOW OAK	POSSIBLY BLACK OAK	Quercus muehlenbergii
YP	RED PINE	YELLOW PINE		Pinus resinosa

abbreviations reflect the common name used by the surveyors. Tree abbreviations and diameter at breast height (DBH), were located along each section line at the approximate distance (in chains) where they were mentioned in the notes. At each section corner, tree abbreviations, DBH, bearing, and distances were noted. Surveyor's comments were added at the end of each section line. They often included a ranked list of tree species, impressions of soil character, and drainage characteristics. These comments, where they added significant ecological information, were copied to the mylars in quotes along the section line. Wetland boundaries were located along each section line with the township sketch maps and/or at the chain distance mentioned in the notes. The township sketch maps were found to compare accurately with the chain distances mentioned in the field notes. The same was true for the locations of natural disturbances such as windthrows and recent fires. The exception to this was where topography was very steep, as along sand dunes, steep ravines, and in some drumlin fields.

The wetland boundaries were interpolated between section lines primarily by using elevation lines on the topographic maps. Soil Survey maps (USDA, various dates) and Soil and Lay of the Land maps (Michigan Land Economic Survey 1925) were found to be helpful in some circumstances where wetland soils could be clearly distinguished and wetlands appeared to cross elevation lines. The presettlement vegetation map of Brewer et.al. (1984) was utilized in the interpretation of vegetation types along the

southwestern Michigan shoreline. There were cases where surveyors did not note their entrance and exit from a forested wetland, but instead noted in their comments that the "...last mile, wet". These situations were most common on flat topography where the land was likely a mosaic of uplands and wetlands. When this occurred, the forested wetland boundary was interpreted more generally, using the comments and noted tree species that were encountered along the section line. Likewise, boundaries of upland cover types were established using the dominant tree species and associated landform and soil types. Boundaries in several complex wetland areas of the Upper Peninsula were established using 1986 aerial photography. MNFI data from field surveys of Great Lakes Marshes and Wooded Dune and Swale Complexes were used to clarify wetland boundaries in sampled areas. Great Lakes shoreline boundaries were interpreted from points of intersection with section lines and the prevailing orientation of current shorelines (where not obviously manipulated artificially). Surveyor's notes on meanders along the shoreline were **not** used, since normal water level fluctuations resulted in inconsistencies along the shoreline, depending on the year of the survey. Boundaries for natural disturbances were interpolated between section lines taking topography and likely fire breaks into account. Cultural features, both Native American and early European, were placed on the mylars as mentioned in the notes.

Because of the amount of information provided on the

township maps for the Upper Peninsula townships, these maps were utilized as the primary information source in those areas. These township maps were enlarged to a scale of 1:48,000 (half the scale of the 7.5 minute topographic maps). The points where wetland boundaries intersected section lines were then easily and accurately transferred to the mylars. The notes on vegetation composition present on the township maps was used to code uplands and wetlands. Additional information on these maps was obtained by recording surveyor's section line information along only the township boundaries and selected wetland areas. Vegetation type boundaries were interpolated between section lines in the same manner as described for Lower Peninsula townships.

The cover type codes used in the Michigan Resource Inventory System (MIRIS) were utilized, in an expanded form, to identify the various cover types, natural disturbances, and cultural features, as they could be distinguished from the GLO notes. MIRIS codes at the four digit level identify the **dominant** species and not necessarily the **only** species present. The MIRIS code system was expanded to capture the complexity of upland and wetland communities known to occur in the pre-settlement landscape that were distinguishable in the survey notes (Table 2).

Mapped wetlands were graded according to the level of degradation apparent from the topographic maps (Table 2). Original project plans included the analysis of aerial photos to establish this grade. But, given that these maps were last

Table 2: EXPANDED MIRIS AND WETLAND GRADE CODES FOR HISTORICAL WETLANDS MAPS

PALUSTRINE

62 NON-FORESTED WETLAND

622 EMERGENT MARSH/MEADOW/PRAIRIE

- 6221 EMERGENT MARSH
- 6222 GREAT LAKES MARSH
- 6223 INTERDUNAL WETLAND
- 6224 WET MEADOW
- 6225 INLAND SALT MARSH
- 6226 LAKEPLAIN PRAIRIE
- 6227 INLAND WET PRAIRIE

623 MUD FLATS

- 6231 MARL FLATS

612 SHRUB-DOMINATED WETLAND

- 6121 BOG
- 6122 ALDER/WILLOW/BOG BIRCH THICKET
- 6123 BUTTONBUSH/DOGWOOD/WILLOW SWAMP
- 6124 PATTERNED PEATLAND

91 LANDSCAPE COMPLEX

911 WOODED DUNE/SWALE COMPLEX

4 FORESTED WETLAND

41 HARDWOOD/CONIFER - HARDWOODS PREDOMINATING

414 LOWLAND HARDWOOD (BROADLEAF)

- 4141 ASH
- 4142 ELM
- 4143 SILVER/RED MAPLE
- 4144 COTTONWOOD
- 4145 BALSAM POPLAR
- 4146 ASPEN
- 4147 WHITE BIRCH
- 4148 BLACK WILLOW

42 HARDWOOD/CONIFER - CONIFERS PREDOMINATING

423 LOWLAND CONIFER

- 4231 CEDAR
- 4232 BLACK SPRUCE
- 4233 TAMARACK
- 4234 BALSAM FIR/WHITE SPRUCE
- 4235 BALSAM FIR
- 4236 JACK PINE
- 4237 HEMLOCK

LACUSTRINE

- 51 MAJOR RIVER
- 52 LAKE OR POND
- 54 GREAT LAKES

WETLAND GRADE:

I = **INTACT**; well buffered, no manipulations.
D = **DEGRADED**; lacking complete buffer.
M = **MANIPULATED**; any activity effecting hydrology.
E = **ELIMINATED**; all or most of area gone.

TERRESTRIAL

3 NONFORESTED (grassland - savanna)

- 31 HERBACEOUS - UPLAND GRASSLAND
- 32 SHRUB - SHRUB SAVANNA
- 33 TREE SAVANNA
  - 331 LAKEPLAIN OAK OPENING
  - 332 OAK BARRENS
  - 333 PINE BARRENS
  - 334 OAK/PINE BARRENS
  - 335 BUR OAK SAVANNA

4 FORESTED

411 NORTHERN HARDWOODS

- 4111 S.MAPLE, BEECH
- 4119 BEECH, HEMLOCK

412 CENTRAL HARDWOODS

- 4121 BEECH, S. MAPLE, BASSWOOD, R.OAK
- 4122 WHITE OAK, HICKORY BLACK OAK
- 4123 BLACK OAK, W. OAK,
- 4124 PIN/BLACK OAK

413 ASPEN/WHITE BIRCH

414 LOWLAND HARDWOODS

421 PINE

- 4211 WHITE PINE
- 4212 RED PINE
- 4213 JACK PINE
- 4215 RED PINE/JACK PINE
- 4216 RED PINE/WHITE PINE
- 4217 WHITE PINE/WHITE OAK

422 OTHER UPLAND CONIFER

- 4221 WHITE SPRUCE
- 4223 BALSAM FIR/SPRUCE/ CEDAR (BOREAL)
- 4226 HEMLOCK
- 4227 HEMLOCK/WHITE PINE
- 4228 HEMLOCK/S.MAPLE

OPEN, LITTLE/NO VEGETATION

- 72 BEACH, RIVERBANK
- 73 OPEN SAND DUNE
- 74 EXPOSED BEDROCK
  - 741 ALVAR
  - 742 BEDROCK GLADE
  - 743 SINKHOLE
  - 744 LIMESTONE LEDGE/OUTCROP
  - 745 SANDSTONE LEDGE/OUTCROP

NATURAL DISTURBANCES/CULTURAL FEATURES

- 92 WILDFIRE
- 93 WINDTHROW
- 94 BEAVER FLOODING
- 95 IMPACTS OF GREAT LAKES WATER LEVEL FLUCTUATIONS
- 96 CULTURAL FEATURES (both Native American and early European)

updated with the 1978 aerial photographs, the vast majority of wetland manipulations are visible from the maps alone. More recent photo imagery was used in Oceana and Grand Traverse counties, where recent development has been most dramatic, and in the analysis of specific restoration projects. The wetland grade codes include:

I for intact; signifying a well buffered (>100 meters), undisturbed wetland;
D for degraded; signifying an incomplete buffer;

M for manipulated; signifying some man-made alteration that could effect the hydrology of the wetland, e.g. roads, drains, upstream impoundments etc.
E for eliminated; signifying the apparent complete (or nearly complete) destruction of the wetland, also applied to drained marshes that are now apparently upland forest.

The original project plans also included a code to distinguish the source of degradation, i.e. agriculture, impoundments, urban development, etc. This was found to be extremely difficult in that many very large wetlands were degraded by many different activities. The coding system established summarizes the most important information necessary for regional planning purposes.

MAP DIGITIZING

Once cover type boundaries had been interpreted and codes were assigned to all cover types, the maps were proofed and then digitized using MicroStation software. Cover type boundaries and associated codes were digitized. To avoid cluttering the final digitized maps, surveyors comments were included (in quotes) only where they added significant information to the final map product.

For example, if the surveyors commented on a wet prairie four times in the course of traversing it, one comment, or a composite of the various comments was included in the digitized map. For most broadly defined upland cover types (such as Northern Hardwoods), a ranked species list was included on each topographic map in order to reflect the relative composition of tree species for that local area. Where wetlands clearly including a mixture of a number of tree species with no clear dominant, a short, ranked list of species was included. An example in this case would be a swamp dominated by three conifer species. This area would be given a three digit code 324 (indicating Lowland Conifer), and a ranked list of those species would appear as text.

During the digitizing process, current MIRIS cover types were brought up on the screen for direct comparisons with the historical interpretations. For wetlands that were traversed by surveyors (those intersecting section lines), if there was disagreement between historical interpretation and current cover type, the historical interpretation was maintained. For apparently intact wetlands occurring entirely within the interior portions of a section, the MIRIS code was adopted for the historical map. In these cases, below the code a (MIRIS) notation will appear, indicating the source of that information. The same is true for other portions of the state where sources other than the GLO notes were used to determine the historical vegetation type. The name and date of that source appears in parentheses.

Digitized maps are stored in the MIRIS system in files

organized by county. Table 3 indicates the layers in MIRIS where digitized information is stored. Any combination of these layers may be turned "on" or "off" depending on the type of information desired by the user.

GIS processing was completed for maps included in this report with Modular GIS Environment (MGE PC-1). Calculated acreages for historical cover types were then comparable with those of current cover types on file with MIRIS for Michigan counties and townships.

Table 3: LAYER INFORMATION FOR HISTORICAL WETLANDS FILES IN MIRIS.

LAYER	DESCRIPTION
1	linework (land cover)
2	code (MIRIS/MNFI land cover)
3	text (select GLO comments)
4	Source (MIRIS), (Anderson, 1817), (MNFI, 1987),
5	text (More GLO comments for Lenawee, Monroe, Wayne, and Macomb counties.)
6	wetland grade (E,M,D,or I)
7	wildfire lines "92"
8	windthrow lines "93"
9	beaver flooding lines "94"
10	shoreline fluctuation "95"
11	Cultural Features (Native American or early European "96"
12	Native American/early European trails
13	landscape complex "911"
14	county border
15	label for 92, wildfire
16	label for 93, windthrow
17	label for 94, beaver flooding
18	label for 95, Great Lakes fluctuation
19	label for 96, cultural features
20	label for 911 landscape complex
21	grade for 911 landscape complex
38	quad tics
39	quad lines
40	quad names
63	section lines

RESULTS AND DISCUSSION

There are limitations associated with the use of the General Land Office surveys that should be clear to all users of interpreted maps. Given that these surveys were not undertaken as a scientific sample of vegetation, they should clearly not be considered as such. They do, however, provide a wealth of information available nowhere else.

We used records from the original surveys where they had been found to be adequate by the Surveyor General. There were a large number of townships re-surveyed because the original surveys were found to be either very inaccurate or completely fraudulent. In these cases, we used the records from the re-surveys completed during the 1840's and 1850's. These survey records were found to be quite reliable, in that they corresponded quite well with features on current topographic maps. Portions of the state where private claims had already become established by 1816 were the most difficult areas to map. Surveys records related to these private claims are often incomplete and quite difficult to utilize. Survey maps from several early roads were found to include useful vegetation information for the private claims portions of Monroe County (Anderson 1817; Risdon 1828).

Historical wetland boundaries are most reliable where they intersect with the section line. The interpolated boundary line between each section line should be considered an approximation that could vary on the ground, based on local variation not apparent with available topographic and soil maps.

All wetlands explicitly identified along each section line were graded based on current condition (I=intact, D=degraded, M=manipulated, E=eliminated). Wetlands with boundaries **not** explicitly mentioned by the surveyors were **not** given a wetland grade. Boundaries for these areas, mainly classed as "Lowland Hardwoods" and "Lowland Conifer" types were interpreted using tree species along each section line, along with surveyors comments, such as "part wet", and "swampy, last half mile". These areas tended to occur in a mosaic of upland and wetland, too complex for surveyors to map and distinguish clear boundaries.

In southern Lower Michigan, the establishment of wetland boundaries associated with Lakeplain Oak Openings was also problematic. These areas were clearly noted by the surveyors, but it is difficult to determine the extent of these areas that was wetland in character. Lakeplain Oak Openings typically include a dry and dry-mesic portion associated with beach ridges on the lakeplain (MNFI 1990). However, since they typically graded into wet-mesic and wet prairies, a portion would also be considered wetland. This should be taken into account when viewing statistics related to historical area coverage for these cover types. Because of extensive agricultural drainage over many years, soils maps usually do not delineate these areas very well. Accurate calculations of wetland/upland percentages in these areas would require detailed on-ground work in locations where they are still intact.

A limited number of trees were noted along each mile-long

section line, so interpretation of boundaries for these more generally defined wetlands and most upland types should be recognized in this context. Historical cover type maps will sometimes appear more generalized when overlain with current MIRIS cover types. Current MIRIS cover type maps were developed using aerial photographs of what is often a highly fragmented modern landscape. We have no equivalent imagery for 1816-1855 cover types. MIRIS cover type maps often demonstrate vegetation changes that have resulted from historical land management, such as drainage, logging, and post-agricultural land use.

The MIRIS cover type code system was found to be useful when expanded to encompass the range of plant communities recognizable from the survey record. The primary weakness of the MIRIS code system is that many types were established with forest industry in mind. As a result many single species forest types are described, when in reality, natural forests are seldom comprised of only one species. The cover type codes on historical wetland maps, when taken to the fourth digit, should be interpreted by the user to indicate the **dominant tree species** of the area, not the **only** tree species present. Users should consult with published reports, consultants, etc. for expanded plant and animal species lists which would likely be associated with the specific cover type.

SAMPLE MAP PRODUCTS AND SELECTED RESTORATION PROJECTS

Presettlement cover type maps can be utilized as a base map for understanding historical wetland locations, dominant species

composition, and drainage patterns. This information is vital for efficient planning of wetland restoration projects. Once digitized, these maps can be processed in a Geographic Information System (GIS) environment. This processing generates a database for information portrayed on the maps, allowing us to query that database for information useful to our purposes. In this section, we will present and discuss various map products and analyses that can be completed using this digital database by focusing on Summerfield Township within Monroe County, Monroe County as a whole, and a two-county portion of the Saginaw Bay shoreline.

SUMMERFIELD TOWNSHIP, MONROE COUNTY

Summerfield Township, in western Monroe County, provides a typical comparison between presettlement and current conditions for the southeastern Michigan lakeplain. Today, land use in this township is concentrated in intensive agriculture. The Petersburg State Game Area is also included within this township (Figures 3 and 4). Tables can be derived from analyses of the of presettlement vegetation and current MIRIS cover type maps (Tables 4 and 5). These tables indicate that agriculture has clearly been the dominant land use and is responsible for the vast majority of wetland losses in the township. Excluding historical Oak Openings from our calculations, and assuming all current acreages of Lowland Hardwoods are in fact wetlands, 15.6% of the 9376 acres of presettlement wetlands of Summerfield Township remain in some form.

FIGURE 3: SUMMERFIELD TOWNSHIP, PRESETTLEMENT VEGETATION

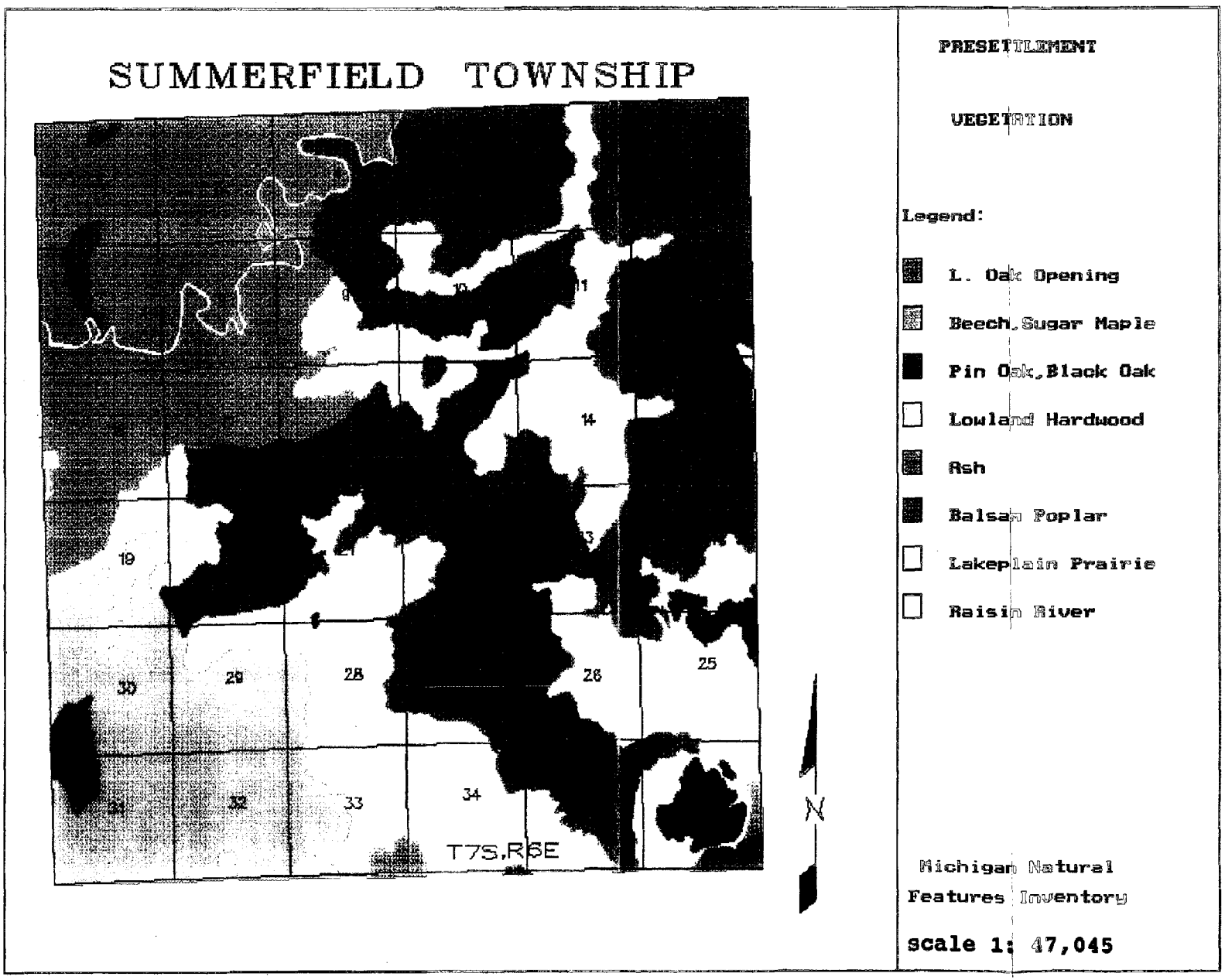


FIGURE 4: SUMMERFIELD TOWNSHIP, PRESENT LAND COVER

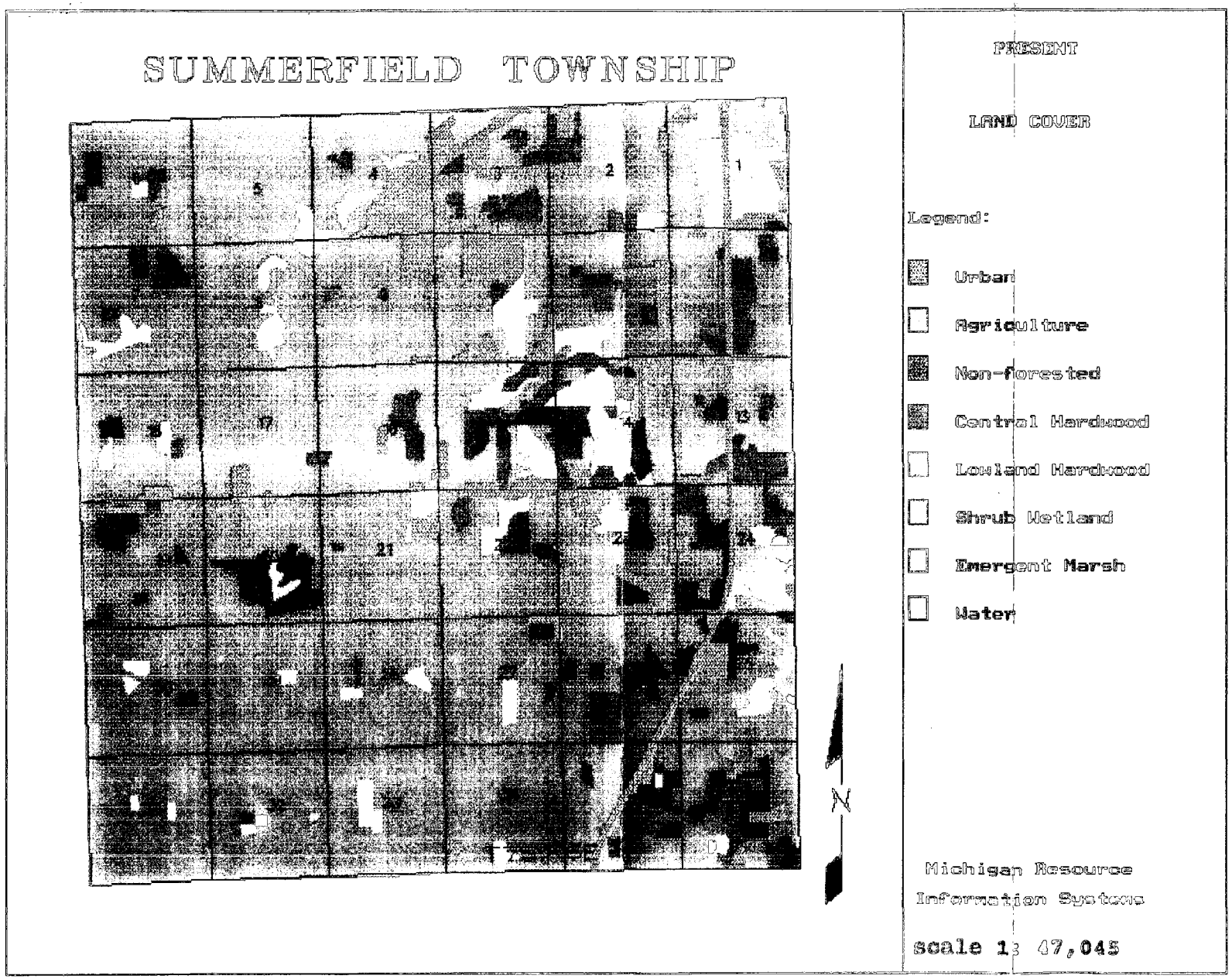


TABLE 4: Summary of Presettlement Cover Types of Summerfield Township, and acreages of each grade for current condition of wetland types.

Cover Type	Code	Total Acreage	%	I	D	M	E
Central Hardwoods (Red Oak, Sugar Maple)	4121	4147	17.8				
Central Hardwoods (Pin/Black Oak)	4124	362	1.5				
Lakeplain Oak Opening	331	9278	39.9				
Lowland Hardwoods	414	2847	12.2		(no grade given)		
Black Ash Swamp	4141	123	0.5				123
Balsam Poplar Swamp	4145	174	0.7				174
Lakeplain Prairie	6226	6232	26.8			1890	4341
Major River	51	76	0.3				
		23,241	99.7				

TABLE 5: Summary of Present Cover/Use Types (MIRIS) for Summerfield Township.

Cover Type	Code	Total Acreage
Urban, Residential	11	952
Commercial, Industrial, etc.	12,13	96
Transportation, Communication, etc.	14	286
Extractive, Open pit	17	8
Open Land, Cemeteries	194	5
Agriculture	2	18,234
Non-Forested, Herbaceous	31	123
Non-Forested, Shrub	32	222
Central Hardwoods	412	1845
Lowland Hardwoods	414	1360
Wetland, Shrub, Scrub	612	38
Wetland, Emergent	622	70
Lake	52	35
		23,274

Most accurate area comparisons between presettlement and current wetlands are derived by comparing presettlement acreages with current MIRIS acreages. Utilizing the wetland grade categories of the presettlement maps may over-estimate current wetland acreages because portions of wetlands graded as Degraded and/or Manipulated are often now completely eliminated.

The remaining wetland acreages as noted by MIRIS are, for the

most part, remnants of manipulated Lakeplain Prairie located in and around the Petersburg State Game Area. Most of the Lakeplain Prairies were eliminated by widespread ditching and draining, which disrupted the characteristic water table fluctuations responsible for their establishment and persistence. When extensive areas are drained, and all wildfires are suppressed, adjacent prairies tend to close in, becoming Lowland Hardwood forests. Portions of the current Non-Forested Shrub, Scrub and Non-Forested Herbaceous areas are probably also remnants of Lakeplain Prairie identified in presettlement vegetation maps.

In upland forest categories, acreages of Central Hardwoods appear to have decreased by only 19%. This reflects the amount of forest land remaining in small farm woodlots, which was derived from historical Lakeplain Oak Openings that became closed-canopy oak forests as a result of wildfire suppression, and Lakeplain Prairie that has been completely drained, and converted to oak-dominated lowland forest (interpreted for MIRIS as uplands).

RESTORATION OPPORTUNITIES

Several tracts in and around the Petersburg State Game Area present excellent opportunities for restoring the Lakeplain Prairies which once characterized the majority of the local landscape. The presettlement vegetation map (attached) plotted at 1:24,000 scale can overlay a 7.5 minute topographic map and help to clarify historical drainage patterns where agricultural drainage has caused significant alterations (also see Figures 3 and 4).

Several private tracts immediately adjacent to the south boundaries of the Game Area (Figure 5), although mostly old fields and closed canopy Lowland Hardwoods, contain pockets of prairie vegetation that may be restored through fire management and re-establishing historical water table fluctuations. The southeast corner of section 14 appears to be drained though the Williams Drain and the Denzel Drain. The southeast corner of section 15 appears to be drained by the Stacy Drain, which runs southwest to northeast through the Game Area.

Investigation into the extent of drain tiling along the Stacy Drain, Denzel Drain, and Williams Drain may suggest some practical alternatives for restoring these prairies if these private tracts were acquired and included within the Game Area.

MONROE COUNTY

Similar to the analysis of Summerfield Township, we can generate maps and tables for individual counties. The presettlement vegetation map of Monroe County indicates the location and extent of the various upland and wetland types. These maps may enhance our understanding of the relative position of certain wetland types within a given watershed, or in relation to other factors, such as soils and major landforms (Figure 6). Tables 6 and 7 indicate presettlement and current conditions for Monroe County.

Land use trends in Monroe County reflect those found in Summerfield Township, with significant acreages of wetlands

FIGURE 5: Private tracts associated with Petersburg State Game Area with potential for prairie restoration.

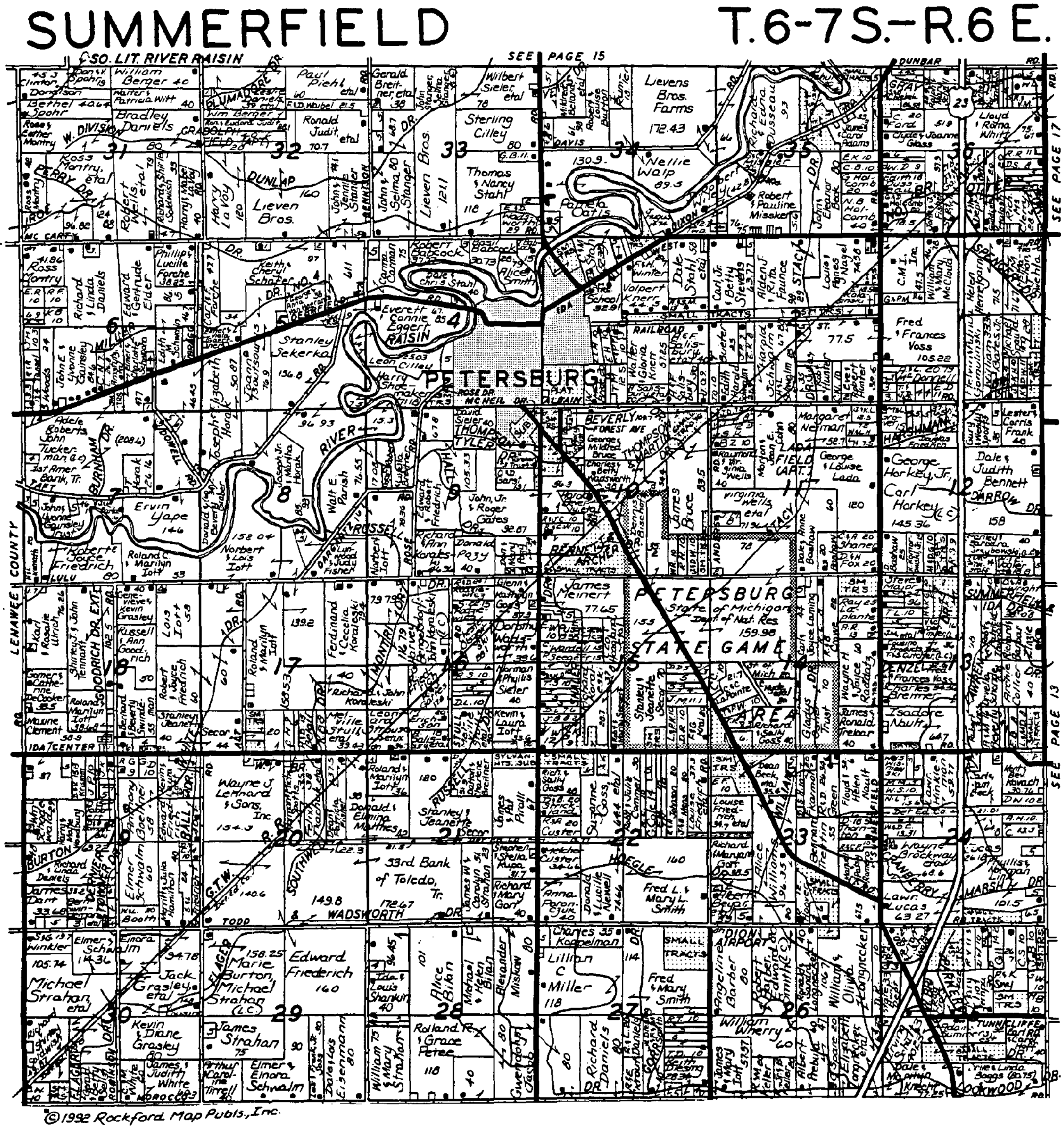
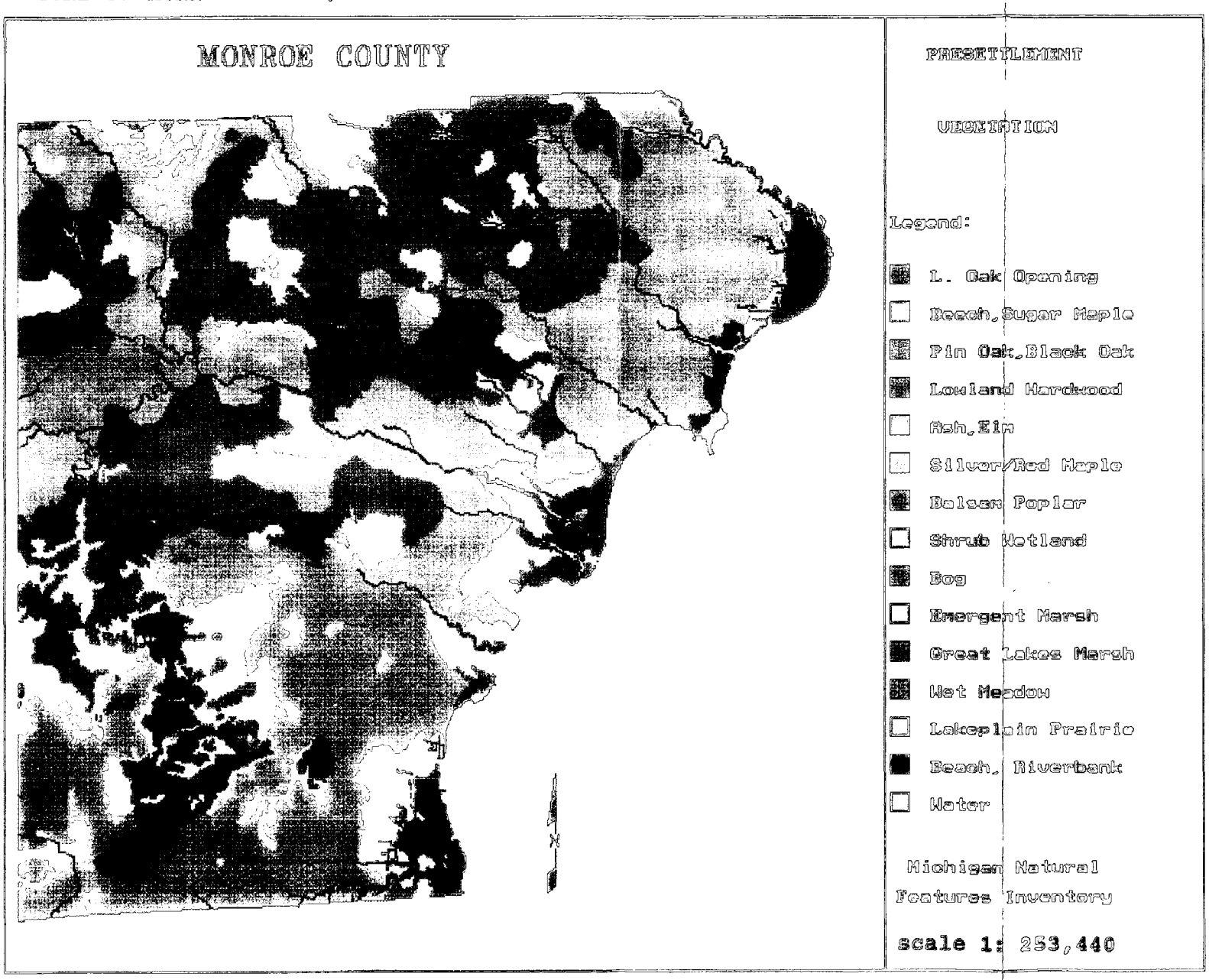


FIGURE 6: MONROE COUNTY, PRESETTLEMENT VEGETATION



converted for agricultural purposes since European settlement in the early 1800's. The extent and diversity of wetlands in Monroe

TABLE 6: Summary of Presettlement Cover Types for Monroe County, and acreages of each grade for current condition of each wetland type.

Cover type	Code	Total Acreage	%	I	D	M	E
Central Hardwoods (Beech, Sugar Maple)	4121	161,152	44.61				
Central Hardwoods (Pin/Black Oak)	4124	14,759	4.10				
Lakeplain Oak Openings	331	47,767	13.22				
Lowland Hardwoods	414	59,796	16.55	(not graded)			
Black Ash Swamp	4141	6,608	1.82	137	597	0	5873
Elm Swamp	4142	205	0.06	109	28	68	
Silver/Red Maple Swamp	4143	30	0.01			30	
Balsam Poplar Swamp	4145	442	0.12	172		269	
Other Lowland Hardwood	4149	125	0.03				125
Shrub Swamp	612	35	0.01	35			
Bog	6121	41	0.01		32		9
Emergent marsh	6221	454	0.12	33			421
Great Lakes Marsh	6222	11,433	3.16			3854	7579
Wet Meadow	6224	388	0.11				388
Lakeplain Prairie	6226	56,158	15.55		1159	9421	45578
Beach, Riverbank	72	49	0.01				
Major River	51	985	0.27				
Lake, Pond	52	781	0.22				
		361,208	99.98				

Table 7: Summary of Present Cover/Land Use Types (MIRIS) for Monroe County.

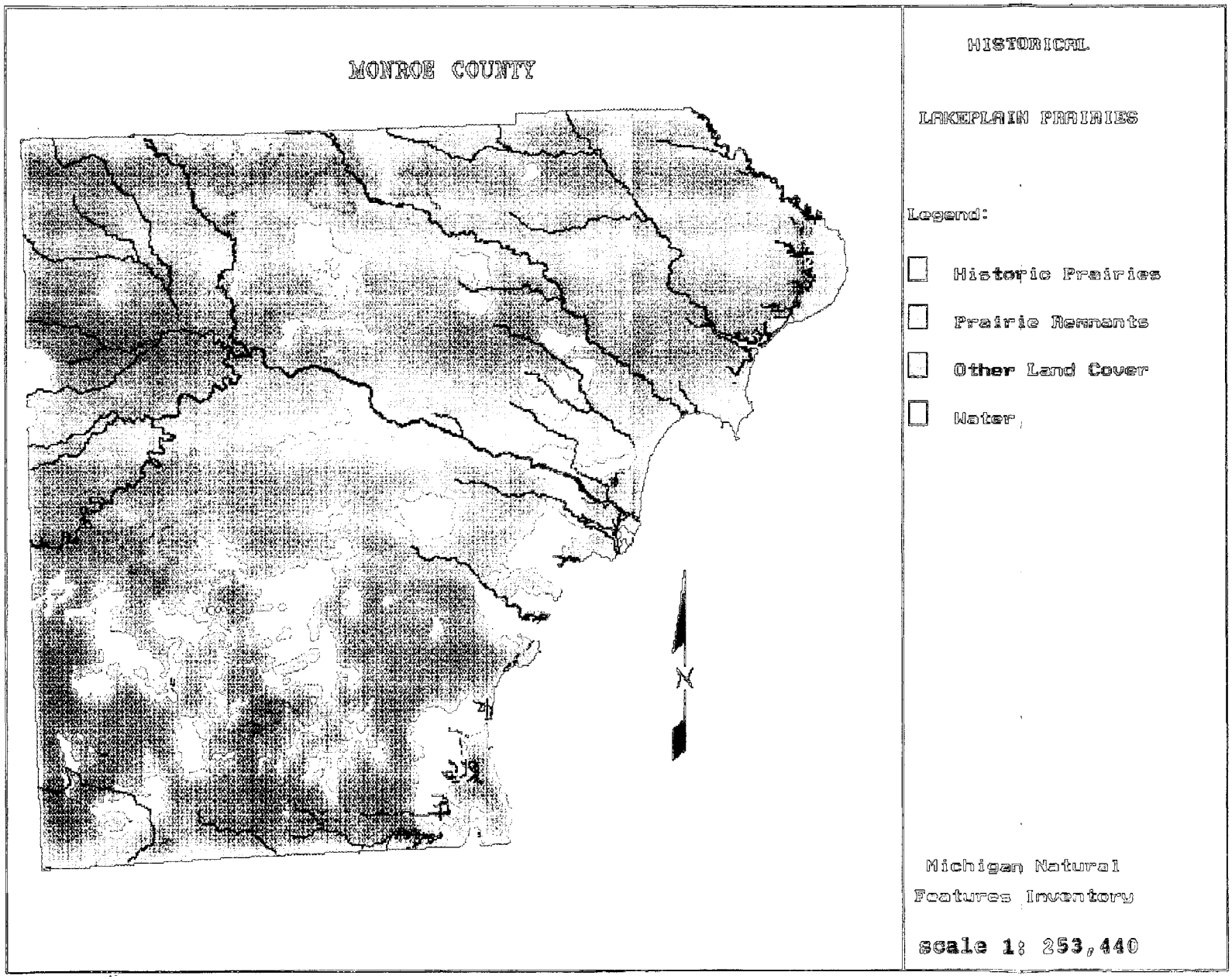
Cover type	Code	Total Acreage	%
Residential, Commercial	11,12	27,917	7.90
Industrial, Communications	13,14	4,579	1.30
Extractive, Open pit, gravel	17	1,490	0.42
Open Land, Cemeteries	19	3,405	0.97
Agriculture	2	264,476	75.19
Non-Forested Herbaceous	31	4,888	1.39
Non-Forested Shrub	32	5,693	1.62
Central Hardwoods	412	18,095	5.14
Aspen/Birch and associated	413	41	0.01
Lowland Hardwoods	414	13,713	3.89
Lowland Conifer	423	25	0.01
Shrub Swamp	612	1,444	0.41
Aquatic Bed Wetland	621	9	<0.01
Emergent Wetland	622	1,812	0.51
Flats	623	8	<0.01
Barren Land	70	542	0.15
Riverbanks	72	39	0.01
		351,743	98.92

County has decreased quite dramatically since that time. Again, by excluding Oak Openings from calculations, and assuming all areas currently typed as Lowland Hardwoods are indeed wetlands, Monroe County today contains 12.5% of the 163,954 acres of wetlands that were present in 1817. Trends in forest and prairie cover as mentioned for Summerfield township are all reflected in statistics for Monroe County as a whole. Areas currently typed as Emergent Wetland and Shrub Swamp are found along the Lake Erie shoreline in what was historically Great Lakes Marsh and Lakeplain Prairie. The prairies further inland have, for the most part, converted to Lowland Hardwoods after extensive drainage and wildfire suppression. Only 8% of the 223,678 acres of upland forests and savannas of Monroe County remain today.

WETLAND INVENTORY APPLICATIONS

Developing a digital database for presettlement wetland types allows us to quickly and accurately locate potential restoration projects targeted to specific types of wetlands. For example, there is increasing interest in locating and restoring Lakeplain prairies due to their global rarity and because they provide habitat for many rare plant species. One may query our database for Monroe County and plot a map of all prairie remnants - that is, all prairies graded as Intact, Degraded, and Manipulated, in one color, with all other historical prairies in another color (Figure 7). These maps clearly indicate where clusters of prairie remnants occur. By combining a number of counties, the

FIGURE 7: MONROE COUNTY, HISTORICAL PRAIRIES



full range of a particular wetland type could be plotted for range-wide inventories and analyses.

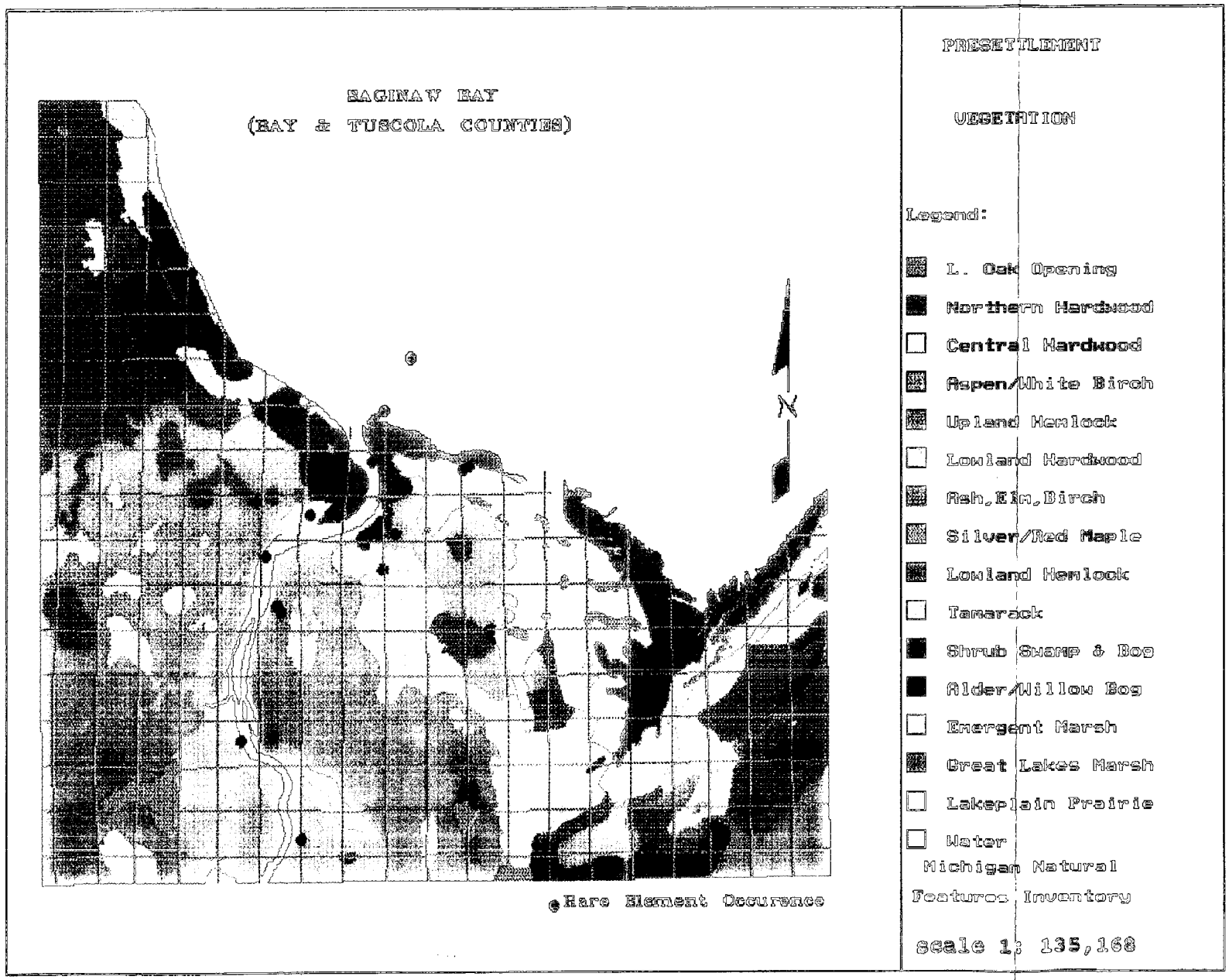
OTHER ANALYSES

Because acreages for current MIRIS cover types are available on a whole-county basis, it is not possible to generate statistics for areas smaller than a county without GIS processing. However, we can generate maps and acreage statistics from presettlement cover type maps for any portion of the coastal zone, regardless of political boundaries.

We can also overlay any other layer currently in MIRIS with these presettlement maps that will enhance the analysis of a given area. For example, the Saginaw Bay shoreline is receiving increasing attention given it's value for wildlife and concern over water quality in the bay. By taking a given portion of this shoreline, we can overlay known occurrences of rare plant and animal species, and high quality natural community occurrences (Figure 8) to identify areas where wetland restoration may enhance habitat for rare species.

Surveyors described the southern portions of the Saginaw Bay shoreline as being "unexcelled habitat for ducks, geese, shorebirds, and fur bearers". Table 8 summarizes the acreages of each presettlement vegetation type included in this area. Although, as noted earlier, comparisons between presettlement and current wetland acreages may be inaccurate when only using the wetland grades of the presettlement maps, they can give a general comparison when no other current statistics are easily available.

FIGURE 8: SAGINAW BAY SHORELINE (BAY AND TUSCOLA COUNTIES), PRESETTLEMENT VEGETATION.



In this case, of the 67,817 acres of presettlement wetlands in the southern Saginaw Bay area, about 15,700, or 23% remain in some form. The majority of these remaining wetlands are located within the Tobico Marsh State Game Area, the Crow Island State Game Area, and the Quanicassee Wildlife Area.

Table 8: Summary of Presettlement Vegetation along Saginaw Bay in portions of Bay and Tuscola, and Saginaw counties; and acreages by current grade for wetland type.

Cover Type	Code	Acreage	%	I	D	M	E
Central Hardwoods	412	45,301	36.21				
Hemlock (uplands)	4226	9,218	7.36				
Northern Hardwoods	4111	20	0.01				
Aspen/White Birch	413	4	<0.01				
Lakeplain Oak Openings	331	605	0.48				
Lowland Hardwoods	414	17,339	13.86				
Black Ash Swamp	4141	9,532	7.61		361	780	8391
Elm Swamp	4142	1,095	0.87		190		905
Silver/Red Maple Swamp	4143	1,053	0.84				1053
White Birch Swamp	4147	153	0.12				153
Hemlock Swamp	4237	44	0.03				44
Tamarack Swamp	4233	5,301	4.23			2353	2947
Shrub Swamp	612	175	0.14				175
Bog	6121	26	0.02				26
Alder/Willow Swamp	6122	108	0.09				108
Emergent Marsh	6221	9,707	7.76		124	8091	1492
Great Lakes Marsh	6222	10,177	8.13			3712	6465
Lakeplain Prairie	6226	13,107	10.48			80	13,027
Major River	51	2,135	1.71				
		125,106					

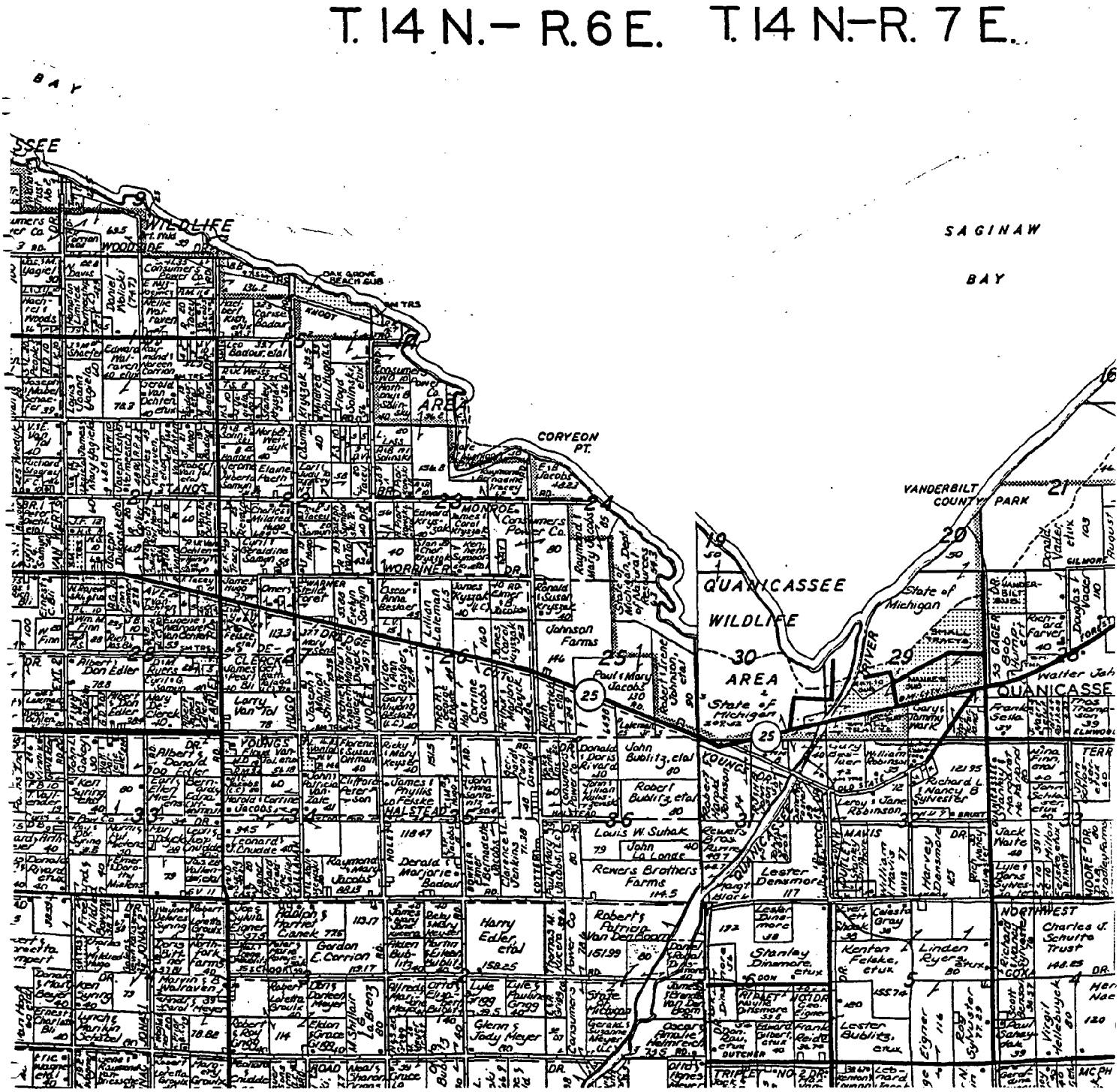
RESTORATION OPPORTUNITIES

Significant opportunities exist for the restoration of Great Lakes Marsh and Lakeplain Prairie all around the Quanicassee River mouth. Historically, the marsh and prairie extended inland up to four miles along the Saginaw Bay shoreline. All of this area, surrounding several State Game Areas, which are located along a narrow strip of shoreline, has been extensively drained for

agriculture.

Study of the presettlement vegetation along this stretch of shoreline has indicated the extent of movement of the marsh/prairie border, depending on the stage of fluctuation in the Great Lakes' water-level. The dynamics of this Great Lakes Marsh system should be utilized for cost-effective wetland restoration. Analysis of the network of agricultural drains in place throughout this shoreline area is one step toward development of a long-term plan for wetland restoration. State acquisition of private holdings immediately adjacent to these state wildlife areas would be necessary (Figure 9). The gradual removal of drains and drain tiles, from the shoreline extending inland, could slowly re-establish the unexcelled wildlife habitat described by surveyors.

FIGURE 9: 1992 Plat map for tracts surrounding the Quanicassee Wildlife Area, Bay County, Michigan.



OVERVIEW OF HISTORICAL WETLANDS IN MICHIGAN'S COASTAL ZONE

Wetlands, as they occurred across the presettlement landscape, are best understood within the context of surrounding plant communities and broader landscape ecosystems. The following discussion of Michigan's historical wetlands will therefore be framed within the context of Michigan's Regional Landscape Ecosystems as defined by Albert et al. (1986). These landscape units were derived by integrating climatic, landform, soil, and vegetative factors. They provide a useful framework for classifying plant communities and understanding the variation in landscape processes as they occur throughout the state. Using this approach, landscape ecosystems are defined in a hierarchy of three levels in a nested series, from broad landscape regions down to district and subdistrict levels (Figures 10 and 11; Tables 9 and 10).

Climatic factors for each of the four landscape regions will be briefly discussed prior to more detailed descriptions of climate, landform and soils, presettlement vegetation, natural disturbances, and post-settlement human impacts for each district and/or subdistrict(s) which comprises the coastal zone in that portion of the state. Much of the following discussion was taken from Albert et al.(1986). Discussions of presettlement vegetation were taken from these previous works, and from data collected while compiling these presettlement vegetation maps.

FIGURE 10: Regional Landscape Ecosystems of Lower Michigan, Regions I and II.

(from Albert et.al. 1986)

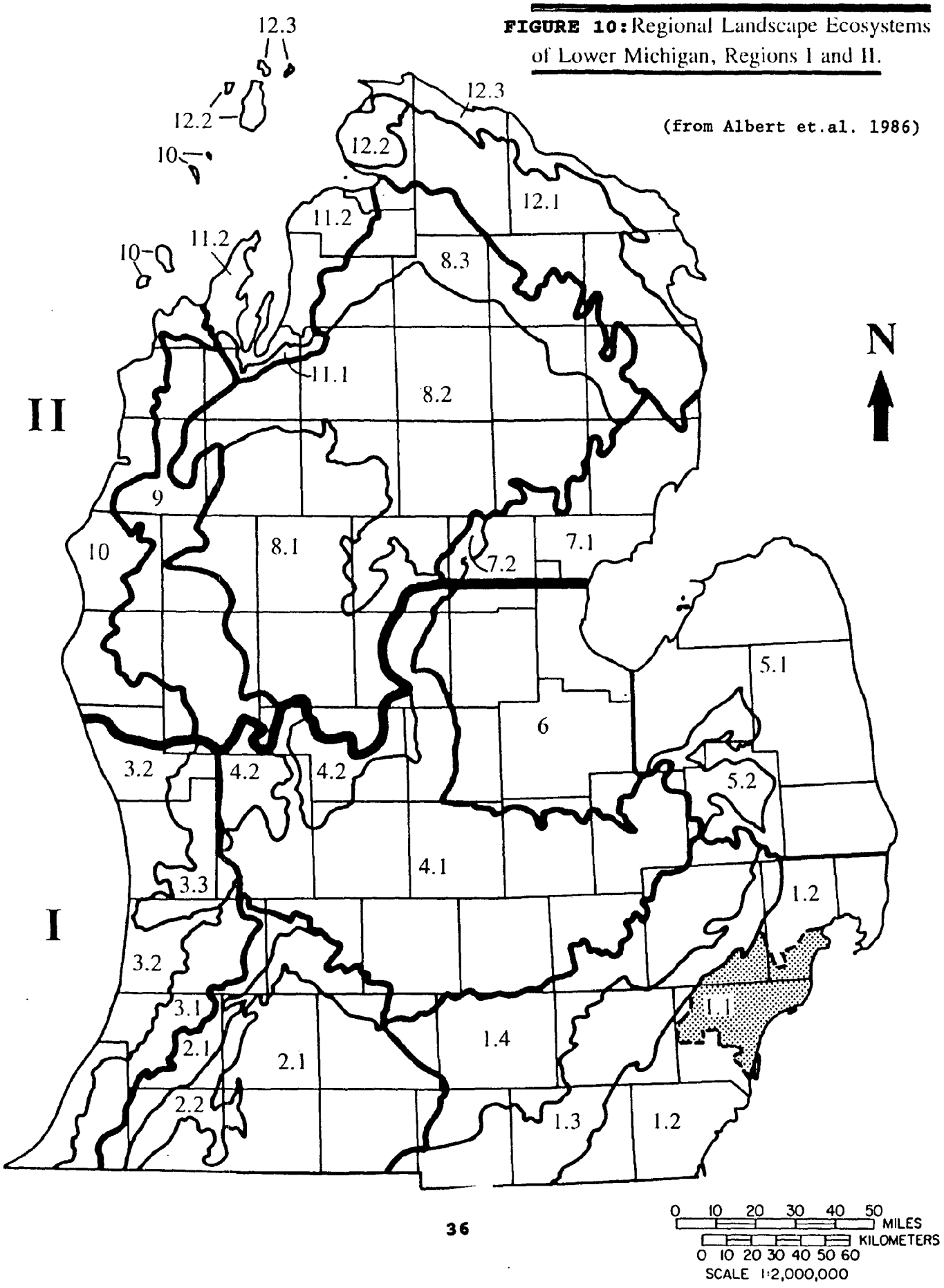


TABLE 9: Regional Landscape Ecosystems of Lower Michigan, Regions I and II.

(from Albert et.al 1986)

No.	District	Subdistrict	Site Condition	Area Sq Mi (km²)
Region I: Southern Lower Michigan				
1.1	Washtenaw	Detroit	Heat island	
1.2		Maumee	Lake plain	2300 (5960)
1.3		Ann Arbor	Fine and medium-textured moraine	1635 (4235)
1.4		Jackson	Interlobate; coarse-textured end moraine, outwash, and ice-contact typography	2060 (5335)
2.1	Kalamazoo	Battle Creek	Outwash and ground moraine	2770 (7175)
2.2		Cassopolis	Coarse-textured and end moraine and ice-contact terrain	720 (1865)
3.1	Allegan	Berrien Springs	End and ground moraine	760 (1970)
3.2		Benton Harbor	Lake plain	1355 (3510)
3.3		Jamestown	Fine-textured end and ground moraine	490 (1270)
4.1	Ionia	Lansing	Medium-textured ground moraine	4810 (12460)
4.2		Greenville	Coarse-textured end and ground moraine	760 (1970)
5.1	Huron	Sandusky	Lake plain	3210 (8319)
5.2		Lum	Medium and coarse-textured end-moraine ridges and outwash	480 (1245)
6.1	Saginaw		Lake plain	2390 (6190)
Region II: Northern Lower Michigan				
7.1	Arenac	Standish	Lake plain	1295 (3355)
7.2		Wiggins Lake	Fine-textured end and ground moraine	110 (285)
8.1	Highplains	Cadillac	Coarse-textured end moraine	2860 (7405)
8.2		Grayling	Outwash	4085 (10580)
8.3		Vanderbilt	Steep end- and ground-moraine ridges	1505 (3900)
9	Newaygo		Outwash	1920 (4975)
10	Manistee		End moraine and sand lake plain	1480 (3835)
11.1	Leelanau	Williamsburg	Coarse-textured end-moraine ridges	100 (260)
11.2		Traverse City	Coarse-textured drumlin fields on ground moraine	750 (1940)
12.1	Presque Isle	Onaway	Drumlin fields on coarse-textured ground moraine	1845 (4780)
12.2		Stutsmanville	Steep and ridges	270 (700)
12.3		Cheboygan	Lake plain	835 (2165)

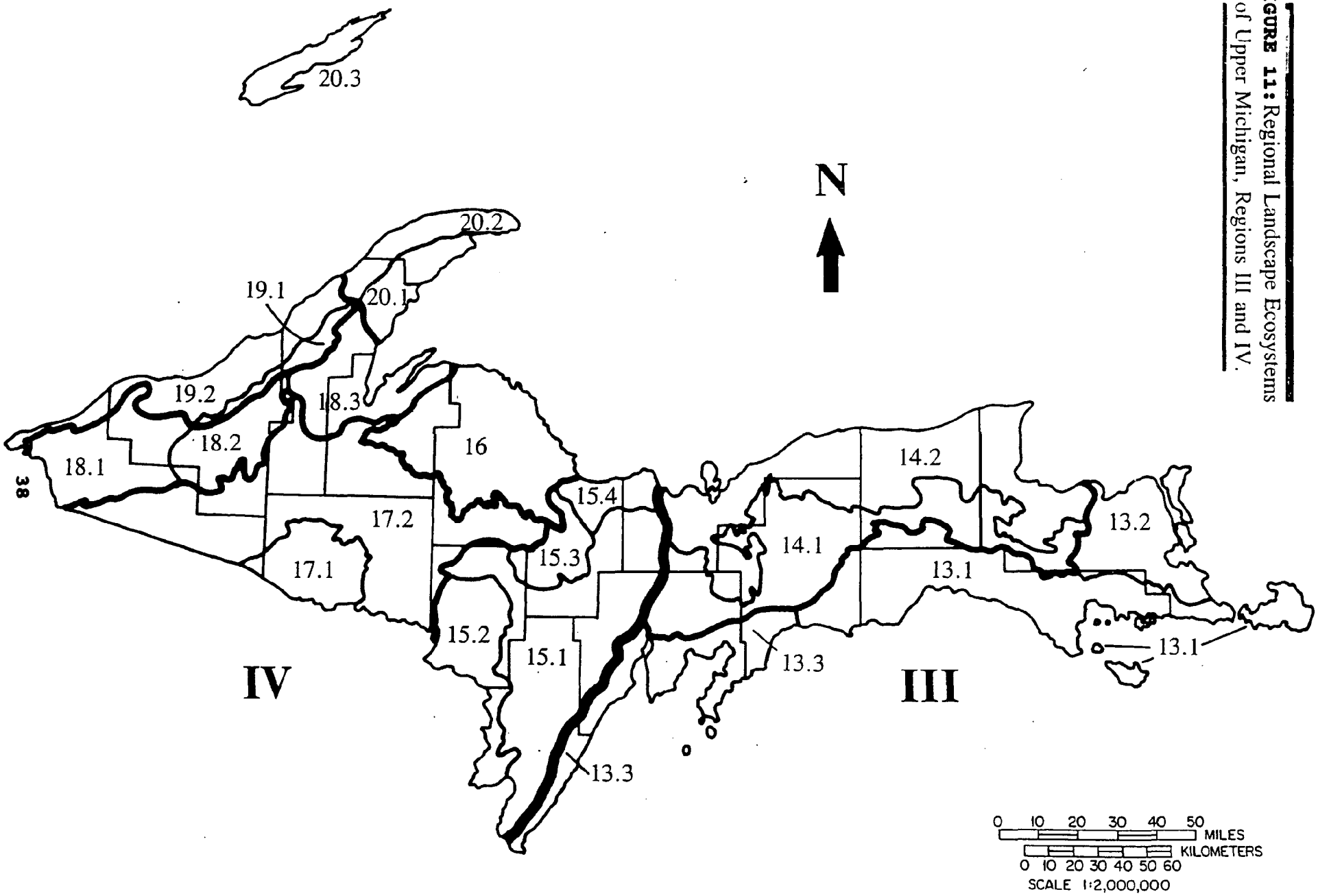
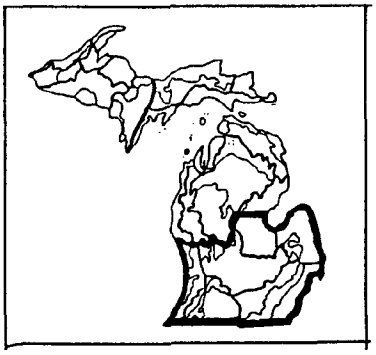


FIGURE 11: Regional Landscape Ecosystems of Upper Michigan, Regions III and IV.

TABLE 10: Regional Landscape Ecosystems of Upper Michigan, Regions III and IV.

No.	District	Subdistrict	Site Condition	Area Sq Mi (km^2)
Region III: Eastern Upper Michigan				
13.1	Mackinac	St. Ignace	Limestone bedrock and sand lake plain	1580 (4090)
13.2		Rudyard	Clay lake plain	600 (1555)
13.3		Escanaba	Limestone bedrock and sand lake plain	780 (2020)
14.1	Luce	Seney	Poorly drained sand lake plain	1515 (3925)
14.2		Grand Marais	Sandy end moraine, shoreline, and outwash plains	1905 (4935)
Region IV: Western Upper Michigan				
15.1	Dickinson	Hermansville	Drumlins and ground moraine	1855 (4805)
15.2		Norway	Granitic bedrock and end moraine	595 (1540)
15.3		Gwinn	Poorly drained sandy outwash	265 (685)
15.4		Deerton	Sandstone bedrock and high, sandy ridges	225 (580)
16	Michigamme		Granitic bedrock	1160 (3005)
17.1	Iron	Iron River	Drumlinized ground moraine	465 (1205)
17.2		Crystal Falls	Kettle-kame topography, outwash, and sandy ground moraine	2390 (6190)
18.1	Bergland	Bessemer	Large, high, coarse-textured ridges and metamorphic bedrock knobs	745 (1930)
18.2		Ewen	Dissected clay lake plain	450 (1165)
18.3		Baraga	Broad ridges of coarse-textured rocky till	575 (1490)
19.1	Ontonagon	Rockland	Narrow, steep bedrock ridge	135 (350)
19.2		White Pine	Clay lake plain	655 (1695)
20.1	Keweenaw	Gay	Coarse-textured broad ridges and swamps	275 (710)
20.2		Calumet	High igneous and sedimentary bedrock ridges and knobs	285 (740)
20.3		Isle Royale	Island of igneous bedrock ridges and swamps	230 (595)

INDEX TO REGIONAL CHARACTERIZATIONS



REGION I. Southern Lower Michigan.

REGIONAL CLIMATE: The climate of the region is strongly influenced by Gulf air mass, with some lake-effect snows and moderation of temperature from Lake Michigan (Albert et al. 1986, Denton 1985, Eichenlaub 1979, Eichenlaub et al. 1990). The southern Lower Peninsula of Michigan experiences a greater frequency of warm humid air masses originating in the Gulf of Mexico and a lower frequency of cold dry air masses of continental origin than the remainder of the state. Winter precipitation is high, 180-260 mm (23-26 percent of annual precipitation). Annual precipitation is 32 to 38 inches (Eichenlaub et al. 1990). Annual average snowfall is 36 inches inland to 100 inches along the Lake Michigan shoreline. The

growing season length is 130 to 170 days (Eichenlaub et al. 1990), similar to that of Regions II. Extreme minimum temperatures are relatively warm, from -16 to -34°F, as a result of buffering by the Great Lakes.

DISTRICT 1. Washtenaw.
SUBDISTRICTS 1.1 and 1.2 Detroit and Maumee: Lake Plain.

CLIMATE: Climate is somewhat moderated by Lake St. Clair, and Lake Erie. The growing season is generally long, ranging from 160 to 170 days at the southern edge of the district and from 140 to 160 days at the northern edge; growing season is longer near the shorelines of the Great Lakes and shorter inland. The average annual minimum temperature is -20°F in the south and -24°F in the north. Snowfall is relatively low throughout the district, ranging from 30 inches in the south to 80 inches in the north. Average annual precipitation ranges from 28 to 34 inches.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The subdistricts are part of a relatively flat plain of glacial lacustrine origin. The lacustrine deposits extend into Ohio along the western end of Lake Erie. The lacustrine deposits, which consist of sands and clays, are thickest along the farthest inland edge of the lake plain and thinnest along the present shorelines of Lakes Huron, St. Clair, and Erie. Along Lake Erie, inland thicknesses of lacustrine deposits are greater than 100 ft, whereas thicknesses of less than 5 ft are common near the Lake Erie shoreline.

Within the broad clay lake plain, there are several broad sand channels, created when sand was deposited into the shallow pro-glacial lakes by glacial meltwater streams. These sand channels can be several miles wide, but the sand in them is generally only 5 to 10 feet thick. Poorly drained mineral soils characterize the clay plain. The sand-channel deposits were reworked by wave action during higher levels of the Great Lakes, creating small sand dunes and spits and intervening depressions. The soils of the dunes and spits is often excessively well drained, whereas that in the swales is poorly or very poorly drained.

PRESETTLEMENT VEGETATION: The presettlement vegetation of the clay lakeplain and sand lakeplain were very different. The majority of

the clay lakeplain supported forest, either upland or wetland. In contrast, the sand lakeplain supported oak barrens (savanna) on the uplands and wet prairies or marshes in the lowlands.

Clay Lakeplain. The forests of the clay lakeplain responded to differences in slope class and drainage. On the flatter portions (10 feet/mile slope or less) of the lakeplain or in shallow basins or depressions, Lowland Hardwoods (414) were prevalent. In the closed depressions, black ash (4141) was the common dominant. Where the topography was flat or gradually sloping, black ash was still the dominant species, but American elm and basswood were also common co-dominants. As slope increased slightly and drainage conditions improved, beech, white oak, white ash, and hickory became more common, but were generally less common than black ash and elm. Cottonwood, sycamore, [trembling] aspen, and [red or silver] maple were other common wetland species of the clay lakeplain.

Central Hardwood forest (4121) occurred on those portions of the clay lakeplain where drainage conditions were best, generally in those areas where streams had improved drainage conditions. These mesic forests were dominated by American beech, sugar maple, white oak, [American] elm, and hickory, but black ash (Lowland Hardwoods, ash=4141) was also relatively common, probably occupying small depressions or vernal pools on the flat plain.

Sand Lakeplain. The beach ridges and low dunes of the sand lakeplain supported open "barrens" or savannas of white and black oak (Lakeplain Oak Opening=331). Small areas of dry prairie also occurred on the ridges, but were much less prevalent than savannas. Depressions and flat portions of the sand lakeplain were often poorly drained, supporting wet prairies (Lakeplain Prairie=6226). Within the wet prairies there were small beach ridges that supported scattered trees and also areas of swamp. White oak was the commonest upland species within the wet prairies, but there were references to black oak, red oak, ash, popple [cottonwood]. Elm was second to white oak, probably on the moist edges of the prairie and within the swamps. Pin oak, presently a common species within the swamps of the sand lakeplain, was seldom referenced in the GLO notes. Black oak, a relatively common species on the uplands, was also referenced by the surveyors within the wet prairies. Perhaps some of the black oak within the wet prairies were pin oak, but it is also possible that pin oak was much less prevalent prior to drainage of the wet prairies and fire exclusion. Pin oak appears to be extremely sensitive to fire (based on its response to fire management at Windsor Prairie in Ontario).

Extensive marshes (Great Lakes Marsh=6222) occurred along the entire coast of Lakes Erie and St. Clair. The marshes, which extended into 4-5 ft deep water, were 1-2 miles wide in places, and extended for miles up major rivers such as the Huron and Saginaw. Upland of the marshes there was typically a broad zones of swamp forest, but locally along Lake St. Clair and Lake Erie, 1-3 mi wide expanses of wet prairie occurred.

Central Hardwoods Forest (4121). Central Hardwoods dominated by beech and sugar maple, have often been called Mesic or Wet-Mesic

Southern Forest or sometimes Mixed Mesophytic Forest. These mesic forests were restricted primarily to the fine-textured soils of the lake plain, that is, the loamy and clayey soils. The micro-relief of the clay plain was very subtle; 1-2 foot differences in elevation caused changes in drainage condition that resulted in corresponding differences in forest condition. Beech, sugar maple, basswood, red oak, and white oak were common in better drained areas, whereas swamp white oak, red elm, American elm, blue beech, red ash, and black ash were more common in slightly moister micro-sites.

Lowland Hardwood Forest (414). Swamp forests occurred on both the clay plain and the sand plain. On the clay plain, black ash, red ash, American elm, and basswood were among the more common species. On the sand lake plain, [American] elm, [red] ash, and silver maple were among the most common species.

Lakeplain Oak Openings (331). Oak openings or barrens dominated by white and black oaks dominated the broad beach ridges and low sand dunes of the lake plain. Sassafras was also relatively common on the ridges. Occasionally the oak barrens or savannas were open enough to be described as dry prairie.

Lakeplain Prairie (6226). Wet prairie (lakeplain prairie) occupied the depression and poorly drained flats of the sand lake plain. Within the wet prairie there were scattered groves of trees, both wetland species such as cottonwood, swamp white oak, and pin oak, and upland white and black oaks. The wet prairies probably persisted as a result of both water level fluctuation and fire, with both seasonal and annual water level changes probably being more important than fire for the persistence of the prairies.

Great Lakes Marsh (6222). Great Lakes Marshes persisted along the shoreline, both on sandy and clayey soils. Organic soils developed beneath the grasses and sedges of the wet meadow. Near the shoreline organic deposits were thin or absent as the result of wave activity. In shallow water, the clay soils were often mixed with organic material, creating highly unstable muds. At least one rare species, Sagittaria montevidensis (Montevidens' arrowhead) occupies this organic-rich habitat.

In shallow water sand soils were much more stable and supported different vegetation than the clays.

NATURAL DISTURBANCE: There were few references to natural disturbances such as fires or windthrows on this portion of the glacial lake plain. The only area of extensive windthrown trees was at the extreme north edge of the subdistrict in portions of St. Clair and Macomb Counties. The windthrows were most extensive on the flat, clay lakeplain, which supported swamp forest.

Water level fluctuation of the Great Lakes, important for maintaining swamp forest, wet prairie, and marsh vegetation, was not well documented in the GLO notes of these subdistricts, but is well documented further north in Subdistrict 5.1 and District 6 along Saginaw Bay of Lake Huron.

HUMAN LAND USE: There is a long history of human land use on the

lake plain, beginning with Native Americans, who settled along the shorelines of the Great Lakes, primarily upon beach ridges. They farmed the floodplains of some of the major rivers, including the Huron River. They may have been responsible for fires that maintained the open conditions of the oak barrens and drier portions of the prairies.

The clay soils of the lake plain were among the first areas in the state farmed by European settlers. Most clay lands have been ditched and tiled and are among the most valued agricultural lands in the state. Portions of the sand plain were also ditched for agriculture, but the wettest areas remain, either as swamp forest, wet prairie, or marsh. Diking and pumping has allowed vast expanses of wet prairie and some areas of marsh to be farmed, especially along Saginaw Bay.

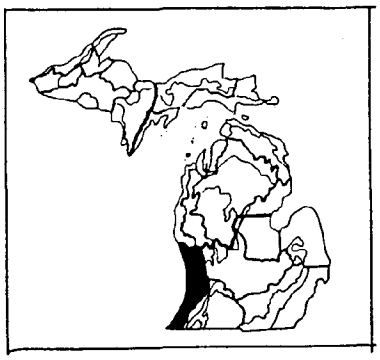
IMPACT OF HUMAN LAND USE ON VEGETATION: Almost all of the Central Hardwood Forests (4121) have been cut and drained for agriculture. The only remaining tracts are small, usually only 40-80 acres in size.

The major areas of Lowland Forest (swamps) (414) that remain are on either the sandy lake plain or near the Great Lakes shorelines, where drainage was not effective. Some of the Lowland Forests presently found on the sand lake plain were originally wet prairies that have become drier as a result of drainage.

Many of the areas of Oak Opening (savanna or barrens) (331), which included some dry prairie, remain unfarmed, but fire suppression has resulted in conversion to oak-dominated forest (Central Hardwood Forest, white and black oak dominated: 4122). Some Oak Openings have been grazed; areas that were cleared for agriculture were often abandoned due to low productivity and unstable, blowing, sandy soils.

Drier portions of the Lakeplain Prairies (6226) became available for agricultural use following drainage. Some of the largest, wettest areas of Lakeplain Prairie persist, but edges of these large wetlands are now farmed and portions of the prairie have become swamp forest as a result of drainage. Some of the Lakeplain Prairies persist as portions of State Game Areas, including St. John's Marsh, Harsens Island Wildlife Refuge, Petersburg, and Pointe Mouillee State Game Areas. Algonac State Park also supports wet prairie. At present, most of the wet prairie of the sand lakeplain has converted to swamp forest, with pin oak, silver maple, and swamp white oak being common dominants. Tupelo (Nyssa sylvatica) and bur oak are also relatively common within these swamps.

Large expanses of Great Lakes Marsh (6226) were destroyed as the ports of Detroit and Monroe were developed. Wave activity from shipping has degraded still more of the coastal marsh. Great Lakes Marsh persists in several areas, but the upland edge, which was originally wet meadow, wet prairie, or swamp forest, has been developed for agriculture.



DISTRICT 3. Allegan.

CLIMATE: The climate is warm due to its southerly location and is also highly moderated by Lake Michigan. This combination gives the Allegan District a long, warm growing season. Compared to areas at the same latitude farther east, the last freezing temperatures occur earlier in the spring and maximum daytime temperatures are reduced.

Winters are mild. The annual average extreme minimum temperature is 18°F. Considerable lake-effect precipitation falls during the fall and winter months.

DISTRICT 3. Allegan.
SUBDISTRICT 3.1. Berrien Springs: End and Ground Moraine.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The district consists of narrow bands of ice-contact and end-moraine ridges 5-20 miles wide. There are numerous kettle lakes within portions of the ice-contact topography. The ridges, which rise abruptly from a surrounding outwash plain, begin in Indiana and continue north through Cassopolis and north into Barry County. The band of ridges is broken in four places by narrow outwash channels.

Height of the ridges varies considerably, from less than 50 ft to greater than 100 ft. The highest ridges, near Three Rivers, are nearly 200 ft, but most are 100-150 ft. Elevations range from 850 to 1150 ft. Glacial drift is approximately 250-350 ft thick in the subdistrict.

Uplands are well drained to excessively drained. Many of the

kettles contain thick organic-soil deposits.

PRESETTLEMENT VEGETATION: The upland ridges were dominated by Central Hardwoods Forests (4121) of beech, sugar maple, and white oak or Central Hardwoods Forest (4122) dominated primarily by white oak. There were no wetlands noted within 6 miles of shore within the subdistrict, but further inland kettle depressions support Lowland Hardwoods (414), Lowland Conifers dominated by tamarack (4233), Shrub Dominated Wetlands (612), and Bogs (6121).

Fine-textured (silt- or clay-rich) End and Ground Moraine. The majority of these moraines supported Central Hardwoods Forests dominated by American beech and sugar maple (4121). Small depressions within the end moraines supported Lowland Hardwoods (414). The ground moraine includes some extensive areas of Emergent Marsh (6221) and Lakeplain Prairie (6226), which are located in broad, flat depressions between the end moraines. These marshes and prairies contained willow, alder, and scattered ash, [American] elm, and [red] maple.

Medium-textured (loam and sandy loam) Ground Moraine. Loamy moraines occupy only a small part of the district. Most of these ridges were dominated by either Central Hardwoods Forests dominated by either American beech and sugar maple (4121) or white oak and black oak (4122). Small depressions within the end moraines supported Lowland Hardwoods (414) or shrubby depressions (612). The shrubby depressions sometimes contained inclusions of marsh.

Coarse-textured (sandy) End and Ground Moraine. The broad, sandy ridges supported Central Hardwoods Forests dominated by either American beech and sugar maple (4121) or white oak and black oak (4122). Oak Barrens (332), dominated by white oak and yellow oak, were locally noted on the steep ridges above the Paw Paw River.

Outwash Channels (sand). The St. Joseph River, which flows through the subdistrict, has a 1/4 to 1 mile wide border of sandy outwash along its margins. This outwash supported a broad Lowland Hardwood Forest (414) dominated by a diversity of species, including sycamore, black ash, [silver] maple, beech, elm, hackberry, and basswood.

NATURAL DISTURBANCE: No natural disturbances were noted in the GLO notes. The Oak Barrens above the Paw Paw River may have been the result of Native American use of fire for management.

HUMAN LAND USE: Central Hardwoods Forests, beech-sugar maple dominated (4121), have been converted to orchards and vineyards. Central Hardwoods Forests, white oak dominated (4122), have been converted to orchards and vineyards.

IMPACT OF HUMAN LAND USE ON VEGETATION: Most of the more gently-sloping ridges and even some of the steeper ridges have been converted to orchards and vineyards. The remaining forested areas are generally the more steeply-sloping, irregular ridges; these are presently dominated by closed-canopy oak-hickory forests. Black

walnut and sassafras are both common.

The white oak-black oak [or yellow oak] barrens (332) have been converted almost entirely to orchards. Conversion to orchard indicates relatively rich soils. This may indicate that the forests were not growing on low-productivity soils, but rather that Native-American fire management had maintained the forest in an open, savanna condition.

Most the Central Hardwood forest type (4121) has been converted to agricultural land use, with orchards being quite extensive. There is also some localized urban development. Only the steepest slopes remain forested.

The white oak-black oak-dominated Central Hardwood forest (4122) has been almost completely converted to orchards, with the exception of a few steeply sloping sites.

The depressions that contained Lowland Hardwoods (414) were quite small, typically located within moderately sloping ridges. Most of the swamp forests within these small depressions have not been developed, but agricultural land use continues right to their boundaries.

The depressions that contained Shrub-dominated wetlands (612) are small, typically surrounded by moderately to steeply sloping ridges. Many of the shrub swamps persist, but the adjacent uplands have been farmed up to their edges.

Emergent Marshes (6221) have been almost completely drained and farmed. The Lakeplain Prairies (6226) have been almost completely drained and farmed.

DISTRICT 3. Allegan.
SUBDISTRICT 3.2. Benton Harbor: Lake Plain.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The subdistrict consists primarily of lake plain, but includes small areas of relatively flat ground and end moraine topography. Although most of the lake plain is flat to gently sloping, coastal sand dunes are steeply sloping. Elevations increase gradually from the Lake Michigan shoreline; highest elevations are in the dunes and on the fine-textured end moraine at the southeastern edge of the district. Elevations range from 580-820 ft.

Sand dunes, up to 200 ft high, and with slopes as steep as 30 degrees, form a narrow discontinuous band, 1-5 mi wide, along the shore of Lake Michigan. Most of the dune formation occurred in

Nipissing Great Lakes time, approximately 4,500 years ago, but the smaller foredunes formed during more recent low-water levels of Lake Michigan (Dorr and Eschman 1984).

Small inland dunes occur east of the coastal dunes. These small dunes developed earlier than those on the coast, when proglacial predecessors of the Great Lakes stood at higher water levels than that of today (Dorr and Eschman 1984).

The underlying bedrock is of Mississippian age, consisting of Marshall Formation sandstones and dolomites and Coldwater shales (Deutsch et al. 1959). Drift is generally thick, ranging from 50 to 400 ft (Akers 1938; Anonymous).

Soil textures range from sand to clay. At the southern edge of the subdistrict, the texture of most of the lacustrine soils is clay loam or silt loam. To the north, the majority of the surface lacustrine deposits are sands. Some lacustrine soils are underlain by finer textured subsoils, causing poorly drained surface and cemented subsurface soils. The soils of the moraines are generally loams or clays.

Soil drainage classes on the sandy lacustrine deposits tend to be excessively drained or poorly drained. The fine-textured soils on moraines tend to be moderately well drained or well drained on uplands and poorly drained in depressions.

On moraines, slopes of 6-12% are common. Soils on upper and middle slopes are well drained. Poorly drained soils are restricted to drainageways and depressions.

Along the Muskegon River at the north edge of the subdistrict, the lacustrine sands are generally excessively drained. A large part of these sands is outwash containing few lenses of fine-textured material to restrict drainage. Low dunes are locally common.

Poorly drained sands characterize a large area of Muskegon and Ottawa Counties. Cemented B horizons are common. Small beach ridges and sand dunes on the poorly drained plain are excessively drained.

In Allegan County, near the towns of Pullman, Bravo, and Pearl, is an area of droughty sand soils. The lake plain is flat, but locally contains small depressions that were shallow embayments on the lake bed. The soils immediately adjacent to the kettles are strongly cemented sands.

PRESETTLEMENT VEGETATION: The presettlement vegetation will be discussed first generally, then in detail by landform and substrate. The majority of the subdistrict is dominated by upland forest. In the southern part of the subdistrict, including Berrien, Van Buren, and Allegan counties, Central Hardwoods Forest, dominated by American beech and sugar maple (4121) is most common on both fine-textured moraines and sandy lacustrine deposits. Within this same three county area, Central Hardwoods Forest dominated by white oak and black oak (4122), is common along the bluffs and broad ridges above major rivers, including the Galien, St. Joseph, and Paw Paw. This oak dominance is probably the result of Native American land management with fire.

Farther north, in northern Allegan, Ottawa, and Muskegon counties, forests dominated by eastern hemlock and American beech (4119) occupied most of the sand lake plain and fine-textured moraines. Hemlock-beech forest also occupied the dunes as far south as Benton Harbor. Upland Conifer Forest dominated by white pine (4211), along with white oak and some black oak, occupied the bluffs and broad ridges above major rivers, including the Grand, Muskegon, and Kalamazoo, and also on the sandy plains adjacent to White and Muskegon lakes. Again, Native American fire management probably maintained the white pine and oaks. White pine also dominated the dunes near Bridgeman.

The largest wetlands were located along the rivers, where both Great Lakes Marsh (6222) and Lowland Hardwoods (414) formed broad bands for several miles inland from Lake Michigan. Both tamarack swamp (4233) and lowland hardwoods swamp (414) were located in bowl-shaped depressions behind the dunes.

Further inland, small kettle depressions with areas of end moraine supported small marshes (6221) and both Lowland Hardwoods (414) and Lowland Conifers (423). Broad depressions on both the flat sand lakeplain and the ground moraine contained emergent marshes (6221), lakeplain prairie (6226), and both Lowland Hardwoods (414) and Lowland Conifers (423).

Sand Dunes. The dunes supported Northern Hardwood Forest dominated by eastern hemlock and American beech (4119). Hemlock-beech forest was the dominant forest type along the dunes of the entire shoreline as far south as Benton Harbor, in central Berrien County. Although hemlock and beech were the dominant species, white pine, red oak, white oak, and sugar maple were also present.

At the northern edge of the subdistrict white pine became increasingly dominant, often with hemlock or white oak as co-dominants; these forests were coded as White Pine Forest (4211). White pine was also dominant in the dunes near Bridgeman in central Berrien County.

Several large areas of open, blowing sand (blowouts) were noted in the GLO surveys. These areas, generally less than a half mile wide, extended as much as a mile inland from the shoreline. In some areas, especially where hemlock and white pine were the dominants, present blowouts may be the result of historic logging.

Sand Lake Plain. Sand lake plain ranged from very poorly drained to excessively drained. The greater part of the sand lakeplain of the subdistrict was dominated by upland forests. Broad expanses of sand lake plain in Allegan County and further south supported Central Hardwood Forests dominated by American beech and sugar maple (4121).

In northern Allegan, all of Ottawa County, and southern Muskegon County, the major forest was Northern Forest dominated by eastern hemlock and American beech (4119). At the northern edge of the subdistrict, especially on the flat sand plains near Muskegon and White lakes, white-pine dominated forests (4211) were extensive; white oak was a common co-dominant. White pine, along with white oak, were also common on bluffs above major rivers. Upland white spruce (4221), growing along with white pine, occurred

locally at the northern edge of the subdistrict south of Whitehall.

Upland Conifer Forests dominated by eastern hemlock (4226) occurred in small stream valleys, probably as a result of moist to wet conditions. Some of the moister drainages might be better treated as Lowland Hemlocks (4237). These streams were generally surrounded by flat to rolling sand lake plain dominated by American beech, sugar maple, and other upland hardwoods, including basswood, American elm, and white oaks.

Wetlands included marshes, lakeplain prairies, and a diversity of swamp forest types. Broad marshes, coded as Great Lakes Marshes (6222), extended several miles up the major rivers, including the Galien, St. Joseph, Kalamazoo, Grand, Muskegon, and White. These marshes were as broad as 1/2 mile. At the mouths of the river there was typically a small lake that was separated from Lake Michigan by coastal dunes. Portions of the margins of these lakes also supported marsh vegetation.

Lowland hardwoods (414) occurred along the Paw Paw, Black and rivers. The Lowland Hardwoods were further differentiated as ash swamp (4141) along the Black River, and as maple swamp (4143) along the Kalamazoo River. Along the Black River there were also stretches of floodplain, where the Black River meandered considerably; this floodplain was not differentiated from adjacent Central Hardwood Forest on the uplands, which were dominated by beech and sugar maple (4121).

Some broad, flat, inland portions of the lakeplain also supported Emergent Marsh (6221). One such area was near Baroda, in Berrien County, where the marsh was in a broad depression between moraine ridges. This and other such marshes were typically drained and farmed. Marshes also occurred in depressions behind the coastal sand dunes; some of these marshes were along the edges of small lakes or ponds.

Tamarack swamps (4233) also occurred in depressions behind the dunes, as did Black ash swamp (4141).

Several lowland forest types occurred in depressions on the sand lake plain, including Lowland Conifer Forests of hemlock (4237) or tamarack (4233) and Lowland Hardwood Forests of ash (4141) or elm (4142). Some of the Lowland Conifer Forests contained several different conifers, including combinations of white pine, hemlock, tamarack, and occasionally northern white-cedar; these were classified as 423.

Fine-textured (silt- or clay-rich) End and Ground Moraine. In Berrien, Van Buren, and Allegan counties, the moraines supported Central Hardwoods Forests dominated by American beech and sugar maple (4121). Further north, in northern Allegan County and in Ottawa County, Northern Forests of American beech and eastern hemlock (4119) occupy the ground moraine. Small depressions within the end moraines supported Lowland Hardwoods (414). The ground moraine includes some extensive areas of Emergent Marsh (6221), which are located in broad, flat depressions between the end moraines. These marshes contained willow, alder, and scattered ash, [American] elm, and [red] maple.

Coarse-textured (sandy) End and Ground Moraine. The broad,

sandy ridges supported Central Hardwoods Forests dominated by either American beech and sugar maple (4121) or white oak and black oak (4122). Coarse-textured moraines are not extensive; they are found only at the southern edge of the district.

NATURAL DISTURBANCE: Blowouts, areas of destabilized sand that are moved landward by the wind, were noted in the GLO notes. Although blowouts are sometimes caused by human manipulation, the GLO notes recorded the presence of large blowouts in the same areas where most of the present blowouts are located today, suggesting that natural disturbances regularly caused blowouts to form. Locally there were references of burnt land and windthrown trees along the Galien River. There were also references to Indian fields near the mouth of the Kalamazoo River, and Indian trails along the Grand River and near Lakeplain Prairies in Berrien County. Several Barrens were noted along the Paw Paw River; these may have been the product of Indian agricultural or game management with fire. Indian trails were also noted in the white pine-white oak forests near Muskegon Lake.

HUMAN LAND USE: Almost all of the sand lakeplain, which characterizes most of the subdistrict, has been farmed. Where drainage of the sand lake plain is generally poor, as between Hoffmaster State Park and Fruitport, most of the land is ditched. Ditches are typically 6-8 feet deep. Blueberries are a common crop on the poorly drained acid sands. Large areas support nurseries and fields of asparagus. Some of the more mesic lakeplain supports orchards and vineyards. The coastal sand dunes have not been exploited for agriculture, but they are popular for residential development. Large portions of the dunes remain forested. Sand mining has been conducted in the coastal dunes, but is now restricted to one site near Bridgeman. Oil wells tap petroleum reservoirs in the underlying Devonian-age marine deposits (Dorr and Eschman 1984).

Clay lakeplain is relatively limited in the subdistrict, where it is concentrated in southern Berrien County, and all but the most poorly drained sites have been drained for agriculture.

Most of the fine-textured end moraine and ground moraine is also farmed. Most of the ground moraine requires ditching. All but the steepest end moraine are farmed, and some of the steep sites have been converted to pasture and hay production.

IMPACT OF HUMAN LAND USE ON VEGETATION: Farming of the droughtier sand soils of the lakeplain resulted in severe wind erosion. Most of these lands have been abandoned, and the fields have regenerated to black cherry, bigtooth aspen, and trembling aspen. Signs of wind erosion are abundant.

Drainage of some organic soils on the sand plain also resulted in severe wind erosion and eventual abandonment.

The original white pine-white oak forested were logged for white pine; fires followed, destroying white pine regeneration and

resulted in the creation of white oak-black oak forests. White pine regeneration is locally good; most white pine is presently either understory or small overstory in size.

The areas of fine-textured end moraine and ground moraine within the subdistrict have been intensively farmed. Orchards and vineyards are generally restricted to better drained, rolling areas of end moraine.

Most of the large expanses of inland Emergent Marsh (6221) were drained and farmed. Most of the Great Lakes Marsh (6222) is located along major rivers, forming 1/4-1/2 mile wide zones. These marshes remain, although some have been modified by boat channels. Near larger cities, these marshes have been partially filled for development of either industrial facilities or recreational facilities, such as marinas.

Lowland Hardwoods (414) occupying broad depressions in either lake plain or ground moraine have generally been drained and converted to agriculture. Those occupying smaller, steeper depressions within the dunes or end moraines persist, as drainage was impractical.

At the northern edge of the subdistrict, in portions of Ottawa and Muskegon counties, greater areas of Lowland Conifers (423) persist than farther south. Tamarack (4233) occurred both broad depressions on the sand lake plain and along some small streams, and as more steeply sloped depressions behind the dunes and within end moraine. The steeper depressions generally remain forested, as do some of the stream-side swamps. Large portions of the broad depressions have been converted to agriculture, but greater portions remain forested than for almost all other forest types.

Hemlock swamps (4237) occurred in broad, flat depressions on ground moraine and sand lakeplain. Most of the hemlock-dominated wetlands have been farmed, but along some of the small streams in Van Buren County, forests remain in areas originally dominated by hemlock.

Most of the hemlock-beech forest (4119) has been farmed, either for row crops or orchard. The majority of this forest type is on sand lakeplain, but it also occurs on ground moraine. The portion of this forest type located on sand dune still remains.

Almost all areas of beech-sugar maple-dominated forest (4121) have been farmed, either for row crops or orchard. This includes broad expanses of both sand lakeplain and fine-textured end and ground moraines. Beech-sugar maple forest persists on portions of the sand dunes.

While the white pine-dominated forests (4211) on the sand lakeplain have all been logged, second-growth oaks persist on many of these original oak-pine sites. Residential development has occurred in most of these forested areas.

White pine, along with hemlock and American beech, dominated portions of the coastal sand dunes. The pines have been logged from most coastal dunes, but locally pockets of white pine remain.

Most of the upland hemlock stands (4226) on lakeplain were cleared for agriculture. Orchards are not common on these lands, possibly due to poorer drainage conditions.

Hemlock, along with lesser amounts of American beech and white pine, dominated the greater part of the coastal sand dunes. Although much of the hemlock was harvested, pockets of mature hemlock persist.

White spruce-dominated forest (4221) occurred only locally in Muskegon County. It was logged, but a large part of it remains as second-growth forest.

DISTRICT 3. Allegan.
SUBDISTRICT 3.3. Jamestown: Fine-textured End and Ground Moraine.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: Steep topography primarily distinguishes this subdistrict. Glacial drift is generally thick, from 50 to 400 ft (Akers 1938), over the Mississipian age sandstones and dolomites of the Marshall Formation and shales of the Coldwater Formation (Deutsch et al. 1959). The soils are generally well drained. The deeply eroded channel of the Grand River adds to the dissected nature of the topography. Soils are loamy, except for the outwash deposits along the Grand River.

PRESETTLEMENT VEGETATION: Only a small portion of this subdistrict is near the shoreline. Vegetation characteristic of areas of the subdistrict further inland will not be discussed here. The presettlement vegetation will be described by landform and soil texture.

Fine-textured (silt- and clay-rich) End and Ground Moraine. The majority of the subdistrict near to the Lake Michigan shoreline is flat ground moraine that supported a forest of almost equal parts hemlock (43%) and American beech (41%), with some sugar maple, basswood, paper birch, and [red or silver] maple. This forest type was classified as hemlock-beech dominated Northern Forest (4119) On the steeper end-moraine ridges, American beech-sugar maple dominated Northern Hardwoods (4111) were present.

A small area of about 300 acres supported Lowland Conifer, hemlock dominated (4237). This was in a relatively broad, flat depression. Small areas of Lowland Hardwoods, ash-dominated (4141) were also located in small depressions in the end moraine and ground moraine.

NATURAL DISTURBANCE: There was no mention of natural disturbances for the subdistrict.

HUMAN LAND USE: Most of the land is presently used for agriculture, but some steeper areas remain forested. Very little of the ground moraine is used for orchards.

IMPACT OF HUMAN LAND USE ON VEGETATION: Most of the land is presently under agriculture. On moraines too steep for agricultural management, forests persist.

The majority of these upland forests have been farmed, but steeper areas remain forested. This large, relatively flat depression has been partially drained for agriculture.

Of the small depressions dominated by Lowland Hardwoods (414), the more steeply sloping depressions appear to remain forested, while those on flatter topography have been drained and farmed.

DISTRICT 5. Huron.
SUBDISTRICT 5.1. Sandusky: Lake Plain.

CLIMATE: This district is cooler than most of the rest of southern Lower Michigan. It has a 151-day growing season. Most air flows entering this district are from a westerly direction, so this district experiences less lake moderation than districts on the west side of the state. During spring and summer, showers caused by air-mass instability are common.

Average extreme minimum winter temperature is 16°F. Snowfall is generally light. Lake-effect precipitation may occur when winds are from the north and east.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The subdistrict is a relatively flat plain of glacial lacustrine origin. The lacustrine deposits, which consist of sands and clays, are thickest along the farthest inland edge of the lake plain and thinnest along the present shorelines of Lakes Huron. The lake clays are 100-300 ft thick near the inland margin and 50 ft or less along Saginaw Bay, where they are locally exposed.

Within the broad clay lake plain, there are several broad sand channels, created when sand was deposited into the shallow pro-glacial lakes by glacial meltwater streams. These sand channels

can be several miles wide, but the sand in them is generally only 5 to 10 feet thick. Poorly drained mineral soils characterize the clay plain. The sand-channel deposits were reworked by wave action during higher levels of the Great Lakes, creating small sand dunes and spits and intervening depressions. The soils of the dunes and spits is often excessively drained, whereas those in the swales is poorly or very poorly drained.

Broad end-moraine and ground-moraine ridges of fine-textured (clay-rich) and medium-textured (loamy) till occupy portions of the subdistrict. Along the eastern edge of the subdistrict, these ridges are only 3-4 inland from the St. Clair River and the Lake Huron shoreline. To the north, these moraines are generally further inland from the Saginaw Bay shoreline. Slopes are generally steeper on these moraines than on the clay lake plain (2-6% vs. 0-2%).

The lake plain is underlain by Paleozoic bedrock; shale, marine limestone and dolomite. Bedrock is exposed along the shoreline at Pointe Aux Barques, and locally inland.

PRESETTLEMENT VEGETATION: The presettlement vegetation of the clay lake plain and sand lake plain were often very different. There were also substantial differences in vegetation from the south end of the district to the north end; hemlock and white pine became increasingly dominant on upland sites further to the north. There were also areas of fine-textured and medium-textured ground moraine and end moraine that supported different forest types.

Clay Lakeplain. Almost the entire clay plain was forested. The forests responded to differences in slope class and drainage. On the flatter portions (5-10 feet/mile slope or less) of the lakeplain at the southern edge of the subdistrict, Lowland Hardwoods (414) were prevalent; the common dominants were black ash and American elm. In closed depressions, Lowland Hardwoods dominated by black ash (4141) were common.

The majority of the clay lakeplain of the subdistrict was dominated by Upland Conifer Forests of eastern hemlock (4226). Topography was flat, with slopes of less than 2%. These forests were not generally considered swamps, but the soils were probably wet, with many vernal pools. Hemlock often comprised 40% or more of the overstory; other common species were American beech, eastern white-cedar, sugar maple, [American] elm, balsam fir, paper birch, white pine, white ash, black ash, basswood, [red] maple, and [trembling] aspen.

On the steeper portions of the clay plain, where slopes were generally greater than 2%, Northern Hardwoods Forests of American beech-sugar maple (4111) were numerous, sometimes comprising greater than 50% of the overstory. Hemlock was a much less common species on these better drained sites.

Sand Lakeplain. Sand lakeplain was not prevalent along the shoreline within the subdistrict except near Port Huron, St. Clair County, and in Tuscola County. The low dunes and relatively flat sand plain supported Upland Conifer Forests of Hemlock-white pine (4227). Small areas of Central Hardwoods, dominated by white oak

and black oak (4122) were also common near the shoreline, both on low beach ridges and sand dunes.

Wetlands within the forested sand plain contained abundant black ash (4141). Along the border with clay lakeplain, Lowland Conifers dominated by tamarack (4233), and occasionally northern white-cedar (4231), were dominant, often forming a dense linear band.

There were also extensive Emergent Marshes (6221) inland from the present Saginaw Bay shoreline. South of Bayport, a large 1/4 to 1/2 mile wide marsh was several miles long. Old beach ridges from a much higher historic lake level (several thousand years ago) form the upland boundaries of this large marsh.

Shoreline of Lake Huron and Saginaw Bay. Extensive Great Lakes Marshes (6222) occurred along the entire coast of Saginaw Bay, and locally along the shore of Lake Huron southeast of Saginaw Bay. The marshes, which extended into 4-5 ft deep water, were 1-2 miles wide in places, and extended for miles up major rivers such as the Quanicassee. Upland of the marshes there was typically a broad zones of swamp forest (414 or 423), but on large expanses of Saginaw Bay, 1-3 mi wide expanses of Lakeplain Prairie (6226) occurred.

Lakeplain [wet] Prairie was concentrated at the far northwestern edge of the subdistrict along Saginaw Bay, in Tuscola and Huron Counties. The wet prairie changed along with the water level of Lake Huron; during periods of low lake levels, prairie grasses and forbs dominated the broad swales, whereas marsh grasses, sedges, rushes, and cattails expanded into the prairies during high water periods. Within the coastal marshes and wet prairies were low beach ridges and sand spits that supported Lakeplain Oak Openings of white oak and black oak (331). Cottonwood and trembling aspen also occurred within the wet prairie. The GLO surveyors commented on the importance of the wet prairies for waterfowl.

Expansive bands of parallel beach ridges and swales, called Wooded Dune and Swale Complexes (911), occupy some of the embayments along Saginaw Bay. White pine dominated the beach ridges, along with some white oak and black oak, which were most common near the shoreline. Trembling aspen and paper birch were also common on the ridges of the complex. The wettest swales were dominated by floating and emergent aquatic plants, and were often noted as ponds by the surveyors. Ponds were typically found in the swales near to the shoreline, whereas further inland swales typically supported swamp forests of cedar, tamarack, and occasionally black ash.

Medium-textured and Fine-textured End Moraine and Ground Moraine. Central Hardwood Forest, American beech-sugar maple dominated (4121) grows on much of the moraines, which generally have better drainage conditions than the clay lakeplain. The central hardwood forests of the moraines also supports lesser quantities of hemlock, basswood, white ash, and [red] maple.

Wetlands are either in depressions within the moraines, on flat ground moraine, or at the base of slopes where moraines meet

lakeplain. Lowland Hardwoods, black ash dominated (4141) is found in many of the wetland depressions within the moraines. Lowland Conifers, dominated by northern white-cedar (4231), occupies broad wetlands in footslope positions. These cedar swamps also contain tamarack, balsam fir, hemlock, and some white pine, along with birch, [trembling] aspen and other hardwoods.

NATURAL DISTURBANCE: Extensive areas of windthrown forest were recorded in the GLO notes. These extensive windthrows are the result of a combination of strong winds off Lake Huron and poorly drained soils. Windthrow appears to have been more common within the wetlands and on the flattest parts of the lakeplain.

Water level fluctuations of 2-3 ft are common along the Great Lakes shorelines, causing tree mortality, shoreline erosion, major alteration in species composition of marshes and wet prairies.

HUMAN LAND USE: Most clay lands have been ditched and tiled and are among the most valued agricultural lands in the state. Portions of the sand plain were also ditched for agriculture, but the wettest areas remain, either as swamp forest, wet prairie, or marsh. Diking and pumping has allowed vast expanses of wet prairie and some areas of marsh to be farmed, especially along Saginaw Bay.

Organic soils were burned to improve their suitability for agriculture. References to this practice are found in the Bay County (Wonser 1934), Tuscola County (Deeter and Matthews 1931), Saginaw County (Moon 1938), and St. Clair County (Deeter 1934) Soil Surveys. One to four percent of the land surface of these counties had burned-over organic soils on clay. Burnt muck soils overlying sand occupied less than 1% of the land surface and those on marl usually less than 0.1%. The muck soils over sand were of less value for farming and were therefore seldom purposefully burned. Following burning, most of the clay soils required further drainage to be suitable for agriculture.

Native American settlements were common along the shorelines of the Great Lakes, primarily upon beach ridges. Indian fires were probably responsible for maintaining oak savannas on the beach ridges near Saginaw Bay.

IMPACT OF HUMAN LAND USE ON VEGETATION:

Residential construction has caused the destruction of large portions of Wooded Dune and Swale Complexes (911). It is common to see numerous drives built across swales, severely impacting natural hydrologic processes. Portions of these complexes remain intact in and around Sleeper State Park, and at Pointe Aux Barques.

Almost all of the Hemlock forest (4226) has been converted to agricultural lands. Extensive drainage systems have impacted the hydrology of the clay lands that originally supported hemlock.

On portions of the clay plain American beech and eastern hemlock are the co-dominants, with very little sugar maple. White birch, white pine, and very locally balsam fir are present. This list of species consists primarily of species normally considered Northern Hardwoods Forest. This forest type is found on the

flatter ground moraine and on clay lakeplain. Most lands which contained this forest type have been farmed.

Most of the clay lands in the northwestern part of the subdistrict that originally supported Aspen/birch forest (413) have been drained and converted to agriculture. Young aspen/birch forests are encountered occasionally, generally following logging of the clay plain.

Most of the clay plain and moraine that supported Central Hardwood forest (4121) has been converted to agriculture. Occasionally small woodlots (20-40 acres) are encountered. These woodlots have generally been selectively logged at least once.

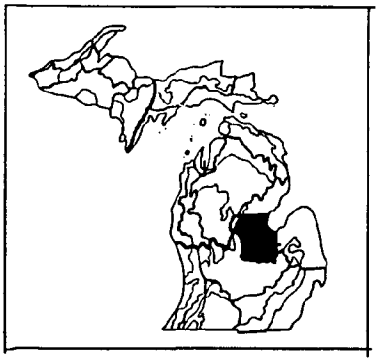
Black ash depressions (4141) persist throughout the subdistrict. Many are too poorly drained to easily convert to agriculture.

Some cedar-dominated wetlands (4231) persist, but most have been converted to agriculture.

There were only small areas of inland Emergent marsh (6221) noted in the original surveys. Portions of these marshes were drained and converted to agriculture, but portions also persist as marsh, although these are probably shrubbier than originally due to adjacent alterations of drainage conditions.

Large portions of the Great Lakes marshes (6222) persist, although boat slip and dock construction have altered large areas of marsh.

Most of the Lakeplain prairie (6226) is wet prairies that has been converted to agriculture. Maintenance of these lands for agriculture often requires both ditching and pumping. Only the wettest portions of the wet prairie, typically within a mile of the shoreline, persist.



DISTRICT 6. Saginaw: Lake Plain.

CLIMATE: The growing season of this district is as long (153 days) as in districts at the southern boundary od the state. Average annual extreme minimum temperature is 14°F. Toward the northern end of the district, there is a sharp climatic gradient due to characteristic positions of air masses. The Arenac District to the north is separated from the Saginaw District on the basis of this gradient, with the Saginaw District being notably warmer.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The district is a relatively flat plain of glacial lacustrine origin. The lacustrine deposits, which consist of sands and clays, are thickest along the farthest inland edge of the lake plain (up to 300 ft thick) and thinnest along the present shorelines of Lakes Huron, where they are generally 50 ft or less thick along Saginaw Bay.

Clay sediments are generally quite thick on the lake plain, but several broad sand channels were created by glacial meltwater streams that deposited sand into the shallow pro-glacial lakes. Many of these sand channels are several miles wide in this district, but the sand in them is generally only 5 to 10 feet thick.

Poorly drained mineral soils characterize the clay plain. The sand-channel deposits were reworked by wave action during higher levels of the Great Lakes, creating small sand dunes and spits and intervening depressions. The resulting features are typically higher and have steeper slopes than any found on the clay lake plain. The soils of the dunes and spits is often excessively well drained, whereas that in the swales is poorly or very poorly drained. Several major streams flow across the sandy lake plain, including the Saginaw, Pine, Chippewa, and Tittabawassee Rivers.

The subdistrict is underlain by Paleozoic bedrock; shale, marine limestone and dolomite. Bedrock is only locally exposed.

PRESETTLEMENT VEGETATION:

Shoreline dunes and sand lakeplain. Extensive Great Lakes Marshes (6222) occurred along Saginaw Bay. The marshes, which extended into 4-5 ft deep water, were 1-2 miles wide in places, and extended for miles up major rivers such as the Quanicassee and Saginaw. Along the western shore of Saginaw Bay, the marshes were generally 1/8 to 1/2 mile wide, much narrower than along the southern edge of the bay.

Shoreward of the marshes were extensive zones of Lakeplain Prairie (6226). These wet prairies extended several miles inland along the Quanicassee and Saginaw rivers, and occurred as far to the northwest as the Kawkawlin River (Bay County). The wet prairies are probably quite variable in plant composition, ranging from true prairie grasses, such as big blue stem, indian grass, and cord grass, to blue joint grass and sedges closer to the marsh edges and in wetter depressions. They also contain a diversity of other aquatics, including rushes, bulrushes, cattails, reed grass, and willow or other shrubs.

Within the coastal marshes and wet prairies were low beach ridges and sand spits that supported Lakeplain Oak Openings of white oak and black oak (331). There was also [trembling] aspen and other lowland hardwoods locally within the wet prairies.

Inland of the coastal marshes and lakeplain prairies there was typically a broad band of lowland forest. Lowland Hardwood (414) was prevalent, with black ash, [American] elm, and [red] maple as common dominants. There was often a component of tamarack and eastern hemlock within the swamps, and alder become common further to the north.

Lowland Conifer Swamps, dominated by tamarack (4233) often occurred broad depressions within the sand lakeplain, especially where these were located 1 or more miles inland from the present shoreline. Examples of such large tamarack swamps were near the Quanicassee River and inland from Tobico Marsh.

Wooded Dune and Swale Complex (911) occurred inland of Tobico Marsh in Bay County. The vegetation of this complex was diverse. Many of the swales contained emergent marsh or shallow ponds, but lowland conifers and hardwoods occupied less wet swales. Upland beach ridges within the complex supported scattered white and red pine, along with white and black oak.

Inland sand lakeplain. Flat, inland expanses of sand lakeplain supported Upland Conifer Forest, dominated by eastern hemlock (4226), with some white pine and also black ash, elm, and other hardwoods. There were also hemlock-dominated Lowland Conifer Swamps (4237); these forests contained most of the same species described from the hemlock uplands, but they were described by the GLO surveyors as swamp. On the flat topography of the sand lakeplain, a few inches of elevation can often result in changes of drainage class, making it difficult to determine whether an area should be called upland or wetland. Seasonally, drainage conditions can also change; flooding is common in both spring and autumn. It probably requires fairly intensive soil sampling to determine whether an area should be called upland or wetland on parts of the lakeplain.

Clay lakeplain. Central Hardwoods, dominated by American beech and sugar maple (4121), dominate the better drained portions of the clay plain at the southern end of Saginaw Bay. Drainage conditions were locally better along the Saginaw River, resulting in upland forests, with increased levels of white oak near the river. Many of the upland forests on clay plain were probably fairly moist, as indicated by the abundance of [American] elm, basswood, and black ash.

Lowland Hardwoods (414) dominated large expanses of the clay plain. Black ash, basswood, and [American] elm were common dominants, but tamarack and northern white-cedar were also present. The flat conditions of the clay lakeplain resulted in an intergrading of upland and wetland hardwoods on the landscape, making detailed mapping difficult.

At the northern edge of the district, Upland Conifer Forest, dominated by Hemlock (4226), becomes common on the clay lakeplain. These forests also contained hardwood species; American beech was often the most common hardwood species, but black ash and [American] elm were sometimes equally common. Northern Hardwood Forest dominated by American beech-sugar maple (4111) replaced Central Hardwoods dominated by the same species (4121) north of the Saginaw River. North of the Saginaw River several species common in Northern Hardwoods Forest became common, including eastern hemlock, balsam fir, and white birch.

Lowland Conifer Forest, dominated by tamarack (4233) occurred on the flat, poorly drained clay plain near the boundary with sand lakeplain. This was probably most common near the Quanicassee

River, but occurred elsewhere in the district.

Fine-textured ground moraine. Fine-textured ground moraine is often very flat and can be difficult to distinguish from clay lakeplain. For this reason, the plant communities found on clay lakeplain are also found on ground moraine. These include Upland Conifer Forest dominated by hemlock (4226), Northern Hardwoods Forest (4111) and Upland Central Hardwoods (4121) dominated by American beech and sugar maple, Lowland Hardwoods (414) dominated by black ash, basswood, and elm, and Lowland Conifers (423) dominated by tamarack (4233) or occasionally northern white-cedar (4231).

Fine-textured end moraine. Fine-textured end moraines generally have slopes greater than 2%, resulting in better drainage conditions than typically found on clay lakeplain. As a result, Northern Hardwoods Forest (4111) or Central Hardwoods (4121) dominated by American beech and sugar maple are common. Associated trees include white oak, [American] elm, basswood, and birch. Hemlock and black ash are generally much less common than on the upland clay lakeplain. At the northern edge of the district, hemlock becomes increasingly common, even on these well-drained forests.

NATURAL DISTURBANCE: Although extensive areas of windthrown forest are generally common near the Great Lakes shorelines, this district had no areas of windthrow noted in the GLO notes. It may be that the district's location, at the southern and western edge of Saginaw Bay, provided protection from the prevailing winds, thus greatly reducing the amount of windthrow.

Water level fluctuations of 2-3 ft are common along Saginaw Bay shorelines, causing tree mortality, shoreline erosion, and major alteration in species composition of marshes and wet prairies. The surveyors noted such water-level fluctuations just a few miles east of the district at Fish Point.

HUMAN LAND USE: Most clay lands have been ditched and tiled and are among the most valued agricultural lands in the state. Portions of the sand plain were also ditched for agriculture, but the wettest areas remain, either as swamp forest, wet prairie, or marsh. Diking and pumping has allowed vast expanses of wet prairie and some areas of marsh to be farmed, especially along Saginaw Bay.

Organic soils were burned to improve their suitability for agriculture. References to this practice are found in the Bay County (Wonser 1934), Tuscola County (Deeter and Matthews 1931), Saginaw County (Moon 1938), and St. Clair County (Deeter 1934) Soil Surveys. One to four percent of the land surface of these counties had burned-over organic soils on clay. Burnt muck soils overlying sand occupied less than 1% of the land surface and those on marl usually less than 0.1%. The muck soils over sand were of less value for farming and were therefore seldom purposefully burned. Following burning, most of the clay soils required further drainage to be suitable for agriculture.

Indian settlements were common along the shorelines of the

Great Lakes, primarily upon beach ridges. Oak savannas (Lakeplain Oak Openings) were probably maintained on beach ridges near the shoreline of Saginaw Bay by Indian land management with fire.

IMPACT OF HUMAN LAND USE ON VEGETATION:

Much of the Great Lakes Marsh (6222) persists, as it is too poorly drained to be converted to agricultural use. In some of the broadest areas of marsh, near the Quanicassee River, diking and pumping has allowed portions of the marsh to be farmed. A much greater portion of the marsh has been altered, either by diking and ponding for waterfowl management, by boat slip or marina development, of filling for urban industrial uses. During surveys of Great Lakes Marshes during the summer of 1988 (MNFI 1988), major alteration in the marshes were noted at Coryeon Point, Tobico Marsh, Nayanquing Point, and Pinconning.

The majority of the Lakeplain [wet] prairie has been ditched and tiled for agriculture. Some areas of wet prairie require pumping of fields to maintain conditions dry enough for farming. Small areas of prairie persist along the upland edges of Great Lakes Marsh, but this accounts for relatively small acreage. Extensive areas of prairie were altered or destroyed along the Saginaw and Quanicassee rivers.

Most of the Lakeplain Oak Openings (331) occurred on small beach ridges within either Great Lakes Marsh or Lakeplain Prairie. Many of these openings have become closed-canopy oak forests; they may have required fires to maintain open conditions. Near the shoreline, and to some degree further inland, the beach ridges that support oak openings were popular residential sites.

Most of the acreage originally covered by Lowland hardwoods (414) has been converted to agriculture, facilitated by construction of drainage ditches and tiling. Occasionally Lowland Hardwoods persist where they occupied depressions in the landscape that were difficult to drain. They also persist immediately adjacent to the Saginaw Bay shoreline, where drainage conditions were too poor for conversion to agriculture.

Most of the acreage originally covered by Tamarack swamp (4233) has been converted to agriculture, facilitated by construction of drainage ditches and tiling. Occasionally tamarack swamps persist where they occupied depressions in the landscape that were difficult to drain.

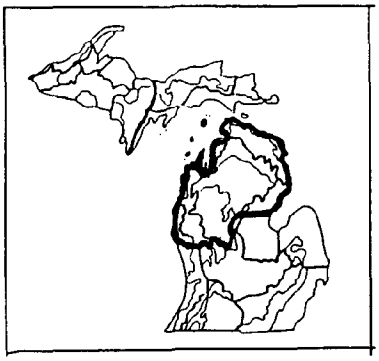
Almost all areas of lowland hemlock (4237) has been converted to agriculture. Drainage ditches and tiles have facilitated this conversion.

Almost all beech-sugar maple-basswood forests (4121) have been converted to agriculture. Drainage and tiling was required to allow most of these fine-textured lacustrine soils to be farmed.

Almost all beech-sugar maple-yellow birch forests (4111) in the northern portion of the district have been converted to agriculture. Drainage and tiling was required to allow most of these fine-textured lacustrine soils to be farmed.

Almost all hemlock-dominated uplands (4226) have been farmed; most of the sandy or clayey lacustrine soils that supported this

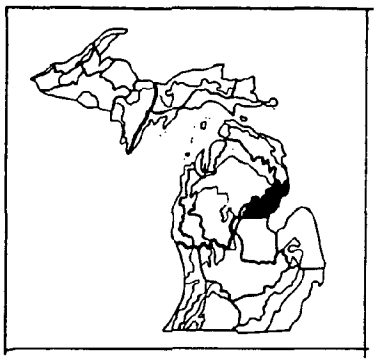
community were somewhat poorly drained and required drainage.



REGION II: Northern Lower Michigan.

REGIONAL CLIMATE: Most air masses cross the Great Lakes before entering this region, resulting in reduced continentality. Compared to areas of equivalent latitude in Wisconsin and Minnesota, the region is warmer in winter and cooler in summer. Lake effect snow and rain characterizes portions of the region within 20-30 miles of the Great Lakes shorelines.

The growing season ranges from 70 days inland to 150 days along the shoreline of Lake Michigan (Eichenlaub et al. 1990). Annual precipitation ranges from 28 to 34 inches. Average annual snowfall ranges from 40 inches inland to 140 inches along Lake Michigan (lake-effect snows). Extreme minimum temperatures are -28°F along Lakes Michigan and Huron, and -50°F inland.



DISTRICT 7. Arenac.
SUBDISTRICT 7.1. Standish: Lake Plain.

CLIMATE: Located along the northwest shore of Saginaw Bay, this district has a growing season length is 130 to 150 days (Eichenlaub 1990), which is significantly shorter than the adjacent Saginaw District to the south. The extreme minimum temperature is -26 to -30°F. Precipitation is relatively uniform throughout the growing season. Average annual precipitation is 28 to 30 inches and average annual snowfall is 40 to 50 inches.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The district is a flat clay and sand lake plain, part of the Saginaw lakeplain to the south. The northern third of the district is a large glacial delta that has thick, droughty sand soils. The Au Sable and Rifle rivers have created a deep, steeply eroded gorges through the thick sands (Dorr and Eschman 1984; Burgis 1977). Within the lake plain, there are large, poorly drained embayments several miles in area; most of which are located several miles inland from the present Great lakes shoreline. Within these embayments there are often numerous small, steeply sided, transverse dune ridges.

The soils of the lake plain are very poorly, poorly, and excessively drained sands or well, moderately well, and poorly drained clay loams and clays. The soils on the small areas of ground and end moraine are primarily moderately well drained or well drained loams and clays.

Glacial drift is 100-200 feet thick. Underlying bedrock consists of Jurassic sandstone, shale, and clay with minor limestone and gypsum, Pennsylvanian sand, silt, clay, shale, limestone, and coal, and Mississippian limestone and gypsum, sandstone, and shale (Millstein 1987, Dorr and Eschman 1984).

PRESETTLEMENT VEGETATION: The flat clay plain supported forests of hemlock (4226) and American beech, sugar maple, and basswood (4111) on well drained sites, with greater amounts of hemlock, and white pine on more poorly drained sites. On poorly drained sites, there were also extensive tamarack (4233), cedar (4231), black ash (4141), and maple (4143) swamps. Alder/willow (6122) swamps were also found on the clay lakeplain.

Sandy lakeplain contained extensive cedar (4231), tamarack (4233) and black ash-dominated (4141) swamps. Hemlock, white pine, and maple dominated swamps were also found here.

Great Lakes Marsh (6222) and Lakeplain Prairies (6226) were also located on sandy lakeplain along the Saginaw Bay shoreline in Arenac County. The higher beach ridges on the lakeplain were dominated by white pine and red oak.

Loamy or clayey soils on the flat ground or end moraines supported forests of hemlock (4226) and Northern Hardwoods (4111) with sugar maple, American beech, white pine, and hemlock. The fine-textured end moraine located just west of Tawas contains sandy soils on it's surface. It supported jack pine barrens (333) and open, burnt-over grasslands (31).

The large embayments supported bogs (6121) or shrub swamps (6122) with stunted trembling aspen or jack pine. The transverse dune ridges supported open oak-pine (334) woodlands.

At the northern edge of the subdistrict, the delta of the Au Sable River supported jack pine-dominated Barrens (333), with white pine, red pine, and some black oak and white oak on fire-protected sites.

NATURAL DISTURBANCE: Windthrow was common in the forests near the Great Lakes shoreline, resulting from a combination of strong winds off Lake Huron, flat topography, and poor drainage conditions.

Water level fluctuations along the Great Lakes shoreline resulted in cyclical floristic variation within the coastal marshes and extensive mortality within the coastal swamp forests.

Fire was noted as common on the jack pine-dominated Barrens (333) of the Au Sable River delta.

HUMAN LAND USE: Agricultural land use is less intensive on this portion of the lake plain than in subdistricts further south, due to both colder climatic conditions and a prevalence of sandy soils. Drainage has occurred on both the clay lake plain and on the flat portions of the loamy or clayey ground and end moraines. Clay soils on the lake plain are used as pasture. Moraines are farmed for both row crops and pasture. Sandy soils have been less intensively converted to agriculture than on other portions of lake plain further south.

Much of the poorly or excessively drained lake plain is managed for either timber or recreational use. The delta of the Au Sable is managed largely by the Huron National Forest for timber. Both jack pine and red pine plantations cover much of the delta.

A large strip mine is located just north of Huron Heights. Urban development in this subdistrict is most intensive around Tawas, Standish, and Au Gres.

IMPACT OF HUMAN LAND USE ON VEGETATION: The moraines and clay lake plain have generally been converted to agricultural use and no longer support the presettlement forest.

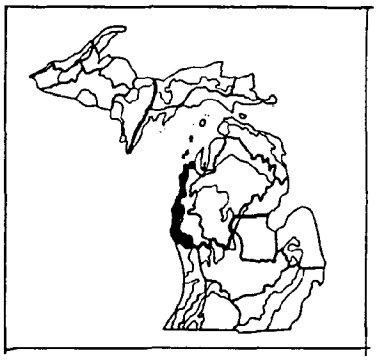
Natural vegetation remains on much of the droughty or poorly drained sand lake plain, but white pine and red pine regeneration has generally been poor, and either aspen or oak regeneration are now characteristic.

The jack pine-dominated Barrens (333) of the Au Sable River delta have been converted to closed-canopy plantations of jack pine or red pine.

Some of the swamps along the Lake Huron shoreline have been converted to agriculture, but those which persist appear to have forest compositions relatively similar to those recorded in the GLO notes.

Many of the Great Lakes Marshes (6222) along Lake Huron have been manipulated for waterfowl management with dikes being constructed on many of the marshes for water control. Small areas of marsh remain intact. Small remnants of Lakeplain Prairie may also exist here. Surveys of some prairie remnants in 1988, immediately following 1986-87 high lake-water levels, indicated possible prairie flora with less diversity than typical of prairies to the south. Further surveys are needed in this area.

Boat slips and channels have also been constructed along many sections of shoreline, resulting in varying degrees of marsh destruction.



DISTRICT 10. Manistee: End Moraine, Dune Sand, and Sand Lake Plain.

CLIMATE: A strong lake modified climate results in a long growing season of 140 to 150 days (Eichenlaub et al. 1990). Annual average extreme minimum temperature is 16°F. The extreme minimum temperature is -32°F. Retarded spring warming coupled with a long growing season make the climate suitable for commercial fruit production. Lake-effect snowfalls are heavy, averaging 100 to 140 inches. The average annual precipitation is 32 to 34 inches.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The district is characterized by diverse topography, including sand dunes, sand lake plain, ground and end moraines, and outwash.

Glacial drift is 400-800 feet thick; bedrock is not exposed. Underlying bedrock consists of Mississippian limestone, sandstone, and shale, and Devonian sandstone, shale, dolomite, limestone, and evaporates (Millstein 1987, Dorr and Eschman 1984). Morainal bluffs and sand dunes rise abruptly along the shoreline of Lake Michigan. Near Manistee, a broad, flat area of lake plain and ground moraine separates the more steeply sloping moraines into northern and southern parts. Elevations range from 580 ft on the Lake Michigan shore to 1150 ft on a large end-moraine ridge in Benzie County. The shoreline is noted for large, high sand dunes, including those of the Sleeping Bear Dunes National Lakeshore, Ludington State Park, and the Huron-Manistee National Forest. Glacial drift thickness averages between 400 and 700 ft for the entire district (Anonymous).

Along the west edge of most of the district, steep morainic bluffs and sand dunes rise rapidly from 580 ft, at the shoreline, to 800-900 ft. Large, high sand dunes, up to 600 ft, are found near Ludington and at other coastal locations. These high dunes date from high Lake Nipissing water levels (Kelley 1962). Large Nipissing-age dunes are also found on North and South Manitou islands and on South Fox Island. Most of the high dunes, both on the mainland and on the islands, are perched on underlying till. The till, varying in texture from gravelly sand to clay, is exposed on the steep lake bluff. The dune soils are excessively well drained sands containing no fine silts or clays.

Many large lakes along the shoreline, including Crystal,

Betsie, Hamlin, White, Silver, and Muskegon lakes, are former bays of Lake Michigan or lower reaches of streams, that were separated from Lake Michigan by the development of sandbars across the mouth of the bay or stream (Dorr and Eschman 1984).

Coarse-textured end-moraine ridges are the predominant landforms in the south and also north of Manistee. In the south, the end moraines, 3-5 mi wide and 100-300 ft high, are separated by 1-3 mi wide outwash channels. North of Manistee, the end-moraine ridges are much steeper and without broad outwash channels between them as compared to ridges in the south. Most of the soils on the end moraines are well drained sands.

Between Manistee and Frankfort, resistant bluffs of medium-textured till rise steeply from the lake, forming moderately to steeply sloping end-moraine ridges. To the east of these ridges are steep ridges of sandy soil.

In the southern half of the district, there are small areas of more gently sloping, fine-textured ground and end moraines. Most of the soils are well drained.

Between Ludington and Manistee is a broad expanse of flat sand lake plain and fine-textured ground moraine. Much of the lake plain consists of wet depressions and small, droughty beach ridges. Most of the ground moraine is poorly drained.

PRESETTLEMENT VEGETATION: Most concentrated at Sleeping Bear Dunes National Lakeshore, Big Sable Point, and Little Sable Point, the dunes were noted as "loose sands" and undoubtedly, in places, vegetated with dune grasses and shrubs. But farther inland, they support a variety of forests, including upland hemlock (4226), hemlock/white pine (4227), white pine/red pine (4216), and red pine/jack pine (4215) dominated forests. Northern Hardwood Forests (4111), often with a significant component of hemlock and/or black oak, were also common. Poorly drained interdunal areas, such as those at Point Betsie, often supported cedar (4231) and/or hemlock (4237) dominated swamps and shrub swamps (612).

Forests with Hemlock and beech were co-dominant (4119) on sandy lakeplain and sandy moraines. This forest type was found north of Pentwater, and south of Manistee. Other upland portions of the sandy lake plain included White Pine Forests (4211), which included significant amounts of white oak, beech, hemlock, black oak, and white ash. Several large Wooded Dune and Swale Complexes (911), supporting a variety of upland/wetland plant communities, are found on the sandy lakeplain in and around the Sleeping Bear Dunes National Lakeshore (The current vegetation of these complexes is described in detail in the 1993 CZM report [MNFI 1993]). Poorly drained portions of the sandy lakeplain supported black ash (4141), elm (4142), aspen (4146), tamarack (4233), cedar (4231), and hemlock-dominated (4227) swamps. Willow/Alder/Bog Birch Thickets (6122), Emergent Marshes (6221), and Great Lakes Marshes (6222) were also found on the sandy lakeplain. As with further south along the Lake Michigan shoreline, Great Lakes Marshes were associated with inland lakes which formed at the mouths of major rivers, such as the Manistee and Big Sable.

Northern Hardwood forests (4111) dominated most of the morainic soils, regardless of their soil texture. Their dominance was a result of the increased precipitation and reduced transpiration along Lake Michigan (Denton and Barnes 1987; Eichenlaub 1979), allowing beech and sugar maple to dominate sandy soils where oaks and pines would otherwise be expected. For this reason, even the droughty sands of the dunes support moisture demanding species such as beech, sugar maple, and basswood. Hemlock dominated forest was also found on ground moraine with finer textured soils. Poorly drained areas with finer textured soils supported black ash (4141), black spruce (4232), and cedar-dominated (4231) swamps.

Sandy outwash deposits supported White pine/red pine (4216) forests and Red pine-dominated (4212) forests which included white oak and jack pine, and locally, Northern Hardwoods (4111).

NATURAL DISTURBANCE: Although many of the Nipissing dunes have been stabilized by forest vegetation, large blowouts are common on the dunes immediately adjacent to Lake Michigan. Some of these blowouts are the product of human disturbance, but many, noted in the GLO notes, are probably naturally caused. The blowouts are large features. South Fox Island blowouts are in areas where timber was not harvested, probably indicating natural origin. Some of these blowouts continue to move landward, burying and killing northern white-cedar trees that are 100-200 years old.

Signs of recent wildfires were noted several times by surveyors on sandy outwash deposits. Occasional, relatively small windthrows were encountered on the moraine ridges of the district.

HUMAN LAND USE: Native American's fields were noted south of Stony Lake, and northwest of Bear Lake at the time of the surveys. Early European settlements were already established at Manistee and both Manitou islands.

Many of the end and ground moraines are used for orchards or vineyards. The protection from late spring frosts afforded by Lake Michigan is responsible for the utilization of the district for extensive orchards of apples, cherries, and peaches (Olmsted 1951).

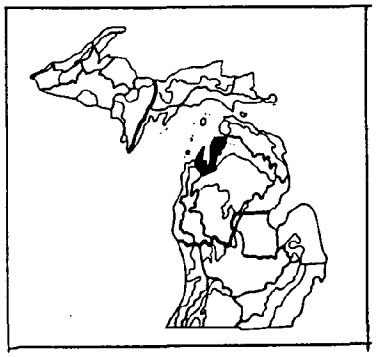
Sand mining occurred on the dunes within the district and oil fields tap the underlying Devonian petroleum reservoirs in the south.

Urban development in this subdistrict has been concentrated along the shoreline, in the town of Manistee, and several other smaller towns.

IMPACT OF HUMAN LAND USE ON VEGETATION: Many wetlands, where they occurred on finer textured soils, were drained for agriculture. Probably due to man-made manipulations and some changes in dune configuration at the Big Sable dunes, the boundaries of Hamlin Lake have changed significantly since the time of the surveys.

Today, the pine dominated forests, for the most part, include only scattered white/red pine, and more white/black oak and aspen than the presettlement condition. Although Northern Hardwood

Forests (4111) in this subdistrict have been logged, species composition remains similar to presettlement conditions.



DISTRICT 11: Leelanau and Grand Traverse Peninsula.
SUBDISTRICT 11.1. Williamsburg: Coarse-textured End-Moraine Ridges.
SUBDISTRICT 11.2. Traverse City: Coarse-textured Drumlin Fields on Ground Moraine.

CLIMATE: The climate is strongly influenced by Lake Michigan; spring and early summer are cooler than the Highplains District to the east (Albert et al. 1986). The growing season is 110 to 150 days, longest along the shoreline of Lake Michigan (Eichenlaub et al. 1990). A combination of early date of last freeze in spring, cool spring temperatures, and reduced thunderstorm severity result in creating an important area for commercial fruit production, primarily apples, cherries, and grapes. The lake-effect snowfall is heavy, averaging 100 to 140 inches annually. Average annual precipitation is 30 to 34 inches. Extreme minimum temperatures are -32°F along Lake Michigan and -40°F inland.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: This district of drumlin fields, coarse textured ground and end moraines, dunes, and sandy lakeplain, is located around Grand Traverse Bay and Lake Michigan. Bays of the lake and several long, narrow inland lakes divide the district into narrow peninsulas. Two of the long, narrow lakes of the district, Torch and Elk lakes, were bays of Lake Michigan until they were cut off by sand deposition during Nipissing time (Dorr and Eschman 1984). Elevation ranges from 580 ft along the Lake Michigan shoreline to 1095 ft inland. Underlying limestone bedrock is exposed in several places, and the glacial drift is less than 50 ft thick over much of the district (Akers 1938; Anonymous). The thickest drift, approximately 350 ft, is located just east of Lake Charlevoix. The glacial drift contains abundant limestone fragments derived from nearby bedrock. Most of the district is occupied by drumlin fields. The drumlins are long, narrow ridges, usually about 1/4 mi wide, 1 mi long, and less than 100 ft high. Slopes are moderate to steep, and the soils are gravelly sand and gravelly sandy loam, mostly well drained. Swamps and small lakes are found in depressions between many of the drumlins, but some depressions are relatively well drained. In

western Charlevoix County, where the drumlin ridges are closely spaced, narrow deposits of thick organic soils, less than 1000 ft wide, separate adjacent drumlins. A narrow band of sandy lakeplain occurs along most large inland lake margins, and along Grand Traverse Bay at the northeast end of the Leelanau Peninsula and at the south extreme of the bay. Coarse texture end moraine and outwash deposits lie along the south end of the district. Throughout the district, most of the poorly drained soils were shallow or deep organic deposits rather than poorly drained mineral soils. Narrow, somewhat low sand dunes border the western shorelines of the Leelanau Peninsula, Mission Peninsula, and of Charlevoix and Antrim counties. This dune border is typically less than a mile wide, accounting for a only a small percentage of the district's surface area.

PRESETTLEMENT VEGETATION: Northern Hardwood Forests (4111) of American beech, sugar maple, basswood, yellow birch, and hemlock characterized the upland portions of the drumlin fields, while eastern white-cedar (4231) dominated most of the wetlands between the drumlins.

Northern white-cedar is common in the wetlands due to the calcareous soils. It was dominant also on the sandy lakeplain bordering many inland lakes and Grand Traverse Bay. Small Wooded Dune and Swale Complexes (911) are located on sandy lakeplain at the south end of the east arm of Grand Traverse Bay, and on the west side of the Mission Peninsula at Bowers Harbor. Shrub swamps (612) also were found on the sandy lakeplain. Other wetland species present include balsam fir, hemlock, white pine, white spruce, red maple, American elm, and trembling aspen.

On the dunes, Northern Hardwoods Forests (4111) of beech, sugar maple, red maple, red oak, hemlock, white pine, and hop-hornbeam were found.

A small portion of medium textured ground moraine located northwest of Elk Lake supported Black Ash Swamp (4141).

The vegetation on the well drained soils of the end-moraine ridge at the southern edge of the district was Northern Hardwood Forest (4111) dominated by sugar maple, beech, and hemlock. More xeric sandy moraines supported white and red pines (4216) intermixed with white and red oaks.

The excessively drained outwash sands, restricted to the southern boundary of the district, supported forests of red pines (4212), and occasionally white pine (4211). Poorly drained portions of the outwash supported cedar-dominated (4231) swamps.

NATURAL DISTURBANCE: Windthrows were noted in several of the black ash and cedar/hemlock dominated swamps close to the shoreline. Windthrows were also recorded in cedar swamps on poorly drained outwash deposits at the south end of the district.

Recent wildfires were noted by surveyors near the shore along the eastern Leelanau Peninsula, and behind sand dunes along the east shore of Grand Traverse Bay.

HUMAN LAND USE: Surveyors noted Native American land uses including small fields and maintained sugar bushes.

Today, the district contains numerous orchards and vineyards. The lake-moderated climate and the rich, calcareous soils both add to the district's agricultural value. The steeper drumlins are used for pasture. Most of the excessively drained outwash deposits are in state forest lands.

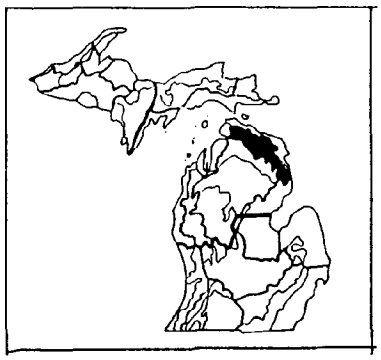
Urban development in this district is most concentrated around Traverse City. A number of smaller towns, highways, and shoreline development also characterize land use in this area.

IMPACT OF HUMAN LAND USE ON VEGETATION: Agriculture has replaced much of the upland forests which characterized this district. Most of the wetlands which occupied the poorly drained soils between drumlin and morainic ridges have been altered; often for use as pasture. Others are completely surrounded by intensive agriculture.

Urban development around Traverse City has eliminated most of the pine/oak forest that once occupied the sandy lakeplain there.

DISTRICT 12. Presque Isle.

CLIMATE: The climate of much of the district is moderated by Lake Michigan and Lake Huron (Albert et al. 1986). The growing season is 140 days long near the Lake Huron shoreline, but at the inland margin of the district (Atlanta, a town near this inland border) the growing season is only 110 days (Eichenlaub et al. 1990). There is a greater chance of late spring and early fall freezes farther inland. Winter snowfall is high throughout the district, ranging from 70 to 140 inches, but lake-effect snowfall is greatest in the west, near Lake Michigan. Average annual precipitation is 28 to 32 inches. Extreme minimum temperatures are as cold as -40°F inland, but only -28°F along the Great Lakes shorelines.



DISTRICT 12. Presque Isle.

SUBDISTRICT 12.1. Onaway: Drumlin Fields on Coarse-textured Ground Moraine.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The subdistrict has rolling to moderately sloping ground-moraine topography. Drumlins are common on the ground moraine of the eastern three-quarters of the subdistrict. In the drumlin fields, individual ridges are typically separated by poorly drained outwash. The western quarter of the subdistrict contains several large lakes and large areas of lake plain interspersed with small ground-moraine deposits. The lacustrine deposits are from early Algonquin time, when the small ground-moraine deposits remained as "islands" above the level of glacial Lake Algonquin (Burgis and Eschman 1981; Dorr and Eschman 1984).

The elevation of the district ranges from 595 to 975 ft. Elevations are generally lower to the northeast near Lake Huron and higher to the southwest along the boundary with the Vanderbilt Subdistrict. Small areas of exposed limestone bedrock are common in the ground moraine. The glacial drift thickness increases to several hundred feet at the southern and western edges of the subdistrict (Haag 1976).

The rolling hills and drumlins of the eastern section of ground moraine, characterized by slopes in the 0-12% slope class, have highly variable drainage and soil texture. Gravelly sandy loams are common. The gravel and angular rock fragments are predominantly limestone, derived from bedrock at the northern edge of the drumlin fields (Burgis and Eschman 1981). The glacial deposits within the drumlin fields are primarily brown, sandy tills, but locally these are overlain by red, sandy till or lacustrine deposits. Readvancing glaciers sculpted the southeastward-trending drumlin fields. Most of the drumlins are less than 60 ft high, 1/8-1/4 mi wide, and about 1 mi long. Karst topography is also present on the ground moraine of the subdistrict.

Moderately well to well drained sands and sandy loams typify the drumlins. The depressions between the drumlins, that are generally poorly drained, constitute a greater portion of the landscape than the drumlin ridges.

The ground moraine is also broken by a broad outwash channel west of the town of Hawks. Soils of the channel vary from sand to

gravel and drainage conditions vary from excessively well drained to very poorly drained. The outwash contains several kettle lakes.

Glacial drift is as thick as 500 feet at the inland margin of the district, and discontinuous within 30 miles the shorelines of Lake Michigan and Lake Huron. The underlying bedrock consists of Mississippian and Devonian marine and near-shore sedimentary deposits (Millstein 1987, Dorr and Eschman 1984). Limestone, dolomite, and gypsum are locally exposed and mined. Devonian bedrock in the district is a source for salt, brine, and major petroleum reservoirs (Dorr and Eschman 1984).

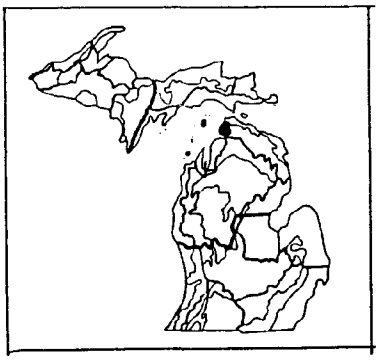
PRESETTLEMENT VEGETATION: Most of the drumlins of the district supported northern hardwood forest (4111), dominated by sugar maple, beech, basswood, hop-hornbeam, white ash, and hemlock. In the southeast and near Black Lake, some sandy drumlins surrounded by droughty outwash supported red pine forest (4212), with red oak, and bigtooth aspen. Some of the smaller, low drumlin ridges were dominated by hemlock (4226) or a mix of hemlock and white pine (4227); similar upland conifer stands were found on the smaller drumlin ridges in Menominee County (Subdistrict 15.1).

The poorly drained outwash and ground moraine surrounding the drumlins typically supported forested wetlands of northern white-cedar (4231). Cedar was commonly the dominant at the upland margins of wetlands, but increasing amounts of tamarack and black spruce occurred in the center of the wetlands. Other species observed in these forested wetlands included trembling aspen, balsam poplar, paper birch, black ash, white pine, hemlock, willow, and speckled alder.

NATURAL DISTURBANCE: Windthrows were noted along the boundary with Subdistrict 12.3 (Cheboygan Lakeplain), but most of these windthrows occurred on the lakeplain, not on the moraines of this subdistrict.

HUMAN LAND USE: Most of the drumlin ridges were cleared for agriculture, primarily for pasture, but also for some row crops and potatoes. The soils are very rocky, and the rocks form huge mounds on the landscape; many have also been built into fieldstone houses. Some of the wetlands have also been drained for pasture, but most remain intact.

IMPACT OF HUMAN LAND USE ON VEGETATION: The northern hardwood forests (4111) have almost all been cleared for agriculture, but some remain as woodlots. Most of the cedar swamps remain intact.



SUBDISTRICT 12.2. Stutsmanville: Steep Sand Ridges.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: This small subdistrict is characterized by large, broad ridges of sandy ground moraines, some nearly 500 ft high. Glacial drift thickness is generally several hundred feet thick.

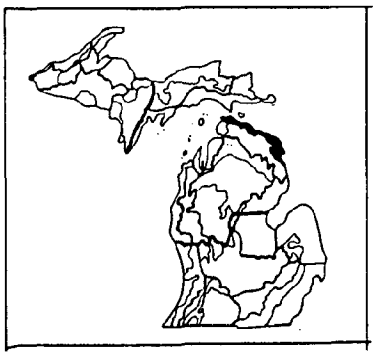
The soils are primarily well drained sands and sandy loams. The moderate to steep slopes of the subdistrict account for the well drained soils. The narrow, often steep valleys between the ridges are poorly or very poorly drained, but they account for only a small part of the subdistrict's surface area.

PRESETTLEMENT VEGETATION: The predominant vegetation of the subdistrict is Northern Hardwoods Forest (4111) dominated by beech, sugar maple, hemlock, basswood, hop-hornbeam, and yellow birch. Lowlands, restricted to relatively narrow valleys between the ridges, are dominated by northern white-cedar (4231), or occasionally tamarack (4233) or mixed conifers (423). The largest wetland noted was approximately 1.5 square miles in area.

NATURAL DISTURBANCE: No natural disturbances were noted by surveyors in this subdistrict.

HUMAN LAND USE: Several Native American fields were noted with one to two miles of the shoreline on the sloping ridges of this subdistrict. Following European settlement, most of the forests were logged, but little agricultural development has occurred on the large, steep ridges.

IMPACT OF HUMAN LAND USE ON VEGETATION: Most of the wetlands persist, although all have undoubtedly been logged. The upland forests probably contain less white pine and hemlock today than the presettlement condition.



SUBDISTRICT 12.3. Cheboygan: Lake Plain.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The subdistrict forms a narrow band of sandy lake plain, 2-10 mi wide, along the shoreline of Lake Huron in northeastern Lower Michigan. Although a veneer of sand covers a large part of the subdistrict's surface, limestone bedrock is near the surface of almost the entire subdistrict, and exposed bedrock and cobble beaches are common. Similar to other sand lake plains in the state, much of the topography is a series of beach ridges and adjacent wet depressions, locally extending several miles inland. These dune and swale complexes are well developed in Sturgeon Bay of Lake Michigan and east of Cheboygan and along Hammond Bay of Lake Huron. Sand dunes, low foredunes, sand spits, and beach ridges line much of the shoreline. The Original Swamp Map of Michigan (Lane 1907) shows most of the subdistrict as swamp. The elevation ranges from 580 ft along Lake Huron to 750 ft inland.

West of Rogers City, the surface soil is primarily sand. Sand depth and the surface features are quite variable. The Ocqueoc River, in northwestern Presque Isle County, cuts through thick sand deposits that extend landward for greater than a mile. These deposits are relatively flat, and their origin is unclear. Large Nipissing age dunes are located near Sturgeon Bay, on Lake Michigan (Dorr and Eschman 1984). Most of the dunes on Lake Huron are much smaller; the largest of these are 30-40 ft high near 40 Mile Beach.

Series of low beach ridges and depressions are very common in embayments, commonly extending three-quarters of a mile or more inland. Near present lake level, the depressions are typically poorly drained and sometimes ponded. Farther inland depressions become better drained; in some places they are excessively drained, as are adjacent beach ridges.

Inland from the beach ridges and depressions are extensive flat, featureless areas of sand lake plain that are usually poorly drained. Within these broad tracts occur low sandy rises with slightly better drainage.

Exposed limestone bedrock and thick deposits of cobbles are common southeast of Rogers City. Waves have eroded the limestone bedrock into steep bluffs. Organic soils cover the cobbles, but fire, which was widespread throughout this portion of the lake plain at the time of the GLO surveys, has destroyed much of the

organic cover, leaving bare cobbles.

Karst depressions occur locally around Long Lake. Long, Grand, and Grass lakes have long and linear basins formed by glacial erosion of the underlying bedrock; the orientation of these lakes is similar to that of the drumlins in adjacent Subdistrict 12.1.

Glacial drift is discontinuous near the shorelines of Lake Michigan and Lake Huron. The underlying bedrock consists of Mississippian and Devonian marine and near-shore sedimentary deposits (Millstein 1987, Dorr and Eschman 1984). Limestone, dolomite, and gypsum are locally exposed and mined. Devonian bedrock in the district is a source for salt, brine, and major petroleum reservoirs (Dorr and Eschman 1984).

PRESETTLEMENT VEGETATION: Large areas of flat, poorly drained sand lakeplain were dominated by Lowland Conifer Forests (423). The conifer species most common dominant on the lakeplain was northern white-cedar (4231). Northern white-cedar dominated in areas where there was some lateral water movement and formed dense stands at the seepy, calcareous margins of the adjacent subdistrict (12.1). Tamarack (4233) was also a common dominant, and often was found growing with cedar; it was more common where drainage conditions were more impeded. Numerous other species were common in the extensive wetlands of the subdistrict, including balsam fir, black spruce, eastern hemlock, white pine, balsam poplar, trembling aspen, paper birch, speckled alder, and shrub willows.

White pine and red pine (4216) were common co-dominants on the well drained, low sandy ridges of the lakeplain, especially near the Lake Michigan and Lake Huron shorelines. These pines also grew together on gravelly or rocky sites near the Lake Huron shoreline.

Hemlock and white pine (4227) were also common co-dominants, often where the drainage conditions were slightly poorer than where white pine and red pine grew together. Birch/ [trembling] aspen (413) and aspen (4146) also occurred locally on flat to rolling portions of the sand lakeplain.

Near the Ocqueoc River, where droughty outwash sands extended for several miles inland from the shore, there were extensive stands of jack pine (4213) and red pine/jack pine (4215). These stands also contained red oak and some white pine.

The areas of Wooded Dune and Swale complex (911) near Sturgeon Bay and Cheboygan contained ridges of white pine and red pine and swales dominated by either northern white-cedar and other conifers, or if they were flooded, by emergent marsh. The Wooded Dune and Swale Complex at Hammond Bay was drier; the ridges were dominated by white pine and red pine near the shoreline, with jack pine and northern pin oak becoming more common further inland. The swales were typically narrow; the drier ones supported balsam fir, aspen, and other upland species, and the wetter swales supported cedar, tamarack, and other lowland conifers or hardwoods. Along the shoreline, Great Lakes Marsh (6222) occurred within the Wooded Dune and Swale Complexes.

Calcareous ponds (52) occurred near the shoreline; these ponds

were sometimes dominated by Emergent Marsh (6221) or small diameter tamarack, cedar, and occasional black spruce.

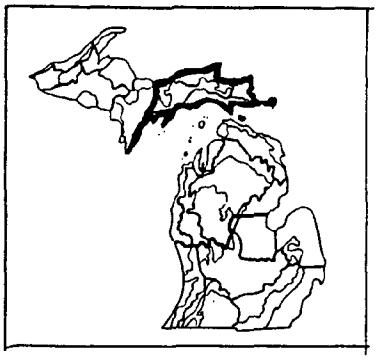
Although Northern Hardwoods (4111) were not generally extensive in the subdistrict, some large tracts were located around Long and Grand Lakes, along the Cheboygan and Black Rivers, and locally along the Lake Michigan and Lake Huron shorelines.

NATURAL DISTURBANCE: Several windthrows were noted; the largest of these were less than 2 square miles in area. The windthrows were concentrated near the boundary of the lakeplain with the drumlins of Subdistrict 13.1. Windthrows were also recorded on Hog, Garden, and High islands.

There were also two large areas of burnt timber. These burns were not noted in the first survey (of the township lines), and may have been the result of early logging operations near Cheboygan, where log mills were already noted in the first survey. Several square miles of timber were burned near Cheboygan and several more were burned near Thompson's Harbor and Grand Lake. Mixed stands of white pine and red pine (4216) appeared to be the forest type most impacted by the fires. Wildfires were also noted on Garden and Hog islands.

HUMAN LAND USE: Early European activity was apparent at Cheboygan at the time of the surveys. Limestone in this subdistrict has been quarried at several locations, including near Alpena, Grand Lake, Adams Point, and Rogers City. Residential development has also been concentrated along the shoreline.

IMPACT OF HUMAN LAND USE ON VEGETATION: Logging has greatly altered the forest composition of many upland forest types, especially those dominated by white pine, red pine, or hemlock. Most of the wetlands have also been logged. No major changes of wetland forest composition have been noted; northern white-cedar has generally regenerated well on the calcareous soils of the lakeplain.



REGION III. Eastern Upper Michigan.

REGIONAL CLIMATE: Due to northern latitude and the close proximity of Lake Michigan, Lake Superior, and Lake Huron, the region has a cool lacustrine climate. Most air masses cross the Great Lakes

before entering this region, resulting in reduced continentality. Compared to areas of equivalent latitude in Wisconsin and Minnesota, the region is warmer in winter and cooler in summer. The lakes also reduce the severity of thunderstorms. Lake effect snow and rain characterizes portions of the region near the Great Lakes shorelines. Much more snowfall occurs in the northeastern part of the region than in the southwestern parts. Much of the region is relatively low in elevation, and most physiographic features do not appreciably influence climate.

The growing season length is less than 100 days inland and up to 150 days along the Great Lakes shorelines (Eichenlaub et al. 1990). Annual precipitation ranges from 32 to 34 inches. Annual snowfall ranges from 180 inches of lake-effect snow along Lake Superior to 60 inches inland. Extreme minimum temperatures range from -28°F along the Lakes Superior and Michigan to -46°F inland.

DISTRICT 13. Mackinac.

CLIMATE: The district is moderated by the Great Lakes and as a result, is the warmest district in Upper Michigan. The growing season for the district as a whole is 125 days (Eichenlaub et al. 1990). Extreme minimum temperatures is -29°F. Lake-effect snowfall occurs throughout the district, most commonly in the Rudyard Subdistrict. The St. Ignace and Escanaba subdistricts are also warmer than the Rudyard Subdistrict. Average annual precipitation ranges from 30 to 34 inches.

DISTRICT 13 Mackinac.
SUBDISTRICT 13.1. St. Ignace: Limestone Bedrock and Sand Lake Plain.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The entire subdistrict is underlain by Silurian and Ordovician age sedimentary bedrock, principally limestone and dolomite, but also including less resistant shale and gypsum (Dorr and Eschman 1984). The resistant Niagaran series dolomite and limestone of Silurian age form the Niagaran Escarpment, which is locally exposed as cliffs and limestone pavement (alvar) along the Lake Michigan shoreline from the Stonington Peninsula in the west to Drummond Island at the far eastern edge of the Upper Peninsula of Michigan, and eastward to Cockburn Island, Manitoulan Island, and the Bruce Peninsula of Ontario. The underlying bedrock is typically less than 50 ft below the surface of the glacial drift (Vanlier and Deutsch 1958; Sinclair 1959, 1960; Vanlier 1963). Limestone is mined in several places within the subdistrict.

A wide variety of landforms of glacial lacustrine origin characterize the subdistrict; including flat lake bed, deltaic deposits of sand, parabolic dune fields, and shallow embayments containing transverse dunes.

Large areas consist of lacustrine sand deposits that have flat to gently undulating surfaces. On this topography, only a few inches of elevation change can greatly alter drainage conditions. Drainage conditions also depend on depth to underlying bedrock or fine-textured substrate.

Ground moraine is locally present. Exposed limestone and dolomite bedrock form flat, pavement-like areas and breccia chimneys are locally exposed.

Soils within the district are diverse. Lacustrine soils were primarily sands, but there are small, local areas of lacustrine clays. The clays are primarily poorly drained. The sands were generally either excessively drained or poorly drained. Excessively drained sands are on beach ridges or dunes. Poorly drained sands are more common, occupying much of the flat lake plain or depressions between dunes and beach ridges. The soils of the ground moraine within the district range from loamy sands to loams; they are often stony. Where bedrock is near the surface, soils are often calcareous and poorly drained. The most common soil orders within the subdistrict are Alfisols (Boralfs), Histosols, and Entisols (Aquepts), with some Orthods and Aquods (Soil Conservation Service 1967).

PRESETTLEMENT VEGETATION: Drummond Island, for the most part described by surveyors as "rolling and stony", was dominated by forests of white spruce, northern-white cedar and tamarack (4223) mixed with Aspen/paper birch forests (413) on thin soils over bedrock. Small portions at the south of the island supported Northern Hardwoods (4111) intermixed with spruce/fir and birch dominated forests. The southwest extreme of the island had experienced many windthrows from storms off of the lake. This area was described as predominantly aspen/birch thicket (413).

Some of the more resistant dolomites and shales, when exposed at the surface, proved to be too droughty for successful forest establishment, and formed communities called Alvar (741). Good

examples of these sites are found today on the northern Maxton Plains of Drummond Island and 5 mi southeast of Gulliver Lake in Schoolcraft County. As a result of severe drought, these areas today support only grasses, herbs, and occasional shrubs on thin soil. A dense mat of roots and rhizomes is exposed on the surface of the bedrock, especially in cracks were there is increased moisture availability. Small wet depressions and lower slopes support an herbaceous and shrub community composed of species tolerant of saturated soil. Thin organic deposits have developed, but they also appear to be subject to destruction by fire in drought years. Trembling aspen forms stunted clones on the droughty uplands and also grows in the depressions.

Great Lakes Marsh (6222) was noted by surveyors along the shoreline of Drummond Island in small, protected coves and embayments. Organic soils in shallow depressions on the eastern and southern side of the island supported Hardwood-Conifer Swamps (42) dominated by cedar, spruce, tamarack, black ash, and aspen.

Much of the coastal zone along northern Lake Huron, where thin soils overlay bedrock, were dominated by Balsam fir/spruce/cedar forests (4223) and Northern Hardwoods (4111). Limestone ledges (744) were encountered by surveyors throughout the forests inland from Pochartrain Shores, and west of St. Martins Bay. The Les Cheneaux Islands are predominantly ground moraine, and also supported cedar/spruce/fir (4223), and aspen/birch forests (413).

Sandy lakeplain along northern Lake Huron supported a number of Great Lakes Marshes (6222) in a number of protected coves in and around the Les Cheneaux Islands. The substrate in these marshes was often clay or marl (MNFI 1988). A Wooded Dune and Swale Complex (911) at St. Vital Bay supported balsam fir, white pine and red oak on the ridges, with Shrub swamps (6122) and Emergent Marshes (6221) in the open swales. Extensive Cedar swamps (4231) grew on the poorly drained soils of the lake plain. An example of this type of wetland occurs just east of Ponchartrain Shores. Further west on St Martins Bay, Great Lakes Marshes (6222) and Wooded Dune and Swale Complexes (911) are found in the protected west side of the bay. The low dune ridges and narrow swales of this complex, as well as that found to the south in Horseshoe Bay, supported cedar, spruce, and paper birch. Marly pools were mentioned by the surveyors in this area. Stunted cedar, tamarack, and white pine grew along the edges of these pools.

The sandy lakeplain portions of Bois Blanc Island supported extensive Cedar swamps (4231), Tamarack swamps (4233) and Cedar/spruce/fir upland (4223). Hemlock (4226) and Northern Hardwood (4111) forest also dominated many uplands on sandy lakeplain and bedrock on Bois Blanc Island.

The thin soils over bedrock which characterize Mackinac Island and the area around St. Ignace supported several forest types. These included Northern Hardwoods (4111) on better drained sites, and both Balsam fir/cedar/spruce (4223), and Aspen/birch (413) on poorly drained sites. Vast areas of organic soils located on lacustrine deposits just north of St. Ignace supported Cedar (4231) and Tamarack swamps (4233), with scattered dune ridges. High

bedrock ridges west of the straits area, and lower morainal ridges northeast of Brevoort Lake supported Northern Hardwood forests (4111).

The vast dune/swale complex at Point Aux Chenes supported tamarack, aspen, birch, and spruce in the narrower swales, with Emergent Marsh (6221) and Shrub swamps (612) in the wider swales. Pines dominated the dune ridges.

On the low parabolic dunes along the sandy lakeplain of Lake Michigan, the moist air and presumably higher precipitation and soil moisture caused most of the dunes to be dominated by Northern Hardwood (4111) forests of sugar maple, beech, hemlock, red oak, yellow birch, paper birch, and basswood. The Brevoort Lake dunes, located near the Lake Michigan shore, were dominated by Northern Hardwoods. In contrast, the dunes located near Round Lake, several miles inland from Lake Michigan, support forests dominated by Red and jack pines (4215), possibly indicating the lack of local micro-climatic influence bringing moisture from Lake Michigan.

The protected embayment at Epoufette supported Great Lakes Marsh (6222), and swamps of cedar, tamarack, cedar, and spruce. From Epoufette to the western end of the subdistrict, the sandy lakeplain along the shoreline was dominated by a chain of Wooded Dune and Swale Complexes (911). Within the complexes, the ridges were dominated by forests of white pine, red pine, white spruce, balsam fir, and hardwoods; the wetter swales were dominated by grasses, sedges, and other aquatic plants, whereas the drier swales supported northern white-cedar swamps and, occasionally, upland forest.

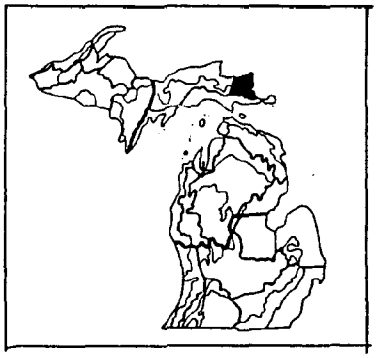
Further inland, the organic soils supported vast swamps dominated by cedar, spruce, and tamarack, while adjacent ground moraine ridges were dominated by Northern Hardwoods (4111), Hemlock/beech (4119), and Hemlock/white pine (4227) forests.

NATURAL DISTURBANCE: The surveyors recorded numerous occurrences of fire in upland and swamp forests on both sand and bedrock. There were wildfires and windthrows on Little St. Martin Island. Many windthrows were noted by surveyors in the cedar and tamarack dominated swamps north of Hughes Point. Beach ridges near the Crow River mouth were burnt off at the time of the surveys.

HUMAN LAND USE: European settlements were well established at St. Ignace, Bois Blanc Island, and at Gros Cap at the time of the surveys in the 1840's. The 1829 survey of Mackinac Island showed only small second growth timber over the entire island, probably as a result of firewood cutting. A British military outpost was established at the southwest end of Drummond Island. Fishing establishments were based at various locations along the shoreline from Epoufette west to Seul Choix Point. Native American settlements were also located on Bois Blanc Island and St. Martins Island. Their sugar camps were also located throughout the area where Northern Hardwoods (4111) dominated. Limestone has been quarries at a number of locations within this subdistrict, Drummond Island, inland areas northeast of Hessel, Millecoquins Lake, and at

seul Choix Bay. Upland areas dominated by pines and Northern Hardwood were cut, and often burned, by the early 20th century.

IMPACT OF HUMAN LAND USE ON VEGETATION: Limestone quarries have had obvious permanent impacts in several locations of this subdistrict. Roads and highways have probably had the most enduring negative impact on coastal wetlands, by disrupting wetland hydrology and facilitating shoreline development. A number of Great Lakes Marshes (6222) along northern Lake Huron were impacted by the construction of M-134 along that shoreline. Urban development is increasing around St. Ignace. Residential development is quite dense on many of the Les Cheneaux Islands which have been connected tot eh mainland by roads. Many of the Northern Hardwood forests (4111) located on ground moraine in this subdistrict have been cleared for agriculture and pasture use. The Wooded Dune and Swale Complexes (911) west of Naubenway remain, for the most part, similar to their presettlement character, with changes limited to upland forest dominants.



DISTRICT 13 Mackinac.
SUBDISTRICT 13.2. Rudyard: Clay Lake Plain.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The entire district is underlain by Silurian and Ordovician age sedimentary bedrock, principally limestone and dolomite, but relatively thick lacustrine clays cover almost all of the subdistrict. The underlying bedrock is typically less than 50 ft below the surface of the glacial drift for much of the district, but the drift is 100-200 ft thick where preglacial valleys dissected the bedrock surface; such valleys underlie the present valleys of the Pine and Carp Rivers (Vanlier and Deutsch 1958; Sinclair 1959, 1960; Vanlier 1963).

Almost the entire subdistrict is a broad clay lakeplain. A small area of sand lake plain is present in the center of the subdistrict. Within this small area of sand plain there is a series of ancient beach ridges and swales, many miles from the present Great Lakes shorelines.

Sandy ground moraine is encountered on Sugar and Neebish islands, and on the mainland at the north end of Munuscong Bay. Soils are generally well drained in the ground moraine.

The clay soils were somewhat poorly drained to poorly drained. The localized sands were generally either excessively drained or

poorly drained.

PRESETTLEMENT VEGETATION: The poorly drained clay plain, common within 3-4 miles of the Great Lakes shoreline in much of the subdistrict, supported Hardwood-Conifer Swamps (42) with balsam fir, balsam poplar, hemlock, northern white-cedar, tamarack, trembling aspen, white pine, black spruce, and white spruce. The poorly drained shorelines of the St. Marys River, at the east edge of the subdistrict, today support some of the most extensive Great Lakes Marshes (6222) of Michigan. These marshes, for the most part, were documented by the surveyors as being narrower than they are today. The may have only described portions of the marsh we recognize as the wet meadow zone, stopping at the water line. Today, the emergent marsh zone can be a mile wide, and the wet meadow zone along the shoreline is often another quarter to half mile wide. The sandy lakeplain along Waiska Bay supported Cedar swamp (4231) and Lowland Hemlock (4227).

Hemlock/sugar maple forests (4228), which also included American elm, basswood, and yellow birch, and Aspen/birch forests (413), were locally common well drained ground moraine of Sugar and Neebish islands. Poorly drained portions of these ground moraines supported Alder/willow swamps (6122).

A large Balsam fir-dominated swamp was located on poorly drained sand lakeplain at the south end of Neebish Island. Large peatlands on sand lakeplain supported "open swamp" dominated by spruce, cedar, and tamarack (423) east of Izaak Walton Bay. Hemlock forests (4226) dominated beach ridges along that shoreline. Peatlands to the northwest and south of Munuscong Bay were also dominated by cedar (4231), spruce (4232), and tamarack (4233).

NATURAL DISTURBANCE: Poor drainage conditions cause widespread windthrow. Large windthrows were noted by surveyors south and west of Sault St. Marie, and on the south side of Sugar Island, in 1845.

HUMAN LAND USE: European settlement had already taken place at Sault St. Marie when the area was surveyed in 1845. Forests had been cleared for several miles around the settlement. Also Native American settlements and trails were noted there by surveyors.

Subsequent development of this subdistrict has seen the extensive forest clearing and swamp drainage for agricultural production. Swamps near the Great Lakes shoreline have been less modified than those elsewhere in the subdistrict. Many Great Lakes Marshes were hayed for marsh hay by creating shallow ditches in the marsh. All of these ditches have now been abandoned.

Railroads and highways extend south from the urban development around Sault St. Marie.

IMPACT OF HUMAN LAND USE ON VEGETATION: Much of the clay plain has been converted to pasture or other agricultural use, following widespread construction of 6-8 ft-deep ditches. However, drainage remains a limiting factor. Where pasture land is abandoned, it quickly returns to shrub willows, speckled alder, tamarack, black

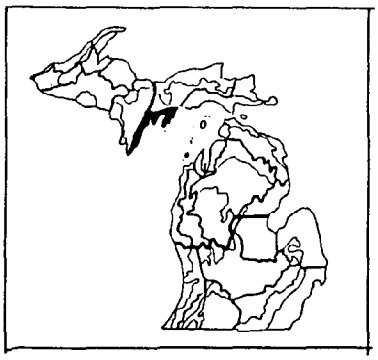
ash, and other species indicative of poor drainage.

The wakes produced by large ships passing through the St. Marys River has degraded many of the Great Lakes Marshes (6222) there.

Many of the Lowland Conifer swamps (423) along Izaak Walton Bay remain, with several roads and railroads bisecting.

On Sugar and Neebish islands, the majority of Hemlock/sugar maple (4228), Aspen/birch (413), and Balsam fir/spruce (4223) forests remain in some form, although probably degraded by past logging. Several large Alder/willow swamps (6122) on these islands remain.

Most of the large peatlands northwest and south of Munuscong Lake remain.



DISTRICT 13. Mackinac.
SUBDISTRICT 13.3. Escanaba: Limestone Bedrock and Sand Lake Plain.

CLIMATE: Climatic differences are used to separate Subdistrict 13.3 from Subdistrict 13.1. The climate of this subdistrict (13.3) is milder (Albert et al. 1986). This subdistrict also receives less snowfall than most of Subdistrict 13.1. Average precipitation is slightly lower.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The soils, glacial landforms, and bedrock geology of this subdistrict are similar to those of Subdistrict 13.1. The primary difference between the two subdistricts is a milder climate in this subdistrict, which results in a greater presence of more southern tree species.

The entire subdistrict is underlain by Silurian and Ordovician age sedimentary bedrock, principally limestone and dolomite, but also including less resistant shale and gypsum (Dorr and Eschman 1984). The resistant Niagaran series dolomite and limestone of Silurian age form the Niagaran Escarpment, which is locally exposed as cliffs and flat limestone pavement (alvar) along the Lake Michigan shoreline of the Stonington and Garden peninsulas. Little Bay de Noc and Big Bay de Noc occupy depressions where soft gypsum and shales were eroded, probably both by glacial and lacustrine processes (Sinclair 1960). Devonian limestone, dolomite, and breccia are locally exposed at the southern edge of the district. The underlying bedrock is typically less than 50 ft below the surface of the glacial drift (Vanlier and Deutsch 1958; Sinclair

1959, 1960; Vanlier 1963). Limestone is mined in several places within the subdistrict.

A wide variety of landforms of glacial lacustrine origin characterize the subdistrict; including flat lake bed, deltaic deposits of sand, parabolic dune fields, and shallow embayments containing transverse dunes. Beach-ridge and swale topography, consisting of dozens of low, linear beach ridges alternating with shallow depressions (swales), commonly forms a narrow 1-2 mi wide band along the shorelines of protected embayments of Lake Michigan.

Large areas consist of lacustrine sand deposits that have flat to gently undulating surfaces. Regional slope is typically only 8 to 10 feet/mile. On this topography, only a few inches of elevation change can greatly alter drainage conditions. Drainage conditions also depend on depth to underlying bedrock or fine-textured substrate. Ground moraine is locally present south of Escanaba and north of the Garden Peninsula.

Outwash deposits were located near the Lake Michigan shore north of Escanaba near Rapid River. Small barchan dunes (crescent shaped) are scattered on the outwash plain.

Soils within the district are diverse. Lacustrine soils were primarily sands, but the sands are often underlain by lake clays or bedrock within only a few feet of the surface. The sands were generally either excessively drained or poorly drained. Excessively drained sands are on beach ridges or dunes. Poorly drained sands are more common, occupying much of the flat lake plain or depressions between dunes and beach ridges. The soils of the ground moraine within the district range from loamy sands to loams; they are often stony. Where bedrock is near the surface, soils are often calcareous and poorly drained. The most common soil orders within the subdistrict are Alfisols (Boralfs), Histosols, and Entisols (Aquepts), with some Orthods and Aquods (SCS 1967).

PRESETTLEMENT VEGETATION: Extensive Cedar swamps (4231) grew on the poorly drained soils of the lake plain, extending inland several miles from the present shoreline. These cedar swamps were interrupted by narrow, low beach ridges. The smaller ridges often supported Upland Conifer Forests of hemlock (4226), white pine (4211), or a mixture of the two (4227). All of these upland conifer types occurred locally on narrow beach ridges along the Lake Michigan shoreline. Low broad upland areas of lacustrine sands supported the same Upland Conifer Forests or occasionally, Northern Hardwoods Forest (4111) dominated by American beech and sugar maple. Although cedar was the tree species most commonly referenced by the surveyors, other common wetland species included tamarack, balsam fir, [red] maple, [paper] birch, black ash, [black] spruce, hemlock, [trembling] aspen, and balsam poplar. Depressions within the extensive wetlands of the lakeplain were often dominated by low productivity Tamarack swamps (4233) or Black spruce swamps (4232).

Along embayments of Lake Michigan there were extensive Wooded Dune and Swales Complexes (911). Within the dune and swale

complexes, the drier ridges were dominated by forests of white pine or red pine (421), along with white spruce, balsam fir, and hardwoods. Lower ridges were often dominated by northern white-cedar, as were some of the drier swales (4231). The wetter swales supported Emergent Marsh (6221).

Along the sandy shoreline of Lake Michigan, Great Lakes Marshes (6222) were generally narrow due to severe wave action. The only extensive marshes within the subdistrict were near Escanaba, at Portage Bay, and in Little Bay de Noc, at the mouth of the White River.

Extensive floodplain occurred along the Sturgeon River. These floodplain forests were dominated by silver maple (4143), and also contained abundant butternut; both of these species are rare in the Upper Peninsula.

Northern Hardwoods Forest (4111) of American beech and sugar maple grew on ground moraine and on thin soils over limestone bedrock. Where bedrock was exposed at the surface, as on portions of the Garden and Stonington peninsulas, grasslands called alvar (741) were found.

Pine Barrens (333) occurred on the outwash sands near Rapid River. Large portions of the pine barrens were noted as burned over at the time of the original surveys. Jack pine was the predominant species on the pine barrens, but red pine was also common.

NATURAL DISTURBANCE: The most common type of disturbance within the subdistrict is windthrow. In the stretch of Lake Michigan shoreline between Menominee and Escanaba, 18 windthrows, mostly under a square mile in area, were noted within 1 or 2 miles of the shore. Winds off Lake Michigan were responsible for most of these windthrow areas. Occasionally the windthrows burned later, as noted by the surveyors. Windthrows destroyed both upland and wetland forests.

Fires were also noted by the surveyors, primarily on pine plains near Native American settlements. Such fires were noted near Menominee, Escanaba, and Rapid River.

HUMAN LAND USE: The surveyors noted Native American settlements near Menominee, Escanaba, Rapid River, and on both the Stonington and Garden peninsulas. Both sugar bushes and gardens were noted near most of these sites. Indian trails were commonly noted, especially along major rivers and the Lake Michigan shoreline.

Following European settlement, logging began, first for white and red pines, then for northern white-cedar and hemlock, and finally for hardwoods and pulp. Logging mills were located along many of the rivers near the Lake Michigan shoreline. Railroads bisect wetlands throughout this subdistrict.

Agricultural land use within the subdistrict has been limited to pasturing of the ground moraine and occasionally small areas of sand lakeplain. Few of the wetlands have been greatly altered for agricultural purposes.

Major roads are located along much of this shoreline. Urban

development is concentrated at Menominee, Escanaba, Gladstone, Rapid River, and Manistique.

IMPACT OF HUMAN LAND USE ON VEGETATION:

Some areas of Northern Hardwoods (4111) have been cut on both sand lakeplain and ground moraine for conversion to pasture.

Most areas of hemlock forest (4226) persist as forest, although the forest composition has generally changed; hemlock regeneration is often poor.

Most areas of White pine (4211) and Red pine forest (4212) persist as forest, although the forest composition has generally changed; white pine regeneration is poor and the remaining forest is characterized by trembling aspen, balsam fir, paper birch, and other early successional species. Most of the Pine Barrens (333) persist; dominance of jack pine remains.

Almost all of the Lowland Conifer (423) swamps persist, although deer browse has resulted in the conversion of large areas to hardwood swamp. Most areas of tamarack swamp (4233) persist. Tamarack and often black spruce remain as common dominants.

Alder/willow swamps (6122) was generally limited to narrow bands along streams, where it typically persists.

Emergent marsh (6221) was localized to the margins of a couple of lakes, where it persists. All of the Great Lakes Marshes (6222) within this subdistrict have been degraded. At Portage Bay, manipulation of the marsh has resulted in the introduction of Eurasian water milfoil, which is of little benefit to wildlife. Along the Whitefish River mouth, docks have greatly altered portions of the marsh; there appears to have been at least local filling of the marsh.

DISTRICT 14 Luce
SUBDISTRICT 14.2. Grand Marais: Sandy End Moraine, Shoreline, and Outwash Plains.

CLIMATE: The climate of the entire district is strongly influenced by Lakes Superior and Michigan, but these influences are greater at the northern edge of the district in Subdistrict 14.2, the Grand Marais Subdistrict, than in Subdistrict 14.1, the Seney Subdistrict. The growing season ranges from less than 100 days in the interior of the district, to 140 days along Lake Superior. The extreme minimum temperature ranges from -30°F. along Lake Superior,

to -46°F. further inland in Subdistrict 14.1. Average annual precipitation ranges from 32 to 34 inches. Annual snowfall is as high as 180 inches near the Lake Superior shoreline; further inland average snowfall is 80 to 100 inches.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: An east-west trending sandstone escarpment of Cambrian age is exposed in several waterfalls, including Tahquamenon Falls, Au Train Falls, Miner's Falls, and Laughing Whitefish Falls, and along the Lake Superior shoreline at Pictured Rock National Lakeshore (Dorr and Eschman 1984). Farther inland, Ordovician sandstone and dolomite are the underlying bedrock (Reed and Daniels 1987).

Sandy ridges of end moraine and pitted outwash are characteristic of the northern edge of the subdistrict. There are locally numerous kettle lakes in the pitted outwash. Recent geomorphological interpretation is that many of the end moraines (as originally interpreted by Leverett 1929) are actually heads of outwash and related stagnation landforms (Blewett and Rieck 1987).

Lacustrine deposits of glacial and postglacial origin are also located along the northeastern edge of the district. Lacustrine deposits within the district consist primarily of droughty sand dunes and beach ridge deposits, but also include some poorly and very poorly drained glacial lacustrine deposits. An extensive complex of sand-spits at Whitefish Point, in northwestern Chippewa County, produced hundreds of alternating swales and sand-spits. Most of the beach ridge and swale deposits along Lake Superior are excessively drained, unlike along most shorelines of the Great Lakes. The Grand Sable Dunes, west of the town of Grand Marais, are large, steep dunes perched on till.

Outwash plains are concentrated along the southern edge of the district. There is also a relatively small area of poorly drained outwash at the extreme west edge of the district. Along the shoreline, outwash is restricted to areas west of Munising, and west of Grand Marais.

Most of the moraine ridges and pitted outwash have well drained, sandy soils. Kettles within the pitted outwash and moraines contains bogs with thick deposits of sphagnum peat. At the far western edge of the district, where sandstone bedrock is only thinly covered by till, soils are moderately well drained. Along the Lake Superior shoreline, sand dunes, sand spits, and beach ridges form a broad zone characterized by vast expanses of excessively drained sand soils. The soils ar classified as Histosols and Entisols (Aquepts), with some Orthods and Aquods (Soil Conservation Service 1967).

PRESETTLEMENT VEGETATION: Sandy lakeplain in this subdistrict supported a number of wetland and upland communities. Emergent marshes (6221), bogs (6121), and alder/willow swamps (6122) were common in the swales associated with the shoreline and small lakes immediately inland.

Vast peatlands, dominated by black spruce (4232), cedar (4231), and tamarack (4233) were common throughout poorly drained

portions of the lakeplain. Several of these areas, mapped by Farrand (1982) as organic deposits were spruce and tamarack swamps which included narrow beach ridges dominated by white and red pine (4216).

Upland portions of the lakeplain that were better protected from wildfires were extensive along the shoreline. These areas supported forests dominated by hemlock (4226), Northern Hardwoods (4111), and Hemlock/white pine (4227). Excessively drained, fire-prone portions included forests dominated by jack pine (4213) and red pine/jack pine forests (4215). Jack pine-dominated forests were extensive along the shoreline between Grand Marais and Whitefish Point.

Wooded Dune and Swale Complexes (911) occurred on the sandy lakeplain. Most examples are excessively drained throughout. However, the complex at Taquamenon Bay was mostly spruce/tamarack-dominated swamp (423), and the swales at Au Train and Whitefish Point included Tamarack swamp (4233) and Shrub swamps (612).

The Grand Sable dunes are active, only locally supporting forests. At their protected east end they supported a small area of Northern Hardwood forest (4111) and a few, small pockets of jack pine (4213) persist within the dunes.

Great Lakes Marshes (6222) were noted near the mouth of the Au Train River and at the southeast end of Grand Island. The Au Train marsh is best described as a fresh water estuary or drowned river mouth created when dunes restricted the river's flow into Lake Superior.

Clay lakeplain at Taquamenon Bay supported spruce and tamarack-dominated swamps (423). Narrow strips of clay lakeplain along the shore in Luce County supported Hemlock/white pine forests (4227).

Coarse textured moraines, most common south of Taquamenon and Pendills bays, supported northern hardwoods, often with significant amounts of hemlock. Red pine/white pine forests (4216) and Red pine "openings" (333) were also common. Small cedar/tamarack /spruce-dominated swamps (423) were also found on these moraines. On somewhat poorly drained tills, where bedrock is near the surface, hemlock and white pine were dominant species. Small cedar and tamarack-dominated swamps (423) also occurred on the end moraines east of Munising.

Sandstone cliffs (745) were noted by surveyors at Pictured Rocks National Seashore and west of Pendills Bay.

Poorly drained outwash was uncommon in this subdistrict. Where it did occur, just west of Munising, there was cedar dominated swamp (4231). Upland outwash supported Hemlock forests (4226), dense Jack pine forests (4213) and Barrens (333) of jack pine, red pine, and occasionally, white pine. Pitted outwash and end moraines supported Northern Hardwoods (4111).

NATURAL DISTURBANCE: The GLO surveyors recorded that forests on much of the surface of T48N, R6W, at the mouth of the Tahquamenon River, had been burned. There were also several mentions of fire in pineries on the sand ridges between Whitefish Point and Grand

Marais. A large windthrow was noted in the cedar/tamarack swamps east of Beaver Lake within Pictured Rocks National Lakeshore.

HUMAN LAND USE: Surveyors noted several Native American trails, fields, and sugar camps west of Taquamenon Bay, and near Munising. Early European settlements were established on Grand Island and west of Munising at the time of the surveys.

The dominant use of this subdistrict has been commercial timber production. Urban development has been mainly limited to the Munising area.

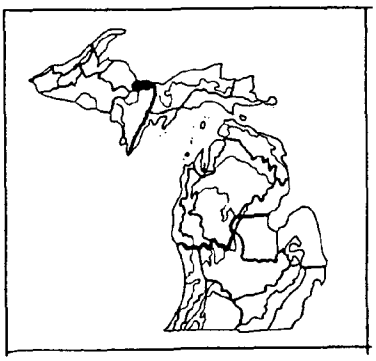
IMPACT OF HUMAN LAND USE ON VEGETATION: Although most of the wetlands in this region persist, they were probably impacted by logging and post-logging fires. Roads and small dams have had the most significant impact on wetland hydrology in this subdistrict.

The upland forests have also been greatly impacted by logging-era activities. On the droughty Raco Plains, jack pine dominance expanded, whereas areas of white and red pine have had poor regeneration. The Kingston Plains were dominated by forests of red and white pine, and Northern Hardwoods with white pine. In the most severely burned areas, the only existing vegetation, 80 years after logging, consists of lichens, sedges, and scattered small (1-3 in dbh) black cherries. Subsequently portions of both plains have been planted to red pine or jack pine.

REGION IV. Western Upper Michigan.

REGIONAL CLIMATE: The region has a strongly continental climate, with only moderate influence from Lake Superior. Temperatures are extremely cold in the winter. Snowfall and rainfall are high adjacent to Lake Superior as a result of moisture laden air from Lake Superior being forced to rise rapidly over the bedrock uplands at the northern edge of the region (Eichenlaub et al. 1990, Eichenlaub 1979, Albert et al. 1986).

The growing season ranges from less than 100 days inland to 150 days along portions of the Lake Superior shoreline (Eichenlaub et al 1990). Annual precipitation ranges from 32 to 36 inches. Annual snowfall ranges from 46 inches inland to 200 inches of lake-effect snow south of Lake Superior. Extreme minimum temperatures range from -28°F along Lake Superior to -50°F inland.



DISTRICT 15. Dickinson.
SUBDISTRICT 15.4. Deerton: Sandstone Bedrock and High, Sandy Ridges.

CLIMATE: Minimum temperatures are moderated along Lake Superior, ranging from -28 to -32°F., but are -38°F at the inland edge of this small subdistrict. The growing season ranges from 140 days along Lake Superior to less than 100 days along the inland margin of the subdistrict. Average precipitation is 32 to 34 days and annual snowfall ranges from 120 to 140 inches.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The eastern portion of the district has large, rounded, sandstone knobs typically covered with a mantle of sandy glacial drift. The western portion has irregular, steep sand ridges. Elevations range from 602-1300 ft.

The bedrock knobs, 100-200 ft high, have steep sides and relatively flat tops. Exposed at the surface or underlying the glacial drift are Cambrian age Munising and Jacobsville sandstones (Dorr and Eschman 1984; Hamblin 1958). Most of the bedrock is covered with a veneer of sand or rocky till. However, bedrock is occasionally exposed in roadcuts, or more dramatically, in steep ravines, such as the one at Laughing Whitefish Falls. Where glacial drift is thick, soils are well drained; where drift is thin, drainage is poor, and large swampy areas occur. The drift is very rocky. West of Munising, large boulders, several feet in diameter, are common on the surface.

The high sand ridges (100-200 ft) in the west have been deeply eroded by postglacial streams. Steep valleys, only 300-400 ft wide, are up to 150 ft deep. The soils are well drained sands.

PRESETTLEMENT VEGETATION: Cedar, spruce, and hemlock dominated many of the small swamps (423) associated with these thin soils over bedrock. Hemlock (4237) is especially common on many of the poorly drained bedrock ridgetops and in the steeper ravines. Well drained sand ridges were occupied by Northern Hardwoods forests (4228) of sugar maple, hemlock, yellow birch, and white pine. Beech is generally absent from the steep ridges.

The long, narrow Wooded Dune and Swale Complexes (911) just east of Marquette, for the most part, included dry swales dominated by red pine and jack pine. Inland from these complexes, however, there were extensive swamps of black ash (4141), alder (6122), elm

(4142), and cedar (4231) along the Chocolay River.

The western extreme of this subdistrict includes an outwash plain that supported forests of jack pine (4213) and red pine (4212), mixed with aspen.

NATURAL DISTURBANCE: No major natural disturbances were recorded by surveyors along this portion of shoreline.

HUMAN LAND USE: The dominant land use in this subdistrict has included logging and, more recently, recreation and intensive residential development, especially along the shoreline.

IMPACT OF HUMAN LAND USE ON VEGETATION: The impact of logging-era activities probably decreased the relative composition of hemlock and white pine in upland forests. A number of small rivers were dammed, impacting wetlands in their drainage. Urban development and road construction along the shoreline has significantly altered upland and wetland vegetation in the area.

DISTRICT 16. Michigamme: Granite Bedrock.

CLIMATE: The climate is continental, with lake effect limited to a narrow zone along Lake Superior. The growing season is short, ranging from 75 in the interior to 100 days along the Lake Superior coast; most of the variation occurs within 10-15 miles of the coast (Albert et al. 1986). Extreme minimum temperature varies from -28°F along the coast to -46°F inland (Eichenlaub et al. 1990). Snowfall is highest inland, averaging 200 inches, and least along the coast, averaging 120-140 inches. The average annual precipitation is 32 to 36 inches, with the most precipitation at high elevations inland.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: Precambrian age bedrock consists of diverse types of metamorphic, igneous, and sedimentary bedrock, including sandstone and shale, gneiss, amphibole, slate, metagraywacke, quartzite, mafic volcanic rocks, and iron formation (Morey et al. 1982). The iron formations were once heavily mined in the Michigamme Range.

Exposed bedrock knobs characterize large parts of the district. Elevations rise rapidly from Lake Superior at 602 ft to

a maximum of 1980 ft at Mount Curwood, the highest point in the state (Albert et al. 1986). Although bedrock generally controls topography, the character of the topography is variable. In some areas the terrain is a mosaic of low rocky ridges less than 50 ft high, with many small lakes and swamps (Albert et al. 1986). In other areas, like the Huron Mountains, large, exposed ridges of granite or sandstone can be 300-500 ft high. There are large areas of sandy ground moraine. The Yellow Dog and the Mulligan plains, two large outwash plains, separated by only a few miles, occur within the district.

The soils are generally sands. Local silt caps of aeolian origin covers some of the rock knobs (Pregitzer and Barnes 1984). The tops of the bedrock knobs have little or no soil. All of the soils are very acid. The soils on the two outwash plains are excessively drained sands. Soils of the entire district are classified as Spodosols, primarily Orthods (Soil Conservation Service 1967).

PRESETTLEMENT VEGETATION: Balsam fir, tamarack, and black spruce were the most common species in the wetlands, which were often in relatively small drainages located between the steep-sided bedrock uplands.

The largest wetlands for this subdistrict were along the shoreline on sandy lakeplain. Great Lakes Marsh (6222) was noted along the Iron River near its mouth. Wooded Dune and Swale Complexes (911) are located at Little Presque Isle, Big Bay, Iron River, the mouth of the Salmon Trout River, and at the Pine River mouth. The complex at Little Presque Isle, which is mostly upland was dominated by Hemlock/white pine forest (4227). The complexes at the Iron and Pine rivers were also mostly upland, with jack pine and red pine (4215) most common. The complex at Big Bay was mostly "open swamp" dominated by spruce and cedar (423). The complex at the Salmon Trout River was dominated by cedar/white pine (4231) inland, and Alder/willow swamps (6122) closer to the shoreline.

Hemlock (4226) and Hemlock/white pine (4227) forests dominated the outwash deposits around Marquette. Northern Hardwoods (lacking beech, except along the Lake Superior shoreline) (4228) were dominant on tills and also on thin soils over bedrock. Scattered white pine, red pine, and red oak were the dominant trees on exposed bedrock ridges. Jack pine forests (4213) dominated the droughty outwash sands of the Yellow Dog and Mulligan plains. The sandy soils of the gullied ridges north of the Yellow Dog plain supported Northern Hardwood forests (4111). On the sandy ground moraine, Northern Hardwood forests dominated the well drained soils. Red pine/white pine forests (4216) dominated the excessively drained soils.

NATURAL DISTURBANCE: Extensive burned forests were reported by surveyors around Marquette. No major windthrow areas were recorded by surveyors in this subdistrict.

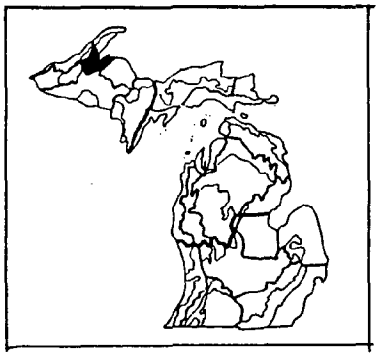
HUMAN LAND USE: Native American encampments and trails were noted

by surveyors at Big Bay. By 1846, when this area was surveyed, iron mining activities by European companies had already begun. Furnaces and forges were already established in and around Marquette. Roads were established leading west and southwest of Marquette, and some rivers had already been diverted for use in mining activities.

Logging and mining have represented a major portion of land use activities in the subdistrict. Urban development around Marquette and recreational uses along the shoreline and inland make up the rest.

IMPACT OF HUMAN LAND USE ON VEGETATION: The diversion of creeks and rivers have undoubtedly impacted associated wetlands, either by flooding or removal of water sources. Some impoundments are highly polluted by mine tailings and chemical products of mining.

Roads leading out of Marquette have also impacted some wetlands. Logging, as with elsewhere in the region, has changed the relative composition of white pine and hemlock in upland forests.



DISTRICT 18. Bergland.
SUBDISTRICT 18.3. Baraga: Broad Ridges of Coarse-textured Rocky Till.

CLIMATE: The growing season ranges from 110 to 130 days, and is longest near Lake Superior (Eichenlaub et al. 1990). It has a relatively cool growing season. Extreme minimum temperatures range from -40° to -48°F. Average annual precipitation ranges from 30 to 36 inches. Heavy lake-effect snowfalls, ranging from 160 to 200 inches, characterize the district.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The landforms of the district are the basis for further dividing the district into three subdistricts. Beginning at the south of the Keweenaw Peninsula, the volcanic bedrock ridges form a narrow, 1-2 mi wide, 200-400 ft high linear rock ridge, from Houghton in the northeast to Bergland in the southwest. This ridge is broken in several places by streams that have eroded through the bedrock. Broad ground-moraine ridges with sandy and sandy loam soils. These ridges extend northeast to Keweenaw Bay of Lake Superior. Soils are often rocky, sandy and sandy loam tills, which are well drained. Poorly drained

soils are generally restricted to the margins of streams.

The western portion of the district is noted for steep ridges of Keweenawan (late Precambrian) basaltic lavas and conglomerates, which rise several hundred feet above the adjacent lake and till plains. The ridges extend from northern Wisconsin to the north end of the subdistrict and on to the tip of the Keweenaw Peninsula of Michigan and are part of the Lake Superior Syncline. Erosion-resistant conglomerates form the steep ridges, between which veins of highly eroded lavas form lakes and wetlands.

South of Bergland and into Wisconsin, the Keweenawan bedrock ridge is partially or completely covered with either fine- or coarse-textured till. Also included within this district is the iron-rich Penokee-Gogebic Range, a narrow band of Huronian age (middle Precambrian) bedrock.

Rocky, acid, red sandy loams and silt loams (Spodosols and Inceptisols) characterize the bedrock controlled topography at the western edge of the district. Poor drainage conditions characterize some parts of the bedrock-controlled plain.

PRESETTLEMENT VEGETATION: The large, sandy and loamy moraines east of L'Anse and north of Baraga, for the most part, supported Hemlock (4226) and Northern Hardwood (4228) forests. Beech was noted in Northern Hardwoods forests northeast of L'Anse. A red pine-dominated Barren (333) was noted immediately east of L'Anse. In moderately drained soils, hemlock was in combination with cedar, balsam fir, and spruce (white or possible, black) forests (4223).

Most wetlands on these moraines were located along river drainages, with cedar, tamarack, spruce, and/or alder as dominants. Large "open" swamps dominated by cedar (4231), spruce (4232), and tamarack (4233) were located just north of Baraga. Southeast of Keweenaw Bay, swamps of cedar (4231) and balsam fir (4235) were located.

Sandy lakeplain at the southwest end of Keweenaw Bay was dominated by swamps of spruce (4232), cedar (4231).

A Great Lakes Marsh (6222) apparently quite boggy in character, ("covered with cranberry vines") was located at the north end of Huron Bay. A similar Great Lakes Marsh was also located at Sand Bay. Field surveys showed that this area was also more characteristic of a Bog or Poor Fen than the Great Lakes Marshes further south in the state (MNFI 1987). Tamarack (4233), cedar (4231), and alder-dominated (6122) swamps were located south of Otter Lake.

Swamps on the clay lakeplain, which was restricted to west of Baraga and L'Anse, were dominated by black ash (4141) and cedar (4231). Uplands were dominated by hemlock and balsam fir (4226). Alluvial soils along the Sturgeon River supported extensive cedar (4231) and black ash (4141) swamps among meandering sloughs. A Great Lakes Marsh (6222) was located at the mouth of the river.

NATURAL DISTURBANCE: A small windthrow was noted at the southern end of Huron Bay, and just south of L'Anse. No major wildfires were noted by surveyors in this area.

HUMAN LAND USE: Many roads, and several sawmills and missions, were already established in this area at the time of the surveys in 1845. Land use since that time as involved mining, logging, urban development, and recreation.

IMPACT OF HUMAN LAND USE ON VEGETATION: As noted elsewhere in this region, logging era activities probably have changed the relative composition of white pine and hemlock in forests of this subdistrict.

Many rivers and streams were diverted for use in mining and logging activities, resulting in impacts to associated wetlands. Roads have also altered wetland hydrology in places. For the most part, the wetlands of this subdistrict persist in some form.

DISTRICT 19. Ontonagon.
SUBDISTRICT 19.2. White Pine: Clay Lake Plain.

CLIMATE: The growing season ranges from 110-140 days growing season, with the shortest growing season at the western edge of the district (Eichenlaub et al. 1990, Agricultural Experiment Station, Univ. of Minn. 1977). Annual snowfall is heavy and lake-effect snows ranges from 120 to 160 inches. Total annual precipitation is 30 to 34 inches. Extreme minimum temperatures range from -30° to -40°F.

BEDROCK GEOLOGY AND SOILS: Bedrock is not exposed at surface except in localized outcrops along streams and at selected portions of the shoreline. Bedrock consists of Precambrian (Middle Proterozoic) sedimentary bedrock, primarily feldspathic to quartzose sandstone and shale, and including lithic sandstone and siltstone (Morey et al. 1982). The shale is locally copper-rich (Dorr and Eschman 1984).

Lake plain from glacial Lake Duluth covers almost all of the district in a band ranging from 1 to 24 miles wide. A narrow exposed ridge of volcanic bedrock occurs at the southern edge (Farrand and Bell 1982). The soils are classified as Aquepts and Boralfs (Soil Conservation Service 1967). Portions of this glacial lake bed are relatively flat, as east of the Porcupine Mountains. In these stretches the lake plain is dissected by numerous small rivers with straight, shallow valleys. Between the Porcupine

Mountains and the Wisconsin border, the subdistrict is narrow and steeply sloping, with deeply eroded streams, often with waterfalls.

Soils consist of leached, calcareous red clays and pink sands that are podsolized; peatlands are not extensive. The soils are moderately well drained loam and clay, derived from local, iron-rich volcanic bedrock. Most of the soils are red in color.

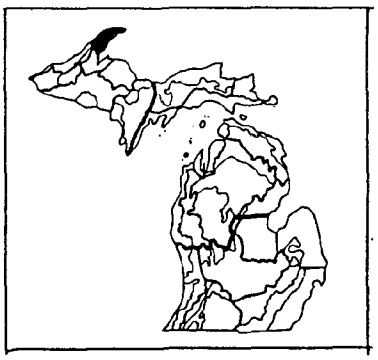
PRESETTLEMENT VEGETATION: Both presettlement and present forests are a mix of Northern Hardwoods (4111) on better drained sites, and conifers (422) tolerant of poorer drainage conditions. These include hemlock, northern white-cedar, balsam fir, white spruce, black ash, basswood, American elm, balsam poplar, and trembling aspen. Sugar maple is only locally dominant.

Emergent marshes (6221) and Alder/willow swamps (6122) were located around the Lake of the Clouds in the Porcupine Mountains. Narrow Wooded dune and swale complexes (911) were located along Misery Bay, Sleeping Bay, and west of the Flintsteel River mouth. Hemlock, cedar, spruce, fir, and alder dominated wet swales in these complexes. Hemlock (4226) and White pine/red pine-dominated forests (4216) were on the beach ridges. The complex at the Flint steel River was on sandy lakeplain, and included Shrub swamps (612) and bogs (6121). Cedar swamps (4231) were common on the sandy lakeplain bordering the Salmon Trout River. Similarly, swamps dominated by cedar, spruce, fir, hemlock, and red maple were located upstream in the Graveraet River drainage.

NATURAL DISTURBANCE: No major windthrows or wildfires were noted by surveyors in this subdistrict.

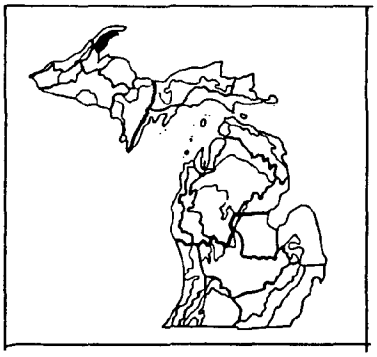
HUMAN LAND USE: A small percent of the land is used for pasture. Most of the land remains forested. Logging-era activities were intensive, providing fuel and timbers for the mining industry and lumber for local construction. Many rivers were diverted for mining/logging purposes. Large tailings ponds are located in Gogebic County.

IMPACT OF HUMAN LAND USE ON VEGETATION: River diversions have undoubtedly impacted associated wetlands. Roads have also impacted wetland hydrology in places throughout the subdistrict. Species composition in forests have changed since the logging era, with white pine and hemlock becoming much less abundant. Urban development around Ontonagon and along the shoreline have eliminated or altered some coastal wetlands.



DISTRICT 20. Keweenaw.

CLIMATE: Climate is dominated by lacustrine influences. Except for air flows from the southwest, all air passes over Lake Superior before reaching this district. Due to combination of lake and orographic effects, snowfalls are heavy, from 140 to 200 inches/year (Eichenlaub et al. 1990). Average annual precipitation ranges from 32 to 34 inches. Growing season is relatively long, over 130 days, but cool. Winters are moderated by Lake Superior.



DISTRICT 20. Keweenaw.
SUBDISTRICT 20.1. Gay: Coarse-textured Broad Ridges and Swamps.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: The subdistrict, located along the eastern edge of the Keweenaw Peninsula, consists of broad ground-moraine ridges, up to 550 ft high, with gentle to moderate slopes. Sandstone outcrops along the shoreline around Little Traverse Bay. Soils are derived largely from the underlying sandstone and shale. There are few lakes, but several extensive wetlands occupy depressions between the ridges and the shoreline near Keweenaw Bay, at the northeastern end of the district. One such coastal wetland, 1-4 miles wide and 25 miles long, is on a lacustrine sand plain.

Soils of the moraines are typically well drained, acid, loamy sands and sandy loams derived largely from the underlying Cambrian sandstones.

PRESETTLEMENT VEGETATION: On the sandy ground moraine of the eastern Keweenaw Peninsula, Northern Hardwoods (4111) and conifers

covered most of the landscape. Sugar maple, basswood, and hop-hornbeam are the most common species. Hemlock (4226) was more common along the shorelines, where it often increased to greater than 50% relative dominance in the overstory (Bourdo, 1954).

Poorly drained portions were dominated by cedar (4231), black spruce (4232), and balsam fir (4235). Cedar swamps ringed by alder thickets (6122) were common in narrow valleys between ridges. On the sandy lake plain along Keweenaw Bay, Wooded dune and swale complexes (911) were found with wide swales dominated by tamarack and black spruce scattered across the bog mat. A Great Lakes marsh (6222) and Wooded dune and swale complex (911) were noted at Lac La Belle.

Hardwood-conifer swamps (42) Cedar/balsam fir/spruce (4223), birch, and black ash, were also found on rocky, poorly drained beach terraces far above the present lake level.

NATURAL DISTURBANCE: Many windthrows were noted by surveyors throughout the poorly drained soils of this subdistrict.

HUMAN LAND USE: Native American encampments were noted by surveyors around Little Traverse Bay in 1845. Logging, mining, and pasture have been the historically dominant land uses in this subdistrict. The deposition of mine tailings along the shoreline is most evident at Gay. A number of areas, both wetland and upland throughout the district have been targeted historically for depositing mine tailings.

More recently, recreational/cottage development along the shoreline and along inland lakes has intensified.

IMPACT OF HUMAN LAND USE ON VEGETATION: Logging and mining activities impacted wetlands associated with rivers in this subdistrict. Road construction and the deposition of mine tailings has also impacted some wetlands.

DISTRICT 20. Keweenaw.
SUBDISTRICT 20.2. Calumet: High Igneous and Sedimentary Bedrock Ridges and Knobs.

SOILS, GLACIAL LANDFORMS, AND BEDROCK GEOLOGY: Erosion-resistant conglomerates form the steep ridges of the subdistrict, between which veins of highly eroded lavas are the sites for lakes and

wetlands. The Lake Superior shoreline consists of rugged volcanic bedrock. Copper-rich lava flows, common on the Keweenaw Peninsula, were extensively mined. Precambrian bedrock, primarily Keweenawan basalts and conglomerates, but also include iron-rich marine sandstones and dolomites of Huronian age (the Gogebic Range), and Archean bedrock.

The subdistrict is noted for steep ridges of Keweenawan (late Precambrian) basaltic lavas and conglomerates, which rise several hundred feet above the adjacent lake and till plains. The bedrock ridges of the Keweenaw Peninsula and of Isle Royale are both part of the Lake Superior Syncline, which extends from northern Wisconsin to the tip of the Keweenaw Peninsula of Michigan. Isle Royale is located at the northern end of the syncline, and is treated as another subdistrict because of its climate, which is strongly influenced by surrounding Lake Superior. It has similar bedrock, physiography, and flora.

Soils formed on the volcanic and conglomerate ridges are rocky, acid, red sandy loams and silt loams (Podsols and Inceptisols). Soils tend to be rockier at the northern end of the district.

PRESETTLEMENT VEGETATION: Black spruce (4232), cedar (4231), and tamarack-dominated (4233) swamps along the northern shoreline where soils derived from are poorly drained till over bedrock. On higher bedrock ridges, red pine, white pine, red oak, and paper birch grew on the thin soils. Cedar/balsam fir (4223), hemlock (4226), and paper birch-dominated (413) forests were located in uplands on thin till and ground moraine west of Ahmeek. In protected bedrock valleys and on till, Northern Hardwood forests were dominated by sugar maple and hemlock (4228). Cedar, hemlock, and balsam fir also dominated poorly drained portions of the sand lakeplain west of Eagle Harbor.

NATURAL DISTURBANCE: Windthrows were noted in swamps along the northern shoreline.

HUMAN LAND USE: European settlements, including Fort William, and a number of mines roads were already established in this subdistrict by 1845 when the area was surveyed.

Dominant land uses in this subdistrict have included mining, logging, and more recently, recreational/cottage development along the shoreline and inland lakes.

IMPACT OF HUMAN LAND USE ON VEGETATION: As with elsewhere in this district, rivers were impacted by historical mining and logging activities. The deposition of mine tailings has impacted coastal wetlands in several places. The large swamp/marsh complex at the north end of Portage Lake was nearly eliminated in the construction of the shipping channel linking that lake to Lake Superior.

ACKNOWLEDGEMENTS

We would like to express our thanks to the Coastal Zone Management Section of the Land and Water Management Division, Michigan Department of Natural Resources, which provided funding for this project. A sincere thanks also goes to Dr. Leroy Barnett, Dave Johnson, and staff of the State Archives of Michigan for their ideas and energy in making historical records available to us in a most accommodating fashion. Thanks also to Historical Consultant, Dennis Au for his helpful comments on Monroe County historical records.

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APPENDIX I

INDEX TO MICHIGAN 7.5 MINUTE TOPOGRAPHIC MAPS WHERE HISTORICAL WETLAND MAPS ARE AVAILABLE IN DIGITAL FORMAT

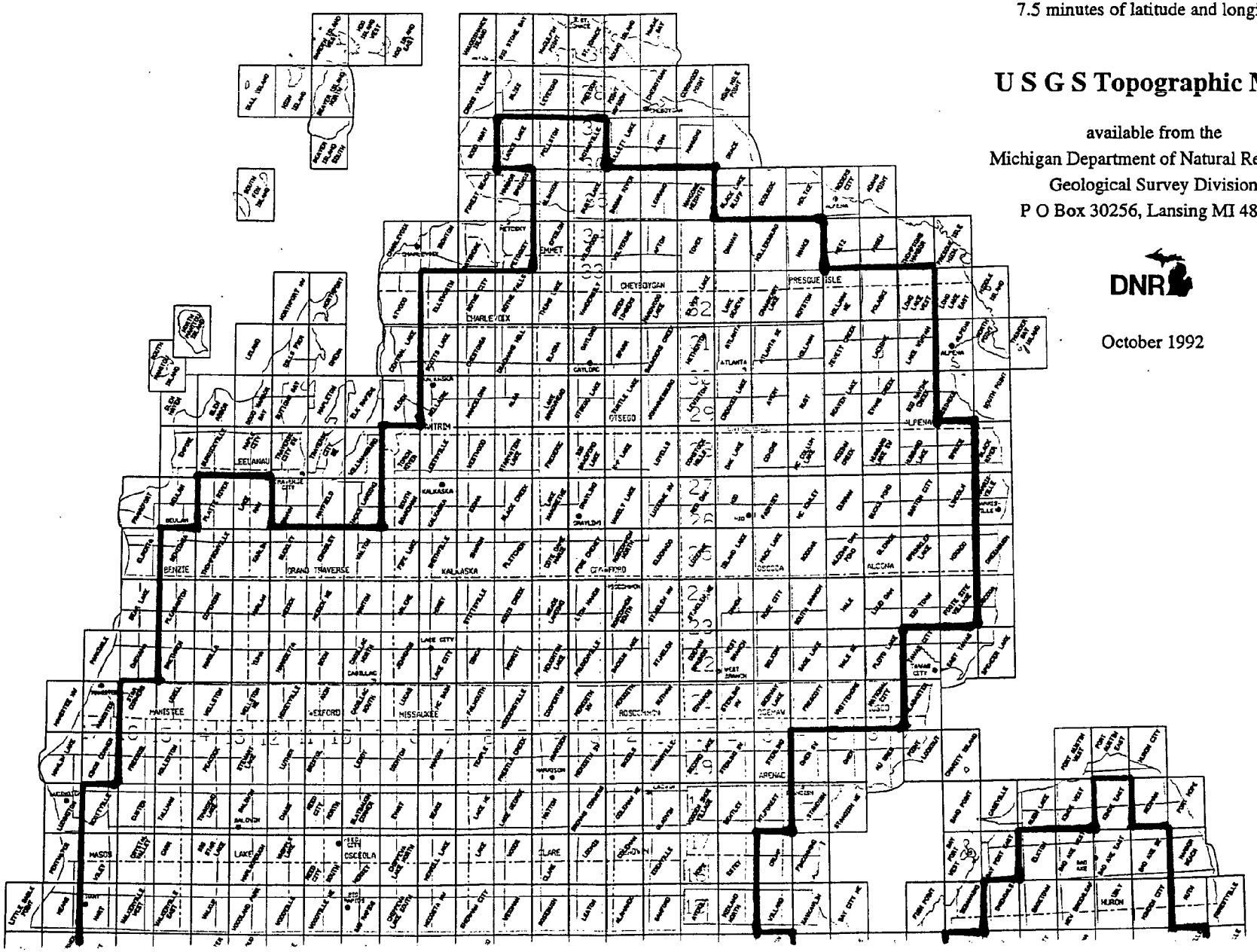
1:25,000 / 1:24,000 scale
2.5 inches = about 1 mile
7.5 minutes of latitude and longitude

U S G S Topographic Maps

available from the
Michigan Department of Natural Resources
Geological Survey Division
P O Box 30256, Lansing MI 48909

DNR

October 1992



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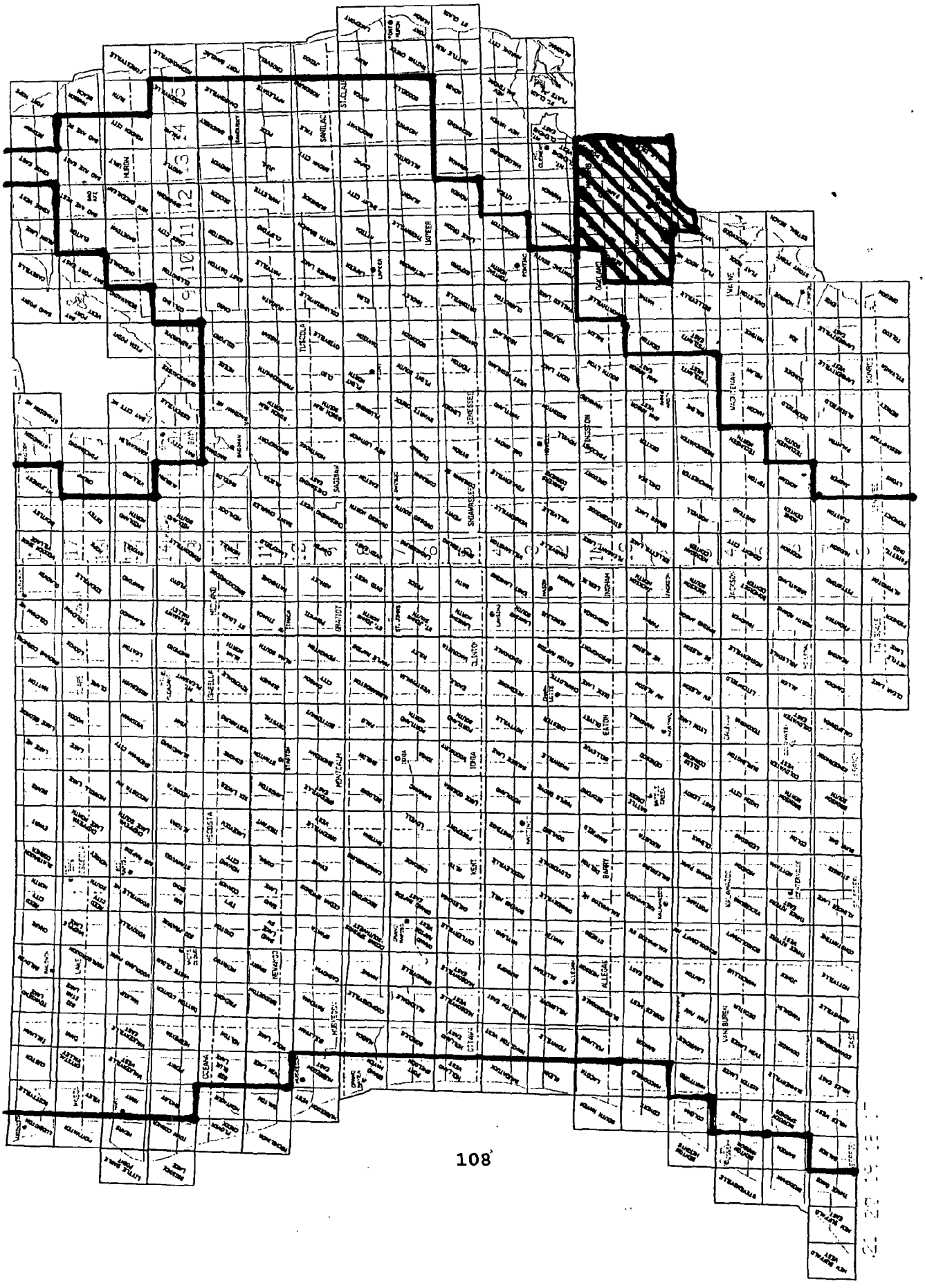
Northern Lower Michigan

Southern Lower Michigan



Eastern Upper Michigan