Wetland Trends in Michigan since 1800:

a preliminary assessment

prepared by:
Patrick J. Comer
Associate Ecologist
Michigan Natural Features Inventory
5th Floor Mason Building
Box 30444 Lansing, MI 48909-7944

1996-03

Wetland Trends in Michigan since 1800: a preliminary assessment

prepared by:

Patrick J. Comer
Associate Ecologist
Michigan Natural Features Inventory
5th Floor Mason Building
Box 30444 Lansing, MI 48909-7944

for

U.S. Environmental Protection Agency and
Land and Water Management Division,
Michigan Department of Environmental Quality

Submitted June, 1996

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Abstract

The growing awareness of wetland losses has been one of the driving forces behind changing views on land-use planning and land management. Knowledge of the type, location, and ecological context of Michigan's wetlands, as they appeared in the 1800s prior to widespread European settlement, provides important insights for developing ecologically meaningful land management strategies. By comparing historical data with more recent data, spatial changes of wetland types for a given land unit may be analyzed and more easily assessed. This report provides background information on the historical wetland data set for Michigan and details methods used for making historic and modern wetland acreage comparisons. Major trends in wetland acreage were then summarized from both a statewide perspective and from within each of the three administrative regions of the Michigan Department of Natural Resources.

The logging era, agricultural development, mining, road construction, and urban development have all had considerable effect on the quantity, structure, and function of the state's wetland resources. Between 28 and 35% of statewide wetland acreage has been lost since 1800. Wetland losses were greatest (43%) in the southern Lower Michigan, intermediate (28%) in northern Lower Michigan, and least severe (16%) in the Upper Peninsula. Statewide, nearly two thirds of lowland conifer swamp acreage has been either drained or converted to other wetland types. About 43% of emergent wetlands have been similarly affected. Both lowland hardwoods and shrub swamps appear to have increased in acreage over historical estimates, primarily due to the conversion of other wetland types.

Limitations of existing data sets prevent more definitive assessments of Michigan's wetland resources. Spatial data on the current wetland extent, such as those of the National Wetlands Inventory (NWI), need to be digitized so that analyses can be conducted in combination with the digital presettlement vegetation map.

Introduction

The growing awareness of wetland losses has been one of the driving forces behind changing views on land-use planning and land management. In a 1990 report to U.S. Congress it was estimated that, within the lower 48 states, 53% of wetland acreage had been lost between 1780 and 1980 (Dahl 1990). As pressure on land resources increases, we increasingly must find new ways to enable economic development while restoring and maintaining the ecological integrity of natural systems. Tools that help to enhance our understanding of natural patterns and processes across large landscapes can often provide insights for land-use planning and land management.

Knowledge of the type, location, and ecological context of Michigan's wetlands, as they appeared in the 1800s prior to widespread European settlement, provides important insights for developing ecologically meaningful land management strategies. By comparing historical data with more recent data, spatial changes of wetland types for a given land unit may be analyzed and more easily assessed. A historical database provides an important reference point for understanding cumulative impacts to natural systems caused by fragmentation, degradation, and conversion. Patterns we see today in species distributions, wetland hydrology, and ecosystem function become more meaningful when placed in a historical context. Natural ecosystems are quite dynamic, and the pattern of Michigan's native vegetation has changed continually over the past 16,000 years since the last glaciation (Delcourt & Delcourt 1981). However, a clear picture of wetland patterns, as they appeared just two hundred years ago, immediately prior to the logging era and intensive agricultural development of the nineteenth century, has many applications for our understanding of current conditions.

The 1990 report to Congress estimated that Michigan had lost approximately 50% of wetland acreage statewide, based on unpublished estimates from the Michigan Department of Natural Resources (MDNR) and the U.S. Department of Interior. Since that report was published, a digital map of Michigan's presettlement vegetation was completed (Comer et al. 1995a). This map depicts historical wetland type and extent, based on the original land surveys conducted by the General Land Office (GLO) between 1816-1856. Although there are inherent weaknesses in this historical database, there is no more detailed record of historical wetlands currently available. Comparison of this map data set with more recent estimates of wetland acreage at the county level provides a much more detailed assessment of wetland trends since the 1800s than has been available so far.

The Land Use/Land Cover layer of the Michigan Resource Information System (MIRIS) provides an approximation of current wetland extent based on the interpretation of 1978 aerial photographs (1:24,000 scale). Although the MIRIS land cover types were not specifically designed to depict wetland extent, this is the only statewide digital data set currently available for depicting modern conditions. MIRIS land cover categories of lowland hardwood, lowland conifer, wooded wetland, shrub-scrub wetland, emergent, aquatic bed, and mud flat are currently utilized to estimate the current extent of regulated wetlands statewide.

The comparison of the the GLO and MIRIS data sets form the basis for this assessment of wetland trends in Michigan since 1800. Given the limitations in both data sets used in this analysis, it is important that this be viewed as a preliminary assessment. Opportunities may exist in the future, with digital soils and wetland maps, for making refinements in both the historical and modern wetland data sets that should provide a higher level of precision than is currently achievable. This report provides background information on the historical wetland data set and methods used for making historic and current wetland acreage comparisons. Major trends in wetland acreage are summarized from both a statewide perspective and from within each of the three administrative regions of the MDNR. In the appendices, tables

indicating historic and modern acreage estimates for four major wetland categories are included. County-by-county descriptions, including a brief discussion of the glacial landforms, soils, upland vegetation, historical wetland type, and wetland trends since the 1800s, are also provided.

General Land Office Surveys

The township plat maps and transcribed field notes of the initial land surveys provide the best available record on Michigan's land cover as it appeared immediately prior to widespread European settlement (Bourdo 1956). The General Land Office (GLO) was established by the federal government in 1785 to survey the nation's western territorial lands. Lands of what was then the Michigan Territory (until statehood in 1837), had to be surveyed prior to their sale to private individuals. The surveys were conducted in Michigan by Deputy Surveyors of the General Land Office between 1816 and 1856 (Base and Meridian lines were established several years earlier). The survey was, therefore, conducted just before the logging-era, which saw the most dramatic transformation in Michigan's vegetation since the last glaciation.

Surveyor's field methods are described in detail by White (1984) and the communications between the Surveyor General and Michigan's Deputy Land Surveyors are found in Caldwell (1990). Surveys were organized around a 36 square mile grid (Figure 1). Each grid would form a township. Townships were organized in association with previously established Meridian and Base lines, forming the familiar layout known as "Township and Range." The Base line was an east-west line from what is now the Van Buren-Allegan County line, east to Lake St. Clair. The Meridian line extended north-south, from Sault Ste. Marie to the Hillsdale-Lenawee County line. As an example, Township 32 North, Range 15 West, locates an area 32 townships north of the Base Line and 15 townships west of the Meridian line. In most of Michigan, outside township boundaries were established several years before the individual square-mile sections were subdivided.

Surveyors were attempting to create an accurate picture of the land resources of the territory and leave markers to indicate township and section boundaries for future settlers. They needed to include enough land resource information for settlers to make a sight-unseen land claim, and mark the lands well enough for the settler to be able to later find the parcel on their own. In order to complete this task, they used compasses and "chains" to make accurate measurements. Chains were 66 feet long (80 chains per mile), and formed by 100 connected subdivisions called "links." As they measured out the boundaries of townships and sections, surveyors made notes on the topography, soils, and vegetation they encountered along each one mile section line. At each section corner and half-mile point, they pounded a wooden post into the ground. That post would later be used to establish legal property boundaries. In two to four quadrants around the post they marked "witness trees." The witness trees were to aid the settler in locating the survey post that had been pounded into the ground.

As with the information noted along each section line, information on witness trees was entered into the surveyor's field notebook. When they had completed the survey of a 36 square mile township, surveyors drew a plat map depicting, in general terms, the types of land resources they encountered within that township. The township plat maps in Michigan 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 the locations of lakes and streams. As the surveys progressed to the north, significantly more information was included on the plat maps. Those produced in Northern Michigan include much information on natural and cultural features. Figure 1 illustrates a hypothetical township plat map that was used to train surveyors on the types of features they needed to include in their reports. They included major topographic features,

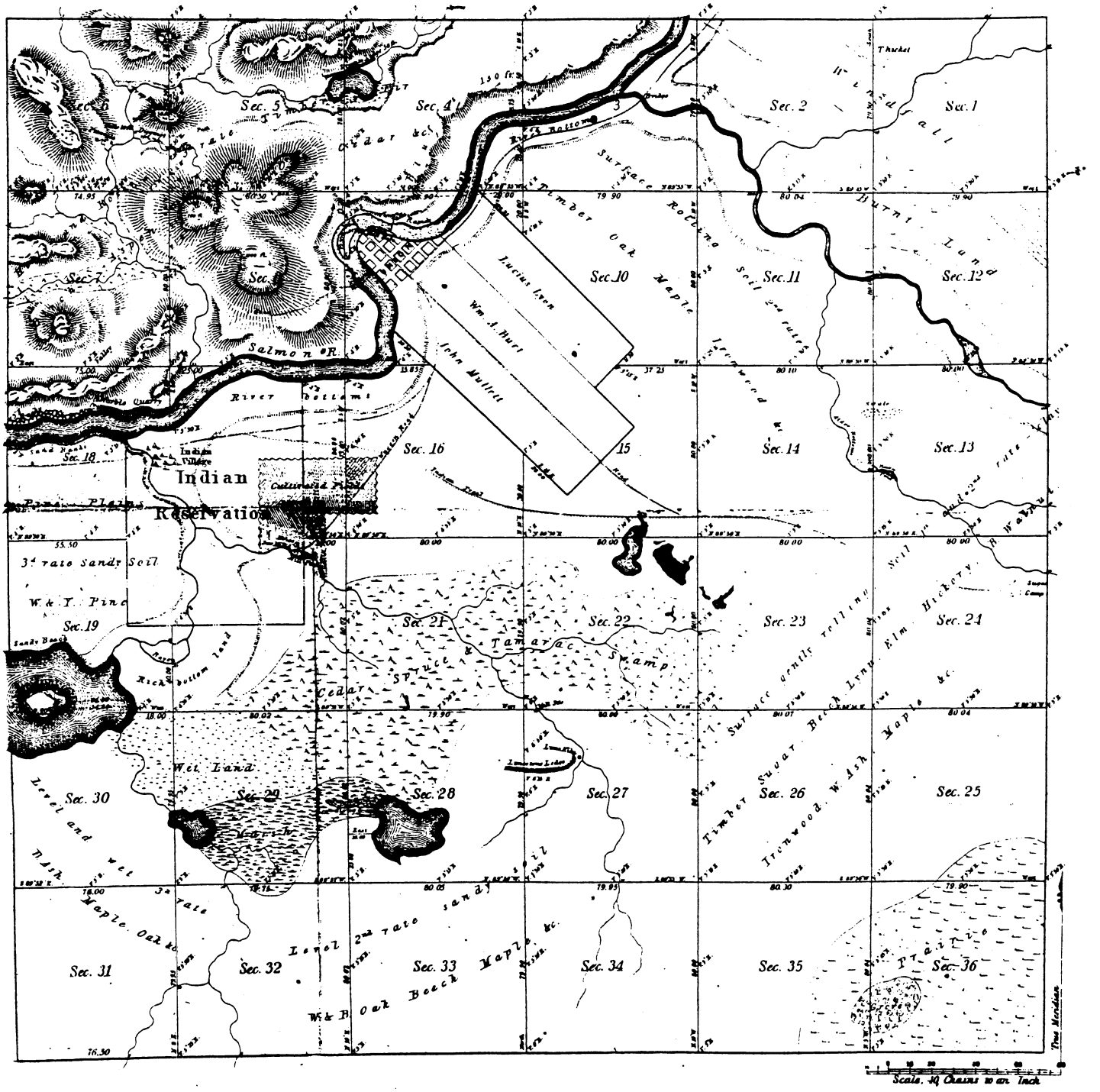

Figure 1: Hypothetical Township Plat Map used to train land surveyors in Michigan.

rivers and streams, lakes, wetlands, existing settlements, trails, and roads. There were also general comments on bedrock outcrops, soils, and vegetation written across the sections where those features were found.

Although survey methods saw minor modifications during the course of the Michigan surveys, the transcribed surveyor's notes are much more consistent in quality throughout the state than the township plat maps. Surveyors were instructed to note the exact location of wetlands, lakes and streams, comment on the agricultural potential of soils, and note the quantity and quality of timber resources as they were encountered along each section line (White 1984; Caldwell 1990). Wherever they marked trees, surveyors recorded the species and its diameter at breast height. Tree species and diameter were also noted when they occurred along the section lines. At section corner and half-mile points, witness trees were selected from nearby trees in the northeast, northwest, southeast, and southwest quadrants. Often just two trees were marked and noted around each corner post. The exact bearing and distance of each witness tree in relation to the associated corner post was also measured and recorded. Recently burned areas, windthrows, and beaver floodings were recorded along the section lines, as were various cultural features, of either Native American or early European settler origin. Surveyors often included a short list of tree species, impressions of soil character, and general drainage characteristics along each surveyed mile. This information was strongly influenced by surveyors' experience, knowledge and values. To interpret surveyors' notes and comments, one must understand the surveyor and the times in which the surveys were conducted.

Methods for Assessing Wetland Trends

The methodology for creating the digital presettlement vegetation map is detailed in Comer et al. (1995b). Acreage estimates were calculated for each upland and wetland cover type in each county and input into a spreadsheet. The historical map depicts 34 different categories of wetlands (Table 1). These categories are broadly subdivided into forested and non-forested wetlands. Within each subdivision, additional categories were distinguished from land surveyors' comments and current knowledge of Michigan wetland types. For the purposes of this acreage comparison, all mud flats were combined with emergent marsh/meadow/prairie types to generate historical emergent wetland acreage estimates. These statistics were compared with MIRIS current acreage statistics calculated for each county. The MIRIS cover types for the emergent wetland category also include a lumping of acreages for both the aquatic bed and mud flat categories. Similarly, the five categories of shrub-dominated wetlands in the historical maps were combined for comparison with the shrub-scrub wetland category with current MIRIS data.

Forested wetlands were categorized distinguishing those dominated by conifer species from those dominated by hardwood, or deciduous species. All nine hardwood types were lumped together and all nine conifer types were lumped together for the purposes of acreage comparison. The historical maps include two categories for mixed hardwood-conifer swamps, distinguishing those where hardwoods predominated from those where conifers predominated. These two hardwood-conifer categories were also lumped with the other types in their respective subdivision for the purposes of the acreage comparison.

Forested wetlands in the current MIRIS data set are divided into lowland hardwood, lowland conifer, and wooded wetland. The category of wooded wetland is problematic when attempting to utilize MIRIS data for comparisons. Statewide, nearly 260,000 acres were classified as wooded wetland, but no clear definition of this category was consistently applied statewide. For the purposes of this comparison, it was assumed that acreages classified in the wooded wetland category could be lumped with either lowland conifer or lowland hardwood categories in proportion to the relative abundance of the latter categories in current MIRIS data. Wooded wetland acreages were thus divided and lumped in each county where they occurred.

Soil surveys were utilized in Baraga, Barry, Midland, and Ontonagon counties to adjust current wetland statistics. Acreage estimates for hydric soils were added up for each county to provide a more accurate county-wide wetland acreage estimate. The four current wetland categories were then adjusted in proportion to the overall wetland acreage adjustment. For example, where hydric soils indicated 80% of the total wetland acreage derived from MIRIS data, each of the four MIRIS wetland categories was reduced by 20% for that county. This adjustment was only done in these four counties because of the apparently high level of disagreement between MIRIS estimates and historical estimates, and hydric soil acreage estimates were available. Other counties with similarly high levels of disagreement between MIRIS data and historical estimates could not be adjusted due to a lack of current hydric soils data.

Table 1: Wetland types and codes recognized in presettlement vegetation maps. (Comer et al. 1995a)

NON-FORESTED WETLAND	FORESTED WETLAND
Emergent Marsh / Meadow / Prairie	**41 Hardwood / Conifer - hardwood dominant**
6221 EMERGENT MARSH	**414** MIXED LOWLAND HARDWOOD
6222 GREAT LAKES MARSH	**4141** ASH
6223 INTERDUNAL WETLAND	**4142** ELM
6224 WET MEADOW	**4143** SILVER MAPLE, RED MAPLE
6225 INLAND SALT MARSH	**4144** COTTONWOOD
6226 LAKE PLAIN PRAIRIE	**4145** BALSAM POPLAR
6227 INLAND WET PRAIRIE	**4146** ASPEN
6228 INTERMITTENT WETLAND	**4147** WHITE BIRCH
	4148 BLACK WILLOW
Mud Flats	
6231 MARL FLATS	**42 Conifer / Hardwood - conifer dominant**
	423 MIXED LOWLAND CONIFER
Shrub-Dominated Wetland	**4231** CEDAR
6121 BOG	**4232** BLACK SPRUCE
6122 ALDER, WILLOW, BOG BIRCH THICKET	**4233** TAMARACK
6123 BUTTONBUSH, WILLOW SWAMP	**4234** BALSAM FIR, SPRUCE
6124 PATTERNED PEATLAND	**4235** BALSAM FIR
6125 MUSKEG	**4236** JACK PINE
	4237 HEMLOCK
	4238 WHITE PINE

The historical and current wetland acreage tables were electronically linked and a table indicating change in wetland acreage was compiled. This table simply divides current acreage by historical acreage to indicate a relative proportion of historical acreage found in each county today.

Results and Discussion

General Land Office Surveys as a Data Source

Historical acreages arranged by wetland type are depicted for each county in Appendix I. There are limitations associated with the use of the General Land Office surveys that should be clear to all users of historical map data. Given that these surveys were not undertaken as a scientific sample of vegetation, they should not be considered as such. However, they do provide a wealth of detailed information available nowhere else. Historical map production involved the interpretation of survey data when plotted on U.S.Geological Survey topographic maps (1:24,000 scale) (Comer et al. 1995b). Wetland type boundaries should be assumed to be most reliable where they intersected with the section line. The interpolated

boundary between each section line utilized elevation lines and should be considered an approximation that could differ on the ground depending on local variation not apparent on topographic maps. Upland and wetland boundaries in interior sections should be most accurate where topography is abrupt. One should assume that wetlands which naturally occur as relatively small, complex shapes, totaling less than 50 acres in area, are under-represented in these maps. The accuracy of aerial coverage should be assumed to increase with the typical natural size of the unit. The aerial coverage of typically small wetlands, such as alder-willow swamp and emergent marsh, are most likely underestimated. Therefore, acreage estimates from these historical maps should be assumed as a conservative estimate of historical wetland extent. The precision of that estimate should be assumed to vary across the state, with areas of abrupt topography and few small, isolated wetlands being most accurately represented. Although there have not yet been calculations made to determine the level of precision in these maps, I estimate that wetland acreage may have been underestimated by as much as 5% in some Michigan counties.

There are a number of discussions of surveyor's bias in their selection of witness trees in the scientific literature (Delcourt & Delcourt 1974, Delcourt & Delcourt 1977; Grimm 1984). The selection of witness trees was undoubtedly "biased" to some degree for practical reasons. Surveyors needed to find easily marked trees that aided the later relocation of the section corner post that they had pounded into the ground. Their instructions indicated that they should choose long-lived trees greater than four inches in diameter for marking. However, this obvious source of "bias" was severely limited by the number of trees that were also immediately adjacent to the corner post. Surveyors could not, for very practical reasons, travel very far to mark a more preferred tree, because they would defeat the purpose of marking a "witness." One should assume that easily marked, long-lived species such as northern white-cedar (*Thuja occidentalis*) and American beech (*Fagus grandifolia*) were used slightly more often than their actual frequency on the land. Shorter-lived species, such as aspens (*Populus tremuloides* or *P. grandidentata*), balsam poplar (*Populus balsamifera*), cottonwood (*Populus deltoides*), and paper birch (*Betula papyrifera*), or typically small diameter species, such as speckled alder (*Alnus rugosa*) were used slightly less often than their actual frequency on the land. It is unlikely that these biases had a significant effect on the acreage estimates for hardwood- vs. conifer-dominated wetlands in the historical maps.

MIRIS Data

As previously mentioned, MIRIS maps were not specifically designed to depict wetland extent. This becomes especially clear in the forested wetland categories where lowland hardwood and lowland conifer acreages are clearly greater than any other estimates of total wetland extent for a given area. Comparing MIRIS acreages with both historical estimates and hydric soils estimates, it is clear in a number of individual counties that current wetland extent is exaggerated. The problem appears to increase with more northern counties. The level of distortion is likely caused by the difficulty of distinguishing upland from wetland in forests dominated by aspens and balsam poplar, or conversely, those dominated by balsam fir (*Abies balsamea*) and white or black spruce (*Picea glauca, Picea mariana*). Both of these groups of tree species are found in complex northern landscapes that include both upland and wetland conditions. While interpreting 1:24,000 scale aerial photographs, it is particularly difficult to distinguish upland from wetland when most tree species are found in both upland and wetland conditions. For this reason, hydric soils acreages were taken from soil surveys in four counties. These data apparently explained much of the distortions in both Baraga and Ontonagon counties, but not all of the discrepancies between historical and current wetland estimates in Midland and Barry counties were explained using hydric soils data. The latter counties probably indicate where historical maps under-represent wetland extent, but there are clearly a number of factors involved. For example, forests dominated by eastern hemlock and white pine were historically quite common throughout flat landscapes surrounding swamps in Midland County. While surveyors did not describe these areas as wetland, the soil moisture regimes of these areas were

undoubtedly very close to those of adjacent wetlands. This factor introduced distortions into historical maps. Further analyses with better data are needed to better assess these and other individual counties.

Unfortunately, we are currently in the position of comparing a conservative estimate of historical wetland extent with a generous estimate of modern wetland extent, magnifying the level of distortion one encounters throughout the state and creating an uncomfortable level of uncertainty with the statewide assessment. It is therefore important to view the results of this comparison as a preliminary assessment. Future, more precise assessments will be achievable as digital soils and/or wetland inventory maps become available statewide.

Statewide Trends

Nearly 200 years of timber production, agricultural development, and urban growth have transformed Michigan's landscape. In 1800, roughly 74% of the surface of the state supported grassland, savanna, and forested uplands. Today, most grasslands and savannas have been eliminated and 37% of the state (about 14,000,000 acres) remains in an upland forest condition. Agricultural uses, either as lands that have been, or are currently in production, also total nearly 14,000,000 acres. Urban development comprises roughly 2.3 million acres, or 6.3% of the state's land surface.

Estimates of historical wetland extent have never been easy to obtain, and until now, none have been based on detailed analysis. Dahl (1990) used estimates from an internal MDNR document (MDNR 1988) that placed Michigan's historical wetland extent (circa 1780) at 11,200,000 acres, or 30% of the total land surface. Calculations from Comer et al. (1995a) indicate a more conservative estimate of historical wetland extent of 8,529,737 acres. This acreage represented 23% of the total land surface for the state. Given the above mentioned weaknesses in the historical data set, one could increase that estimate by about 1% to 8,900,000 acres, but for the purposes of comparison, the calculated estimate was used. Estimates of current wetland extent also vary depending on the source. Dahl (1990) used unpublished 1983 estimates by the National Wetlands Inventory (NWI) that placed 1980 acreage at 5,583,400 (15%). Unfortunately, there is no published record of the methodology NWI used to arrive at their estimate. Total wetland extent as calculated from MIRIS data is 6,138,538 acres, representing 16% of the total land surface of the state.

Comparing our historical estimate with MIRIS calculations indicates a statewide wetland loss of 2,391,199 acres between about 1800 and 1980. This amounts to a 28% loss in wetland acreage statewide. If one utilizes the NWI estimates of wetland extent circa 1980, there would be a loss of 2,946,337 acres, or a 34.5% wetland acreage loss statewide. Given the uncertainties with existing data, a conservative estimate of wetland loss statewide should be placed within the range of 28-35%.

Based on the direct comparison of historical estimates and MIRIS data, the highest wetland losses statewide were found in Monroe (87%), Wayne (84%), Huron (78%), Sanilac (77%), Macomb (74%), St. Clair (73%), Lenawee (69%), and Ottawa (65%) counties, respectively (Figure 2, Table 2). Fifteen Michigan counties show wetland losses equal to or greater than 50%. All of these counties are located in the southern half of the Lower Peninsula and Saginaw Bay watershed. Wetland losses are clearly associated with the human population centers and the feasibility of sustained agricultural drainage.

Forested Wetlands

From a statewide perspective, the most significant change in the relative composition of wetland types is the decline in acreage of conifer-dominated swamps. About 1800 there were approximately 5.5 million acres of conifer swamp in Michigan. That represented nearly 15% of the total land surface of the state. Most conifer swamps were dominated by northern-white cedar, tamarack (*Larix laricina*), and black spruce, although balsam fir, eastern hemlock (*Tsuga canadensis*), white pine (*Pinus strobus*), and

jack pine (*Pinus banksiana*) also dominated some swamps. Because of the scale of data gathered from the General Land Office surveys, and because conifer species are commonly found intermixed it is difficult to establish with certainty the relative abundance of swamps dominated by any of the above mentioned species.

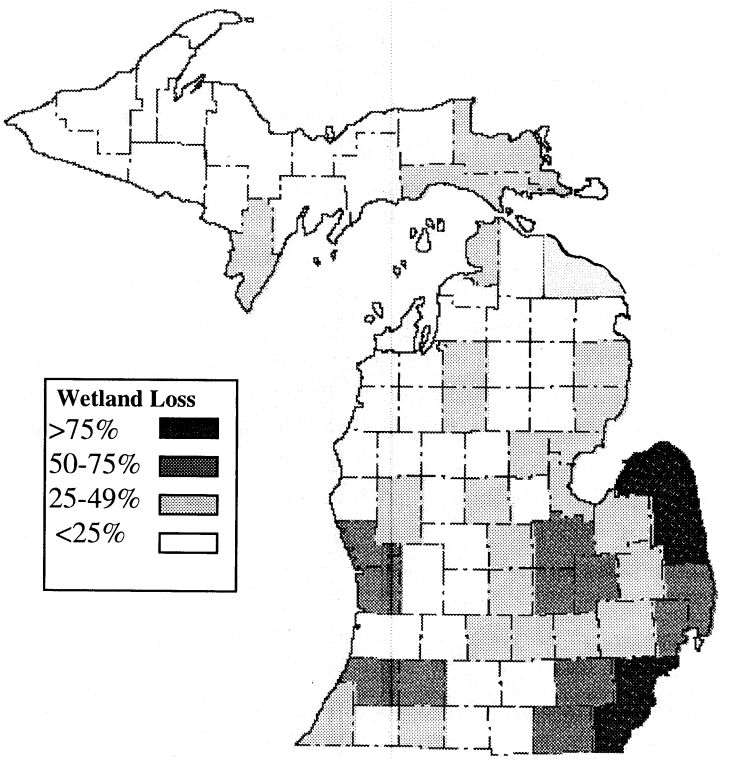

Figure 2: Relative wetland loss since 1800 for each Michigan County.

Calculations from historical maps indicate that over 50% of the conifer swamps statewide were a mixture of dominant species. Many of these areas undoubtedly contained small-scale pockets dominated by cedar, tamarack, and/or black spruce. Based on calculations from historical maps, nearly 23% of all conifer swamps statewide were dominated by northern-white cedar, 16% by tamarack, and just under 2% by black spruce.

Based on the comparison of historical estimates and MIRIS data, there has been a 66% loss in conifer-dominated wetland acreage statewide (Table 2). This represents the drainage or conversion of roughly 3.6 million acres. Roughly 30% of the loss of lowland conifer acreage resulted from their conversion to lowland hardwood, emergent wetlands, and shrub swamps through extensive logging activity. The rest were completely drained, mostly in the Saginaw Bay watershed and throughout the southern

Lower Peninsula. Only 14 counties statewide (five in the northern Lower Peninsula, nine in the Upper Peninsula) retain more than 50% of historical acreage in conifer swamp. Data from the Forest Management Division of MDNR indicate that in 1980 there were approximately 1.1 million acres of northern-white cedar swamp in the state. Using this figure, swamps dominated by other conifer species totaled about 700,000 acres statewide (Botti 1991).

Table 2: Ratio of current to historical wetland acreage for each Michigan County, ranked by relative wetland loss within each region.

PROPORTIONAL WETLAND ACREAGE CHANGE current/historical acreage					
COUNTY	**Lowlands Hardwoods**	**Lowland Conifers**	**Shrub Swamp**	**Emergent Wetland**	**Total**
CHIPPEWA	8.70	0.27	9.52	3.19	0.55
MACKINAC	41.69	0.36	10.91	0.78	0.63
MENOMINEE	9.39	0.48	3.15	1.51	0.74
DELTA	68.41	0.46	1.90	1.52	0.76
ALGER	151.41	0.56	4.92	0.62	0.79
SCHOOLCRAFT	11.85	0.52	0.45	16.53	0.82
ONTONAGON*	4.51	0.34	1.37	0.93	0.88
DICKINSON	97.91	0.60	6.54	3.12	0.92
MARQUETTE	19.95	0.58	2.49	6.03	0.94
BARAGA*	11.25	0.53	2.21	2.59	0.96
KEWEENAW	58.53	0.58	5.98	9.22	0.97
IRON	11.47	0.58	8.50	3.81	1.00
LUCE	53.02	0.72	1.09	4.06	1.10
HOUGHTON	24.26	0.35	2.9	2.47	1.17
GOGEBIC**	4.50	0.78	1.71	2.22	1.43
Region 1 Total	16.64	0.49	1.59	3.81	0.84
* adjusted with soils data **soils data not available					
Region 2 County	**Lowlands Hardwoods**	**Lowland Conifers**	**Shrub Swamp**	**Emergent Wetland**	**Total**
HURON	0.53	0	6.61	0.44	0.22
SANILAC	0.52	0	2.29	0.12	0.23
SAGINAW	0.69	0	6.23	0.05	0.50
BAY	0.68	0	5.85	0.12	0.51
TUSCOLA	1.52	0	4.76	0.13	0.51
OGEMAW	3.96	0.1	15.49	1.22	0.55
ISABELLA	1.12	0.14	23.19	2.43	0.60
ARENAC	1.26	0	15.01	0.89	0.62
EMMET	405.33	0.22	615.03	4.11	0.65
PRESQUE ISLE	8.66	0.34	8.75	0.57	0.68

PROPORTIONAL WETLAND ACREAGE CHANGE current/historical acreage					
COUNTY	**Lowlands Hardwoods**	**Lowland Conifers**	**Shrub Swamp**	**Emergent Wetland**	**Total**
MISSAUKEE	5.83	0.24	5.15	1.06	0.70
KALKASKA	14.76	0.22	5.96	1.45	0.72
IOSCO	2.16	0.23	70.07	1.29	0.74
ALCONA	2.86	0.37	19.53	2.55	0.74
GLADWIN	4.55	0.03	47.58	0.88	0.77
ALPENA	8.92	0.33	33.09	4.06	0.82
WEXFORD	4.27	0.29	5.12	1.54	0.83
MONTMORENCY	12.49	0.56	10.02	1.7	0.88
ANTRIM	4.31	0.41	19.45	1.7	0.89
GRAND TRAVERSE	8.97	0.06	23.56	2.54	0.90
ROSCOMMON	12.12	0.41	2.73	2.41	0.92
CRAWFORD	24.86	0.5	7.54	0.33	0.93
CLARE	5.05	0.2	8.86	0.57	0.96
CHEBOYGAN	25.94	0.37	4.24	1.34	0.96
MASON	3.59	0.1	11.34	1.75	0.96
OTSEGO	12.86	0.68	7.1	1.55	1.01
LEELANAU	12.25	0.53	66.33	0.97	1.05
OSCEOLA**	4.89	0.35	5.07	1.09	1.13
LAKE**	9.07	0.2	14.53	1.2	1.13
OSCODA**	4.17	0.59	13.85	1.76	1.14
MANISTEE**	3.49	0.08	62.23	1.88	1.14
CHARLEVOIX	13.92	0.45	29.45	1.43	1.15
BENZIE**	33.01	0.26	36.76	7.07	1.37
MIDLAND*	2.52	0	25.08	4.89	1.46
REGION 2 Total	2.07	0.24	7.83	0.64	0.72
* adjusted with soils data **soils data not available					

Region 3 County	**Lowlands Hardwoods**	**Lowland Conifers**	**Shrub Swamp**	**Emergent Wetland**	**Total**
MONROE	0.2	0	20.67	0.03	0.13
WAYNE	0.22	0	0.48	0.02	0.16
MACOMB	0.29	0.02	9.12	0.07	0.26
ST CLAIR	0.39	0	0.72	0.17	0.27
LENAWEE	0.32	0	2.75	0.23	0.31
OTTAWA	0.58	0	0.34	0.35	0.35
SHIAWASSEE	0.65	0.01	7.19	0.26	0.40
WASHTENAW	0.56	0.02	7.93	0.1	0.43
MUSKEGON	0.74	0.1	6.58	0.25	0.44
GENESEE	0.44	0	8.98	0.53	0.44

PROPORTIONAL WETLAND ACREAGE CHANGE current/historical acreage					
COUNTY	**Lowlands Hardwoods**	**Lowland Conifers**	**Shrub Swamp**	**Emergent Wetland**	**Total**
KALAMAZOO	0.38	0.03	57.97	0.16	0.49
VAN BUREN	0.58	0	10.3	1.58	0.49
CLINTON	0.81	0	1.75	0.29	0.53
ST JOSEPH	0.74	0.07	44.91	0.09	0.54
OAKLAND	0.59	0.04	5.93	0.55	0.54
INGHAM	1.8	0.01	1.61	0.26	0.55
EATON	1.44	0	0.95	0.82	0.55
NEWAYGO	1.79	0.06	5.37	0.17	0.58
LAPEER	0.75	0.03	5.65	2.62	0.60
GRATIOT	0.79	0.04	7.89	0.18	0.62
BERRIEN	0.94	0	3.94	0.3	0.69
LIVINGSTON	2.13	0.02	61.58	0.15	0.72
IONIA	1.24	0	2.45	0.08	0.81
CASS	1.44	0.01	12.14	0.44	0.84
ALLEGAN	1.28	0.02	4.81	0.78	0.84
BRANCH	1.8	0	1.96	0.09	0.85
KENT	1.15	0.09	2.41	0.36	0.86
JACKSON	3.52	0.05	70.52	0.05	0.88
CALHOUN	2.46	0.02	35	0.12	0.91
OCEANA	2.89	0.07	7.4	1.31	0.91
MONTCALM	1.22	0.2	18.68	1.17	0.93
HILLSDALE**	1.9	0	6.25	0.38	1.15
MECOSTA**	6.69	0.28	7.88	3.36	1.32
BARRY*	3.96	0.03	25.63	0.88	1.36
Region 3 Total	0.85	0.05	5.19	0.21	0.57
State Total	**1.54**	**0.34**	**2.7**	**0.57**	**0.72**
* adjusted with soils data **soils data not available					

About 1800, hardwood-dominated swamp was characteristic of about 1.7 million acres statewide, mostly concentrated in the southern Lower Peninsula. That represented about 4.5% of the state's total surface area. Hardwood swamps in Michigan were dominated by ash species such as black ash (*Fraxinus nigra*) and red ash (*Fraxinus pennsylvanica*), elms, including American elm (*Ulmus americana*) and slippery elm (*Ulmus rubra*), and maples, such as silver maple (*Acer saccharinum*) and red maple (*Acer rubrum*). Less common deciduous trees dominating these swamps were cottonwood, black willow (*Salix nigra*) in the south, and quaking aspen (*Poulus tremuloides*), bigtooth aspen (*Populus grandidentata*), and balsam poplar further north. Both pin oak (*Quercus palustris*) and swamp white oak (*Quercus bicolor*) are sometimes dominant in southern deciduous swamps, but were rarely recorded in the original land surveys. Deciduous tree species were most commonly found in mixed stands, with 70%

of hardwood swamps mapped as mixed hardwoods on the historical maps. Of the individual species, black ash was most commonly found dominating swamps by itself, with nearly 17% of hardwood swamps mapped as such. Aspens were second most commonly noted as a swamp dominants, representing nearly 2% of deciduous swamp acreage. The latter wetland type was most commonly noted in the northern Lower Peninsula.

Based on the comparison of historical estimates and MIRIS data, there has been a 54% increase in hardwood swamp acreage statewide (Table 2). This represents an increase of roughly 918,000 acres now characterized as hardwood swamp. While it is clear that hardwood swamps were drained and converted for agriculture, the overall increase in acreage can be explained almost entirely by the conversion of conifer swamps to aspens and red maple. Recent estimates made by the U.S. Forest Service forest inventory for Michigan (Leatherby & Spencer 1993) document the current acreages of these forest types, many of which include forested wetlands throughout the state, but are most concentrated in the northern Lower Peninsula and Upper Peninsula. Statewide, aspen-dominated forest (including both upland and wetland types) has increased from roughly 300,000 acres in 1800 to approximately 3.1 million acres in 1993; representing approximately a ten-fold increase. On an individual county basis, increases in hardwood swamp acreage varied tremendously. The largest relative increases were in counties with relatively small historical acres recorded (Appendix II). Statistics from only 22 Michigan counties indicate a decrease in lowland hardwood acreage. All of these counties are found in the Saginaw Bay watershed and elsewhere in the southern half of the Lower Peninsula. Seven counties indicate acreage decreases greater than 50%. These include Monroe (80%), Wayne (78%), Macomb (71%), Lenawee (68%), Kalamazoo (64%), St. Clair (61%), and Genesee (56%).

Shrub Swamps

About 1800, there were approximately 430,000 acres of shrub-dominated wetlands, representing just over one percent of the state's surface area. Most shrub swamps were concentrated in the Upper Peninsula, with roughly 328,000 acres, or 76% of the statewide acreage. Shrub-dominated wetlands were classified into five different categories on the historical maps, including muskeg, alder-willow swamp, patterned peatland, bog, and buttonbush-willow swamp. Muskegs, most abundant at roughly 140,000 acres, were extensive, acid peatlands dominated by leatherleaf (*Chamaedaphne calyculata*) and peat moss (*Sphagnum* spp.), and stunted, widely scattered black spruce and tamarack. Muskeg was most concentrated in Schoolcraft and Luce counties. Alder-willow swamps were common statewide, but over half of the 125,000 acres statewide were located in the Upper Peninsula. Speckled alder (*Alnus rugosa*) typically dominated these swamps, but several species of willow (*Salix* spp.) and Viburnums (*Viburnum* spp.), dogwoods (*Cornus* spp.), and sweet gale (*Myrica gale*) were often characteristic. Today, alder-willow swamps are most commonly found along streams and lake margins, in areas not well described during the original land surveys. Because of this, the historical acreage of alder-willow swamp is probably underestimated. Patterned peatlands, limited almost entirely to Schoolcraft and Luce counties, characterized roughly 111,000 acres in the 1840s. These shrub-herb peatlands are characterized by alternating, acid sedge-peat ridges and relatively calcareous hollows oriented across a gentle slope, perpendicular to the direction of groundwater flow. Leatherleaf, bog birch (*Betula pumila*), shrubby cinquefoil (*Potentilla fruticosa*), and bog rosemary (*Andromeda glaucophylla*) are common shrub species found among a diversity of sedges (*Carex* spp.) and *Sphagnum* mosses. Bog, as classified in the historical maps, represented approximately 36,000 acres, spread throughout the state. These areas were acid peatlands dominated by leatherleaf, Labrador tea (*Ledum groenlandicum*), bog rosemary, and *Sphagnum* mosses, most commonly found in deep basins (kettles) surrounding lakes. Buttonbush-willow swamps accounted for roughly 18,000 acres, concentrated in the southern half of the Lower Peninsula. These

swamps probably included a range of hydrological conditions, with more deeply inundated areas commonly dominated by buttonbush (*Cephalanthus occidentalis*), and more shallow inundated areas dominated by willows (*Salix* spp.) and dogwoods (*Cornus* spp.). Again, because of the relatively small size of these swamps, their acreage was almost certainly underestimated on the historical maps.

A pattern of acreage change similar to that found in lowland hardwoods also exists for shrub swamps (Table 2). With the extensive logging of conifer-dominated swamps, and the altered hydrology associated with road construction, many forested wetlands were converted to shrub swamps. Based on the comparison of historical estimates and MIRIS data, there has been a 170% increase in shrub swamp acreage statewide. This represents an increase of roughly 730,000 acres statewide. Statistics from only five counties statewide indicate a net decrease in shrub swamp acreage. In the southern Lower Peninsula, these include the counties of Ottawa (66% loss), Wayne (52%), St. Clair (28%), and Eaton (5%). In the Upper Peninsula, Schoolcraft County indicates a 55% loss in shrub swamp acreage. Given the relatively low level of development in that county, this change could be partially explained as differences in data acquisition. Aerial photo interpretation to establish MIRIS's current estimates probably categorized many areas of muskeg and patterned peatland as emergent wetland. Both muskeg and patterned peatland fall into the shrub swamp category of the presettlement vegetation map. However, part of this change can also be explained by the extensive establishment of ponds throughout the Seney National Wildlife Refuge. These areas would be categorized as open water in MIRIS. The acreage change may also indicate where the suppression of wildfires may have had an impact on the open peatlands. Effective fire suppression during this century may have allowed some portions of shrub-dominated peatlands to succeed to forested wetland. The role of wildfire in the extensive peatlands of the eastern Upper Peninsula remains unclear and deserving of further investigation.

Emergent Wetlands

Emergent wetlands historically comprised approximately 845,000 acres, or just over 2% of the state's total surface area. As with selected wetland types already mentioned, emergent wetlands that tend to occur in small, isolated pockets, or along the margins of lakes and streams, were probably underestimated somewhat on the historical maps. About 75% of statewide historical acreage in emergent wetlands was located in southern Lower Michigan. On the historical maps, emergent wetlands were categorized into eight different types, including emergent marsh, inland wet prairie, lake plain prairie, Great Lakes marsh, wet meadow, intermittent wetland, interdunal wetland, and salt marsh. Emergent marsh not associated with the Great lakes shoreline is estimated to have characterized over 365,000 acres, or 57% of all emergent wetlands statewide. These marshes were found in shallow depressions and on the margins of many lakes and streams. Today, they are typically dominated by a wide variety of emergent, narrow- and broad-leaved herbs as well as floating-leaved herbs. Inland wet prairie was second most abundant of the emergent wetland types, occupying over 233,000 acres historically. These, along with the wet prairies found on the glacial lake plain, are presumed to have been dominated by a diversity of grasses. This distinction was apparently great enough that land surveyors consistently distinguished wet prairie from marsh throughout southern Michigan in the 1800s. Today, wet prairies typically are dominated by a combination of grasses, sedges, and forbs. Characteristic grasses of wet prairie include blue joint grass (*Calamagrostis canadensis*) and prairie cordgrass (*Spartina pectinata*). On slightly better drained portions of these prairies, big blue stem (*Andropogon gerardii*) and Indian grass (*Sorghastrum nutans*) are more common. Lake plain prairie is distinguishable from inland wet prairie by a several characteristic plant species, but also by the location of these prairies within distinctive upland-wetland landscapes formed on the glacial lake plain. These prairies occupied roughly 159,000 acres in the 1800s, concentrated along the Saginaw Bay shoreline and southeastern counties along Lake St. Clair, the Detroit River,

and Lake Erie (Comer et al.1995c). Great Lakes marshes are emergent wetlands found throughout the shoreline bays, coves, and riverine estuaries. The historical maps indicate that roughly 81,000 acres of these wetlands were found in Michigan in 1800. Today, Great Lakes marshes are typically characterized by a distinctive set of vegetative zones extending from deep to shallow water (Albert et al. 1987, 1988, 1989). Floating herbs typically are found along the margin of open water with narrow-leaved emergent herbs, sedge meadows, and finally scattered shrubs dominating zones further inland.

Wet meadow was also distinguishable by land surveyors and occupied roughly 9,700 acres statewide. This was the only emergent wetland type more commonly found in the Upper Peninsula than anywhere else in the state. Today, wet meadow is characterized by several species of sedge in combination with blue joint grass and a variety of forbs. They are most commonly found along stream margins. Intermittent wetlands are shallow wetlands that experience wide fluctuations in water levels seasonally and from year to year. Because of their small size and isolated nature, the statewide historical acreage estimate of roughly 5,600 acres should be presumed an underestimate. These wetlands typically display a distinctive vegetative zonation with a diversity of narrow-leaved herbs, based on the fluctuating water levels. Surrounding the margins of these typically acid wetlands is often a band of leatherleaf. Succeeding zones of sedges and rushes (*Juncus* spp.) are characteristic. In portions of the state, especially southern Lower Michigan, plant species with affinities to the Atlantic Coastal Plain are found in these wetlands. Both interdunal wetlands and salt marshes were noted on historical maps in very small acreages. Interdunal wetlands are sedge- and rush-dominated communities found between dune ridges along the Great lakes shoreline. They typically experience fluctuating water levels and often appear to vary in synchrony with Great Lakes water level fluctuations. Salt marshes were described by surveyors in only a few locations, primarily in the southern Lower Peninsula. Always the rarest wetland type in the state, only two are known to remain in the state, located where glacial drift is shallow enough to permit brine from deep saline aquifers to remain concentrated and emerge at discrete points. The odor of hydrogen sulfide and the appearance of Olney's bulrush (*Scirpus olneyi*) are characteristic of salt marshes in Michigan.

According to MIRIS data, there were approximately 483,000 acres of emergent wetlands statewide around 1980 (Table 2). Comparing MIRIS data with calculations from historical maps, there has been a 43% decline in acreage statewide. That represents a statewide loss of approximately 363,000 acres. Most significant declines (79%) occurred in the southern half of the Lower Peninsula, while there was a 36% decline in the northern Lower Peninsula. Statistics from the Upper Peninsula indicate a 281% increase in acreage (roughly 187,000 acres) since 1800. It is unlikely that many emergent wetlands resulted directly from the conversion of other wetland types. Much of this increase probably reflects the classification of what were historically described in the shrub swamp category (muskeg and patterned peatland) as emergent wetlands in the MIRIS data, based on aerial photo interpretation. Similarly, in more southern counties indicating more modest increases in emergent wetland acreage, the underestimation of small, isolated wetlands on historical maps probably accounts for this phenomenon. From a statewide perspective, emergent wetland losses were most significant in the southern counties of Wayne (96%), Monroe (97%), Saginaw (95%), Jackson (95%), Macomb (93%), Ionia (92%), Branch (91%), St. Joseph (91%), and Washtenaw (90%). Twenty four counties in the southern Lower Peninsula and six counties in the northern Lower Peninsula indicate emergent wetland losses greater than 50%.

Regional Trends

Because of the tremendous natural variability in Michigan's wetland systems, it is instructive to analyze wetland trends from a regional perspective. The three administrative regions (Figure 3) of the

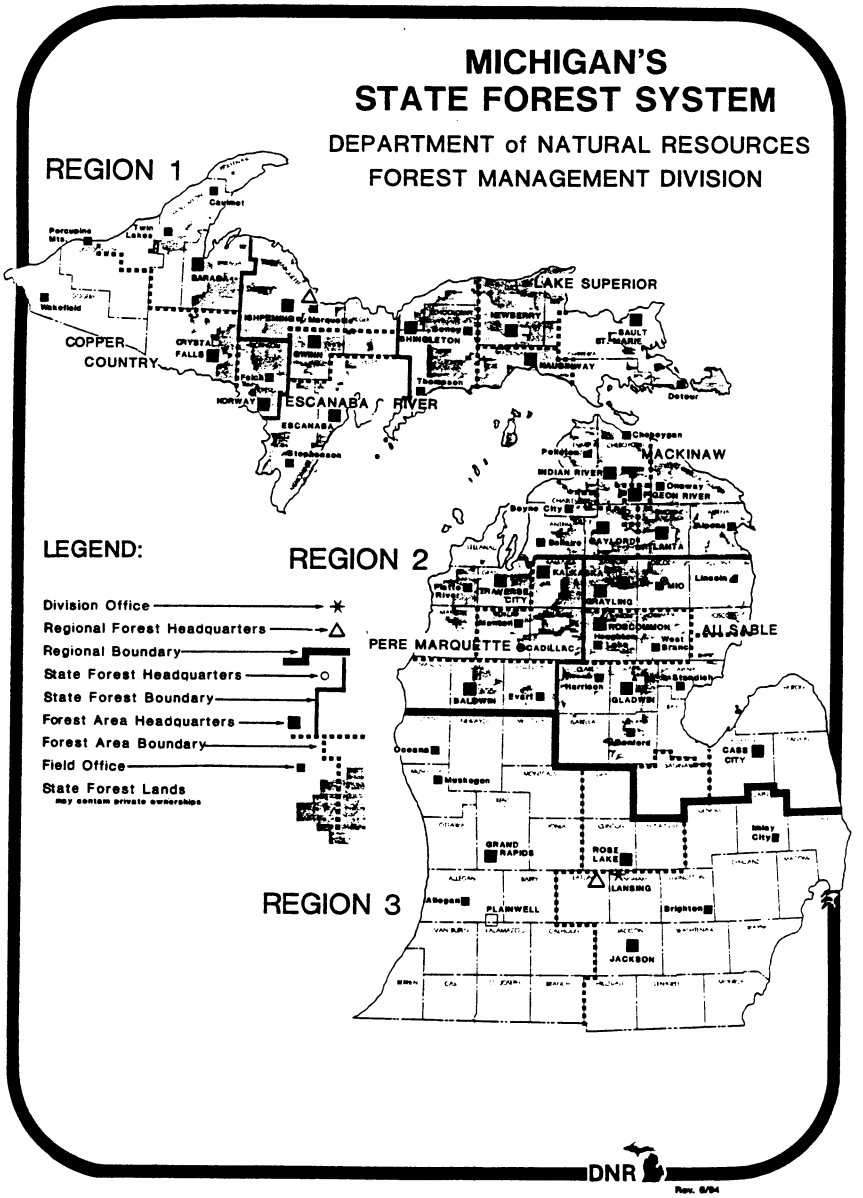

Figure 3: Adminstrative regions of the Michigan Department of Natural Resources.

Michigan DNR will frame this discussion. Region 1 includes the Upper Peninsula, Region 2 includes the northern Lower Peninsula, and Region 3 includes the southern Lower Peninsula.

Region 1

In 1800, uplands of the Upper Peninsula were mostly forested, representing about 68% of the land surface. For the most part, these forests were dominated by conifers such as eastern hemlock, white pine,

and balsam fir. Conifers were found in combination with northern hardwoods on over 2,000,000 acres. Windthrow was probably the prevalent dynamic in most of these forests. Wildfire played a significant role in the dynamics of roughly 600,000 acres of pine-dominated forest and savanna, which tended to be concentrated on droughty sands on outwash plains. Today, upland forests account for about 6.6 million acres, or roughly 62% of the region's surface. Currently productive and abandoned agricultural lands account for nearly 900,000 acres, or 8.3% of the region. Urban development only accounts for about 170,000 acres, or 1.6% of the region.

Historically, wetlands accounted for about 3.1 million acres, or 29% of the Upper Peninsula (Table 3). The majority of the region's wetlands occurred in eastern and central counties such as Chippewa, Schoolcraft, Mackinac, Delta, and Menominee. Forested wetlands were dominated by conifer species such as northern-white cedar, tamarack, black spruce, and balsam fir. Mixed conifer swamp accounted for about 2.1 million acres, or 20% of the U.P. surface. Cedar swamp dominated over 300,000 acres in the region, while tamarack swamp was found on about 150,000 acres. Black spruce and mixed conifer-hardwood swamp accounted for about 107,000 acres. Hardwood-dominated swamp was mostly limited to river floodplains in southern portions of the region, totaling about 32,000 acres. Shrub swamp, which included extensive alder-willow swamp, patterned peatlands, and muskeg concentrated in Schoolcraft, Luce, and Delta counties, accounted for about 328,000 acres region-wide. Emergent wetlands made up less than one percent of the region, totaling about 67,000 acres. Great Lakes marsh concentrated along the St. Mary's River accounted for much of the emergent wetland acreage in the region.

Table 3: Regional acreage totals of each wetland category for 1800s and 1980.

REGIONAL WETLAND ACREAGE BY CATEGORY					
REGION	**Lowland Hardwoods**	**Lowland Conifers**	**Shrub Swamp**	**Emergent Wetlands**	**Total**
Region 1 1980	**543,939**	**1,339,227**	**521,392**	**254,144**	**2,658,702**
1850	32,682	2,741,647	327,999	66,622	3,168,988
Region 2 1980	**1,108,780**	**499,725**	**314,133**	**93,726**	**2,016,364**
1840	535,123	2,090,197	40,095	145,347	2,810,762
Region 3 1980	**963,295**	**37,827**	**327,103**	**135,248**	**1,463,472**
1820	1,132,390	721,133	63,047	633,416	2,549,986
Statewide 1980	**2,616,014**	**1,876,779**	**1,162,627**	**483,118**	**6,138,538**
1800	1,700,195	5,552,977	431,141	845,385	8,529,737

Estimates of wetland loss for Region 1 are confounded by apparent weaknesses in historical and modern data sets. Wetland losses since 1800 are probably somewhat overestimated in Mackinac and Menominee counties, and underestimated in Gogebic, Houghton, Iron, and Luce counties. Comparison of available data indicates a net wetland loss of 16% for the region. That represents the drainage of about 500,000 wetland acres. Net wetland loss appears to have been most significant in Chippewa (45%), Mackinac (37%), Menominee (26%), and Delta (24%) counties. As with elsewhere in the state where conifer swamps were abundant, many conifer swamps in the Upper Peninsula were either drained or converted to other wetland types. Region-wide, approximately 51% of conifer swamp acreage, totaling roughly 1.4 million acres, was either completely drained, flooded, or converted to other wetland types through intensive logging activity. Mostly as a result, other wetland categories indicate significant regional increases

over historical estimates. Lowland hardwoods, including significant acreage of aspens, paper birch, and balsam poplar, increased to 16.6 times their historical estimate. That represents a net increase of about 511,000 acres in mixed lowland hardwoods. Shrub-dominated wetlands appear to have increased in acreage by 59%, or roughly 193,000 acres. Emergent wetlands apparently increased by 281%, or roughly 187,000 acres.

Region 2

In 1800, uplands of the northern Lower Michigan were mostly forested, with small inclusions of open savanna and grassland, and represented about 64% of the land surface. About two thirds of these forests were dominated by northern hardwoods of American beech, sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), basswood (*Tilia americana*), red oak (*Quercus rubra*), red maple, and black cherry (*Prunus serotina*). They also included a significant component of conifers such as eastern hemlock, white pine, and balsam fir. These conifer species were most abundant in upland forests close to Lake Huron and in the Saginaw Bay area. Windthrow was probably the prevalent dynamic in most of these forests. Wildfire played a significant role in the dynamics of roughly 2.4 million acres of pine-dominated forest, savanna, and grasslands, which were concentrated on droughty sands on outwash plains throughout interior portions of the region. Today, upland forests account for about 5.1 million acres, or roughly 40% of the region's surface. Currently productive and abandoned agricultural lands account for nearly 4.6 million acres, or nearly 37% of the region. Urban development accounts for about 506,000 acres, or 4% of the region.

Historically, wetlands accounted for about 2.8 million acres, or 22% of northern Lower Michigan (Table 3). The majority of the region's wetlands were concentrated in northeastern counties such as Alpena, Presque Isle, and Alcona, or in the Saginaw Bay area, in Huron, Sanilac, and Tuscola counties. Forested wetlands accounted for over 2.6 million acres, or 20% of the region's surface. Northern-white cedar swamp dominated nearly 900,000 acres in the region. Mixed conifer swamp accounted for about 760,000 acres, while tamarack swamp was found on about 318,000 acres. Black spruce and mixed conifer-hardwood swamp accounted for about 80,000 acres. Mixed hardwood swamp and black ash swamp totaled over 480,000 acres in the region. Aspen and birch swamp was most abundant in this region, totaling almost 26,000 acres. Shrub swamp, including extensive bog and alder-willow swamp, was most concentrated in Roscommon, Missaukee, and Cheboygan counties, and accounted for about 40,000 acres region-wide. Emergent wetlands made up just over one percent of the region, totaling about 145,000 acres. Inland emergent marsh found throughout the region, and Great Lakes marsh and lake plain prairie along Saginaw Bay, accounted for much of the emergent wetland acreage in the region.

Estimates of wetland loss for Region 2 are somewhat more solid than Region 1, even though significant weaknesses remain in historical and modern data sets. Wetland losses since 1800 are probably somewhat underestimated in eight counties, including Midland, Benzie, Charlevoix, Manistee, Oscoda, Lake, Osceola, and Leelanau. Comparison of available data indicates a net wetland loss of 28% for the region. That represents the drainage of about 787,000 wetland acres, most concentrated in the Saginaw Bay and Thumb areas. Net wetland loss appears to have been most significant Huron (78%), Sanilac (77%), Saginaw (50%), Bay (49%), and Tuscola (49%) counties. As with elsewhere in the state where conifer swamps were abundant, many conifer swamps in northern Lower Michigan were either drained or converted to other wetland types. Region-wide, approximately 76% of conifer swamp acreage, totaling roughly 1.6 million acres, was either completely drained, flooded, or converted to other wetland types through intensive logging activity. Mostly as a result, both lowland hardwoods and shrub swamp categories indicate significant regional increases over historical estimates. Lowland hardwoods, including significant acreage of aspens, paper birch, and balsam poplar, doubled in comparison to their historical

acreage estimate. That represents a net increase of about 572,000 acres in mixed lowland hardwoods. Shrub-dominated wetlands appear to have increased in acreage by roughly 270,000 acres. Emergent wetlands, most notably lake plain prairie, have decreased acreage by 36%, or roughly 52,000 acres.

Region 3

In 1800, uplands of the southern Lower Michigan were mostly forested, but also included extensive savanna and grassland concentrated in the glacial interlobate centered in Calhoun County, and on extensive outwash deposits extending north into Newaygo County. Closed-canopy forest represented about 65% of the land surface. About two-thirds of these forests were dominated by American beech, sugar maple, and basswood, or oaks and hickories such as black oak (*Quercus velutina*), white oak (*Quercus alba*), red oak, pignut hickory (*Carya glabra*), and shagbark hickory (*Carya ovata*). Near Lake Michigan, these forests also included a significant component of conifers such as eastern hemlock and white pine. Savannas in southernmost counties were dominated by white oak, bur oak (*Quercus macrocarpa*), and black oak. Further north and west, white pine was commonly co-occurring with oaks in the savannas. Wildfire played a significant role in the dynamics of roughly 3.1 million acres of oak-hickory and oak-pine forests, savannas, and grasslands in the region. Today, upland forests account for about 2 million acres, or roughly 15% of the region's surface. Currently productive and abandoned agricultural lands account for nearly 8.3 million acres, or nearly 61% of the region. Urban development accounts for about 1.6 million acres, or 12% of the region.

Historically, wetlands accounted for about 2.5 million acres, or 18% of southern Lower Michigan (Table 3). The region's wetlands were somewhat evenly distributed, though concentrations were found on the glacial lake plain of Monroe, Wayne, Macomb, and St. Clair counties. Forested wetlands accounted for over 1.8 million acres, or 13% of the region's surface. Mixed hardwood swamp and black ash swamp combined totaled over 1.1 million acres in the region. Tamarack swamp, mixed conifer swamp, and conifer-hardwood swamps, when combined, accounted for nearly 700,000 acres. Shrub swamp, mostly characterized as alder, buttonbush, and willow swamp, accounted for about 63,000 acres region-wide. Emergent wetlands made up over 4.5% of the region, totaling about 633,000 acres. Inland emergent marsh (236,000 acres) and wet prairie (222,000 acres) were found throughout the region, while lake plain prairie (131,000 acres) was most concentrated along Saginaw Bay and the southeastern lake plain. These three types accounted for most of the emergent wetland acreage in the region.

Wetland losses since 1800 in Region 3 are probably somewhat underestimated in 10 counties, including Barry, Mecosta, Hillsdale, Calhoun, Cass, Branch, Gratiot, Berrien, Jackson, and Ionia. Wetland losses are probably slightly overestimated in Newaygo County. Comparison of available data indicates a net wetland loss of 43% for the region. That represents the drainage of nearly 1.1 million wetland acres, most concentrated in southeastern counties. Net wetland loss appears to have been most significant in Monroe (87%), Wayne (84%), Macomb (74%), St. Clair (73%), and Lenawee (69%) counties. Although conifer swamps where not abundant in the region historically, about 95% of conifer swamps, or about 680,000 acres in southern Lower Michigan were either drained or converted to other wetland types. Lowland hardwoods decreased in acreage by 15%, or nearly 170,000 acres, in comparison to their historical acreage estimate. Shrub-dominated wetlands are the only wetland category that appears to have increased for this region, apparently increasing by roughly 250,000 acres. Emergent wetlands, especially among wet prairies of inland areas and the lake plain, have decreased acreage by 79%, or roughly 500,000 acres.

Conclusions

Significant wetland losses and conversions have taken place throughout the state of Michigan since 1800. Over time, the logging era, agricultural development, mining, road construction, and urban development have all had considerable effect on the quantity, structure, and function of the state's wetland resources. While this study indicates that statewide wetland losses have been somewhat less than previous estimates had suggested, dramatic changes in wetland composition, as illustrated by the extensive drainage and conversion of cedar and tamarack swamps, or the drainage of wet prairies, were greater than any previous study had indicated.

Weaknesses in existing data sets prevent more definitive assessments of Michigan's wetland resources. Spatial data on the current wetland extent, such as those of the National Wetlands Inventory (NWI), need to be digitized so that analyses can be conducted in combination with the digital presettlement map to further evaluate the types of wetland conversions that have taken place. This study was limited to comparing county-wide statistics for wetland categories, then inferring from this information the types of wetland conversions that actually took place. Digital NWI maps would allow for direct electronic overlays that would yield far more precise assessments of typical conversion scenarios, and could lead to many insights into wetland functions and dynamics. NWI maps also include several more wetland types, so a greater diversity of native wetland types could be better assessed than is currently possible. As digital soils maps are made available, they may provide the needed information for minor adjustments in historical data to clarify historical wetland acreage where historical maps are least reliable.

Acknowledgements

I would like to express my thanks to the U.S. Environmental Protection Agency and the Land and Water Management Division, Michigan Department of Environmental Quality, for provided funding for this project. I also thank the Michigan Resource Information System for providing access to their current land use/land cover data. Thanks also go to Michigan Natural Features Inventory staff members Charamy Butterworth and Jodi Raab for patiently developing and populating the presettlement acreage tables that were used for this project. Also, Lyn Scrimger provided the graphic on wetland loss by county. Mike Penskar and Denny Albert provided many useful comments on earlier drafts of this report.

Literature Cited

Botti, W. 1991. Condition of the Northern White Cedar Resource. In: Workshop Proceedings: Northern White Cedar in Michigan. Michigan State University Agricultural Experiment Station. Research Report 512. pp. 50-53.

Bourdo, E. A., Jr. 1956. A Review of the General Land Office Survey and of its Use in Quantitiative Studies of Former Forests. Ecology 37(4) pp.754-768.

Caldwell, N.C. (Ed.) 1990. Special Instructions to Deputy Surveyors in Michigan. 1808-1854. Michigan Museum of Surveying, Lansing, MI.

Comer, P.J., D.A. Albert, H.A. Wells, B.L. Hart, J.B. Raab, D.L. Price, D.M. Kashian, R.A. Corner & D.W. Schuen. 1995(a). Michigan's Presettlement Vegetation, as Interpreted from the General Land Office Surveys 1816-1856. Michigan Natural Features Inventory, Lansing, MI. digital map.

Comer, P.J., D.A. Albert, H.A. Wells, B.L. Hart, J.B. Raab, D.L. Price, D.M. Kashian, R.A. Corner & D.W. Schuen. 1995(b). Michigan's Native Landscape, as Interpreted from the General Land Office Surveys 1816-1856. Report to the U.S. Environmental Protection Agency, Water Division and the Wildlife Division, Michigan Department of Natural Resources. Michigan Natural Features Inventory, Lansing, MI. 78 pp.

Comer, P.J., W.A. MacKinnon, M.R. Penskar, M.L. Rabe, D.L. Cuthrell, and D.A. Albert. 1995(c). A Survey of Lakeplain Prairie in Michigan. Report to MDNR Coastal Management Program, Michigan Department of Natural Resources. Michigan Natural Features Inventory, Lansing, MI. 234 pp.

Dahl, T.E. 1990. Wetlands Losses in the United States 1780's to 1980's. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C. 21 pp.

Delcourt, P.A., & H.R. Delcourt. 1981. Vegetation Maps of Eastern North America: 40,000 yrs. B.P. to the present. In: R. Romans (Ed.), Proc. 1980 Geobotany Conference, Plenum, New York, pp.123-166.

_____. 1977. Presettlement Magnolia-Beech Climax of the Gulf Coastal Plain: Quantitative Evidence From The Apalachicola River Bluffs, North -Central Florida. Ecology. 58 pp.1085-1093.

_____. 1974. Primeval Magnolia-Holly-Beech Climax in Louisiana. Ecology. 55 (3) pp. 638-644.

Farrand, W.R. & D.L. Bell. 1982. Quaternary Geology of Michigan. Univ. Mich. Dept. Geol. Sciences, Ann Arbor, MI. 2 maps.

Grimm, E.C. 1984. Fire and other factors controlling the Big Woods vegetation of Minnesota in the mid-nineteenth century. Ecological Monographs. 54(3): 291-311.

Leatherberry, E.C. & J.S. Spencer. 1996. Michigan Forest Statistics, 1993. North Central Forest Experiment Station. Forest Service - U.S. Department of Agriculture. St. Paul, MN 55108. 144 pp.

USDA Soil Conservation Service. various dates. Soil Survey of (all available Michigan counties).

Veatch, J.O. 1953. Soils and Lands of Michigan. Michigan State College Press. 241 pp. + 1:750,000 scale map.

White, C. A. 1984. A History of the Rectangular Survey System. Bureau of Land Management, U.S. Department of Interior, Washington D.C.

Appendix I

Historical and Modern Wetland Acreage Tables

Appendix I: Presettlement Wetland Acreages for each Michigan County, MDNR Region, and state total.

Historical Acreage circa 1800										
Category	Lowland Hardwoods		Lowland Conifers		Shrub Swamp		Emergent Wetland		COUNTY ACREAGE	% OF COUNTY
Code	41		42		612		622			
	acreage	%	acreage	%	acreage	%	acreage	%		
Region 1										
County										
ALGER	216	0.04%	125,257	20.90%	3,798	0.63%	4,736	0.79%	134,006	22%
BARAGA	2,264	0.39%	95,307	16.24%	11,905	2.03%	1,757	0.30%	111,233	19%
CHIPPEWA	4,427	0.41%	404,064	37.72%	4,384	0.41%	14,138	1.32%	427,013	40%
DELTA	825	0.11%	289,639	38.48%	21,142	2.81%	8,692	1.15%	320,297	43%
DICKINSON	576	0.12%	133,224	26.81%	3,387	0.68%	1,287	0.26%	138,474	28%
GOGEBIC	4,587	0.63%	113,207	15.46%	15,256	2.08%	1,889	0.26%	134,939	18%
HOUGHTON	2,226	0.33%	77,111	11.56%	4,360	0.65%	3,091	0.46%	86,787	13%
IRON	377	0.05%	138,626	17.89%	6,342	0.82%	2,080	0.27%	147,426	19%
KEWEENAW	134	0.04%	70,883	19.69%	3,254	0.90%	479	0.13%	74,750	21%
LUCE	950	0.16%	182,723	30.81%	54,995	9.27%	6,957	1.17%	245,626	41%
MACKINAC	1,184	0.17%	294,076	43.29%	2,674	0.39%	6,370	0.94%	304,341	45%
MARQUETTE	1,762	0.15%	254,250	21.30%	24,434	2.05%	3,726	0.31%	284,171	24%
MENOMINEE	5,960	0.89%	292,790	43.53%	9,781	1.45%	3,789	0.56%	312,320	46%
ONTONAGON	3,828	0.45%	31,835	3.74%	6,409	0.75%	1,758	0.21%	43,830	5%
SCHOOLCRAFT	3,366	0.43%	238,656	30.58%	155,880	19.97%	5,875	0.75%	403,776	52%
REGION 1TOTAL	32,682	0.30%	2,741,647	25.36%	327,999	8.12%	66,622	0.62%	3,168,988	29%
Region 2										
COUNTY										
ALCONA	11,463	2.58%	105,297	23.73%	722	0.16%	892	0.20%	118,373	27%
ALPENA	8,203	2.17%	189,003	49.93%	675	0.18%	1,204	0.32%	199,085	53%

Historical Acreage circa 1800										
Category	**Lowland Hardwoods**		**Lowland Conifers**		**Shrub Swamp**		**Emergent Wetland**		**COUNTY ACREAGE**	**% OF COUNTY**
Code	**41**		**42**		**612**		**622**			
	acreage	**%**	**acreage**	**%**	**acreage**	**%**	**acreage**	**%**		
ANTRIM	2,690	0.77%	26,567	7.63%	177	0.05%	589	0.17%	30,022	9%
ARENAC	50,465	21.43%	63,507	26.97%	359	0.15%	4,496	1.91%	118,827	50%
BAY	37,326	12.99%	12,992	4.52%	378	0.13%	27,531	9.58%	78,228	27%
BENZIE	537	0.24%	21,993	9.90%	162	0.07%	303	0.14%	22,995	10%
CHARLEVOIX	1,898	0.66%	44,718	15.47%	241	0.08%	859	0.30%	47,716	17%
CHEBOYGAN	2,079	0.41%	110,817	21.78%	3,748	0.74%	2,855	0.56%	119,499	23%
CLARE	7,064	1.92%	54,561	14.82%	1,764	0.48%	3,934	1.07%	67,322	18%
CRAWFORD	344	0.10%	32,527	9.02%	954	0.26%	1,937	0.54%	35,762	10%
EMMET	57	0.02%	71,929	23.35%	10	0.00%	361	0.12%	72,357	23%
GLADWIN	14,104	4.27%	96,040	29.09%	376	0.11%	3,966	1.20%	114,485	35%
GRAND TRAVERSE	1,692	0.54%	29,100	9.28%	164	0.05%	761	0.24%	31,718	10%
HURON	76,096	14.20%	132,218	24.68%	500	0.09%	9,566	1.79%	218,379	41%
IOSCO	17,073	4.72%	79,176	21.88%	198	0.05%	3,582	0.99%	100,028	28%
ISABELLA	15,377	4.16%	33,128	8.96%	226	0.06%	1,001	0.27%	49,732	13%
KALKASKA	1,224	0.34%	45,629	12.50%	855	0.23%	1,264	0.35%	48,972	13%
LAKE	2,742	0.75%	33,212	9.03%	656	0.18%	1,440	0.39%	38,050	10%
LEELANAU	617	0.26%	16,442	6.85%	25	0.01%	576	0.24%	17,659	7%
MANISTEE	11,611	3.26%	33,664	9.44%	112	0.03%	2,596	0.73%	47,983	13%
MASON	8,217	2.52%	37,371	11.44%	787	0.24%	2,647	0.81%	49,022	15%
MIDLAND	41,473	12.27%	36,128	10.69%	290	0.09%	646	0.19%	78,536	23%
MISSAUKEE	3,167	0.86%	75,299	20.50%	4,031	1.10%	3,303	0.90%	85,799	23%
MONTMORENCY	1,241	0.34%	73,106	20.31%	851	0.24%	1,637	0.45%	76,835	21%
OGEMAW	4,192	1.14%	62,106	16.88%	888	0.24%	1,018	0.28%	68,205	19%
OSCEOLA	4,857	1.32%	36,688	10.01%	2,672	0.73%	4,958	1.35%	49,175	13%

Historical Acreage circa 1800										
Category	**Lowland Hardwoods**		**Lowland Conifers**		**Shrub Swamp**		**Emergent Wetland**		**COUNTY ACREAGE**	**% OF COUNTY**
Code	**41**		**42**		**612**		**622**			
	acreage	**%**	**acreage**	**%**	**acreage**	**%**	**acreage**	**%**		
OSCODA	2,424	0.66%	25,881	7.08%	483	0.13%	1,134	0.31%	29,922	8%
OTSEGO	479	0.14%	30,791	9.14%	629	0.19%	1,198	0.36%	33,097	10%
PRESQUE ISLE	4,962	1.13%	152,984	34.99%	1,177	0.27%	2,997	0.69%	162,120	37%
ROSCOMMON	1,832	0.49%	88,957	23.97%	10,942	2.95%	3,543	0.95%	105,274	28%
SAGINAW	81,635	15.63%	9,176	1.76%	431	0.08%	28,578	5.47%	119,820	23%
SANILAC	70,231	11.38%	124,283	20.14%	3,087	0.50%	1,475	0.24%	199,076	32%
TUSCOLA	45,249	8.69%	81,517	15.65%	725	0.14%	21,674	4.16%	149,164	29%
WEXFORD	2,503	0.68%	23,393	6.35%	800	0.22%	829	0.23%	27,525	7%
REGION 2 TOTAL	535,123	4.23%	2,090,197	16.52%	40,095	0.32%	145,347	1.15%	2,810,762	22%
Region 3										
COUNTY										
ALLEGAN	42,869	7.95%	32,918	6.10%	2,202	0.41%	3,797	0.70%	81,785	15%
BARRY	7,608	2.06%	21,394	5.79%	539	0.15%	9,598	2.60%	39,140	11%
BERRIEN	19,553	5.27%	5,051	1.36%	1,169	0.31%	13,293	3.58%	39,066	11%
BRANCH	24,651	7.41%	6,723	2.02%	1,074	0.32%	24,668	7.42%	57,115	17%
CALHOUN	20,446	4.45%	32,039	6.97%	660	0.14%	32,553	7.08%	85,697	19%
CASS	13,320	4.09%	9,925	3.05%	793	0.24%	22,203	6.82%	46,241	14%
CLINTON	24,875	6.77%	17,187	4.67%	3,886	1.06%	11,171	3.04%	57,119	16%
EATON	18,972	5.12%	35,164	9.49%	3,740	1.01%	1,987	0.54%	59,862	16%
GENESEE	26,379	6.35%	9,299	2.24%	399	0.10%	6,662	1.60%	42,739	10%
GRATIOT	54,138	14.80%	16,092	4.40%	132	0.04%	2,258	0.62%	72,619	20%
HILLSDALE	23,758	6.12%	10,460	2.69%	1,181	0.30%	15,584	4.01%	50,984	13%
INGHAM	16,781	4.68%	35,347	9.85%	3,947	1.10%	22,125	6.17%	78,200	22%
IONIA	21,144	5.70%	16,279	4.39%	4,361	1.18%	4,109	1.11%	45,893	12%

Historical Acreage circa 1800										
Category	**Lowland Hardwoods**		**Lowland Conifers**		**Shrub Swamp**		**Emergent Wetland**		**COUNTY ACREAGE**	**% OF COUNTY**
Code	**41**		**42**		**612**		**622**			
	acreage	**%**	**acreage**	**%**	**acreage**	**%**	**acreage**	**%**		
JACKSON	10,978	2.37%	20,985	4.53%	642	0.14%	67,918	14.67%	100,523	22%
KALAMAZOO	25,332	6.82%	15,386	4.14%	273	0.07%	16,656	4.49%	57,647	16%
KENT	37,697	6.76%	15,834	2.84%	3,609	0.65%	8,534	1.53%	65,674	12%
LAPEER	40,239	8.75%	38,319	8.34%	2,080	0.45%	2,506	0.55%	83,144	18%
LENAWEE	95,409	19.58%	9,731	2.00%	1,590	0.33%	17,696	3.63%	124,426	26%
LIVINGSTON	14,906	3.98%	25,125	6.71%	314	0.08%	39,787	10.62%	80,132	21%
MACOMB	58,516	18.94%	5,348	1.73%	240	0.08%	12,304	3.98%	76,407	25%
MECOSTA	5,725	1.57%	38,583	10.56%	1,074	0.29%	1,321	0.36%	46,702	13%
MONROE	67,155	18.59%		0.00%	70	0.02%	68,384	18.93%	135,609	38%
MONTCALM	30,202	6.51%	40,455	8.72%	1,097	0.24%	4,377	0.94%	76,131	16%
MUSKEGON	21,977	6.52%	23,384	6.93%	582	0.17%	11,594	3.44%	57,536	17%
NEWAYGO	17,624	3.20%	54,406	9.87%	2,261	0.41%	8,794	1.59%	83,085	15%
OAKLAND	43,185	7.44%	38,546	6.64%	3,001	0.52%	29,205	5.03%	113,937	20%
OCEANA	10,935	3.13%	33,411	9.57%	878	0.25%	1,204	0.34%	46,429	13%
OTTAWA	24,928	6.76%	17,163	4.65%	11,022	2.99%	5,784	1.57%	58,896	16%
SHIAWASSEE	37,032	10.70%	19,826	5.73%	99	0.03%	16,446	4.75%	73,403	21%
ST CLAIR	78,439	15.53%	29,467	5.83%	3,743	0.74%	28,535	5.65%	140,184	28%
ST JOSEPH	10,752	3.22%	6,105	1.83%	338	0.10%	31,773	9.53%	48,969	15%
VAN BUREN	45,649	11.44%	26,908	6.75%	683	0.17%	2,253	0.56%	75,493	19%
WASHTENAW	41,265	8.93%	13,031	2.82%	1,861	0.40%	41,655	9.01%	97,812	21%
WAYNE	99,953	23.41%	1,243	0.29%	3,511	0.82%	46,680	10.93%	151,387	35%
REGION 3 TOTAL	1,132,390	8.14%	721,133	5.18%	63,047	0.45%	633,416	4.55%	2,549,986	18%
State Total	**1,700,195**	**4.55%**	**5,552,977**	**14.86%**	**431,141**	**1.15%**	**845,385**	**2.26%**	**8,529,737**	**23%**

Appendix I: Approximate 1980 Wetland Acreage for each Michigan County.

MODERN WETLAND ACREAGE BY CATEGORY FOR EACH REGION					
COUNTY	**Lowland Hardwoods**	**Lowland Conifers**	**Shrub Swamp**	**Emergent Wetland**	**Total**
ALGER	14,694	69,584	18,687	2,946	105,911
BARAGA*	25,471	50,522	26,368	4,549	106,910
CHIPPEWA	38,509	109,715	41,756	45,074	235,054
DELTA	56,414	133,594	40,128	13,221	243,357
DICKINSON	20,659	80,192	22,146	4,010	127,007
GOGEBIC	74,064	88,139	26,011	4,187	192,401
HOUGHTON	54,001	27,372	12,657	7,622	101,652
IRON	4,330	80,632	53,923	7,933	146,818
KEWEENAW	7,820	40,920	19,474	4,418	72,632
LUCE	50,389	131,029	59,909	28,231	269,558
MACKINAC	49,337	106,975	29,162	4,967	190,441
MARQUETTE	35,154	147,454	60,874	22,485	265,967
MENOMINEE	55,942	139,292	30,848	5,729	231,811
ONTONAGON*	17,270	10,863	8,799	1,640	38,573
SCHOOLCRAFT	39,885	122,945	70,649	97,132	330,611
Region 1 Total	543,939	1,339,227	521,392	254,144	2,658,702
*total acreage adjusted with soils data					
REGION 2					
COUNTY	**Lowland Hardwoods**	**Lowland Conifers**	**Shrub Swamp**	**Emergent Wetland**	**Total**
ALCONA	32,734	38,770	14,104	2,273	87,881
ALPENA	73,150	63,165	22,324	4,888	163,527
ANTRIM	11,600	10,811	3,439	1,000	26,850
ARENAC	63,811	612	5,388	3,989	73,800
BAY	34,453	-	2,211	3,390	40,054
BENZIE	17,721	5,810	5,937	2,146	31,614
CHARLEVOIX	26,425	19,980	7,098	1,232	54,735
CHEBOYGAN	53,925	40,958	15,899	3,814	114,596
CLARE	35,685	10,860	15,617	2,242	64,404
CRAWFORD	8,542	16,141	7,200	1,281	33,164
EMMET	23,104	16,168	6,150	1,485	46,907
GLADWIN	64,220	2,518	17,874	3,492	88,104
GRAND TRAVERSE	15,183	7,423	3,871	1,932	28,409
HURON	40,614	155	3,303	4,165	48,237
IOSCO	36,940	18,150	13,840	4,615	73,545
ISABELLA	17,239	4,758	5,249	2,433	29,679
KALKASKA	18,053	10,224	5,096	1,837	35,210

MODERN WETLAND ACREAGE BY CATEGORY FOR EACH REGION					
COUNTY	**Lowland Hardwoods**	**Lowland Conifers**	**Shrub Swamp**	**Emergent Wetland**	**Total**
LAKE	24,872	6,720	9,525	1,723	42,840
LEELANAU	7,558	8,748	1,671	556	18,533
MANISTEE	40,519	2,555	6,982	4,884	54,940
MASON	29,500	3,772	8,925	4,629	46,826
MIDLAND*	104,562	10	7,274	3,159	115,005
MISSAUKEE	18,471	17,725	20,741	3,494	60,431
MONTMORENCY	15,498	40,982	8,527	2,789	67,796
OGEMAW	16,601	5,971	13,760	1,238	37,570
OSCEOLA	23,773	12,817	13,540	5,389	55,520
OSCODA	10,119	15,292	6,690	2,000	34,101
OTSEGO	6,163	20,832	4,463	1,855	33,313
PRESQUE ISLE	42,965	52,446	10,300	1,711	107,422
ROSCOMMON	22,213	36,691	29,819	8,544	97,267
SAGINAW	56,400	15	2,686	1,366	60,467
SANILAC	36,800	1,190	7,081	174	45,245
TUSCOLA	68,673	558	3,455	2,723	75,409
WEXFORD	10,694	6,897	4,096	1,278	22,965
Region 2 Total	1,108,780	499,725	314,133	93,726	2,016,364
* total wetland acreage adjusted with soils data					
REGION 3					
COUNTY	**Lowlands Hardwoods**	**Lowland Conifers**	**Shrub Swamp**	**Emergent Wetland**	**Total**
ALLEGAN	54,699	499	10,598	2,948	68,744
BARRY*	30,147	589	13,826	8,484	53,046
BERRIEN	18,293	-	4,605	4,045	26,943
BRANCH	44,249	-	2,100	2,198	48,547
CALHOUN	50,386	749	23,085	3,897	78,117
CASS	19,203	137	9,621	9,800	38,761
CLINTON	20,110	113	6,786	3,189	30,198
EATON	27,372	323	3,560	1,637	32,892
GENESEE	11,697	52	3,584	3,537	18,870
GRATIOT	42,763	653	1,038	400	44,854
HILLSDALE	45,215	42	7,381	5,988	58,626
INGHAM	30,259	454	6,349	5,822	42,884
IONIA	26,138	39	10,699	310	37,186
JACKSON	38,652	1,054	45,264	3,545	88,515
KALAMAZOO	9,588	409	15,849	2,647	28,493
KENT	43,285	1,387	8,695	3,081	56,448
LAPEER	29,997	1,229	11,741	6,569	49,536
LENAWEE	30,257	44	4,372	4,095	38,768

MODERN WETLAND ACREAGE BY CATEGORY FOR EACH REGION					
COUNTY	**Lowland Hardwoods**	**Lowland Conifers**	**Shrub Swamp**	**Emergent Wetland**	**Total**
LIVINGSTON	31,720	569	19,324	6,119	57,732
MACOMB	17,022	116	2,186	857	20,181
MECOSTA	38,274	10,630	8,457	4,443	61,804
MONROE	13,713	26	1,445	1,829	17,012
MONTCALM	36,930	7,971	20,493	5,127	70,521
MUSKEGON	16,241	2,327	3,829	2,936	25,333
NEWAYGO	31,480	3,321	12,144	1,531	48,476
OAKLAND	25,430	1,689	17,788	16,122	61,029
OCEANA	31,608	2,433	6,494	1,583	42,118
OTTAWA	14,560	9	3,748	2,008	20,325
SHIAWASEE	24,215	248	711	4,241	29,415
ST CLAIR	30,590	-	2,683	4,959	38,232
ST JOSEPH	7,914	413	15,190	2,778	26,295
VAN BUREN	26,649	72	7,034	3,549	37,304
WASHTENAW	22,923	227	14,756	4,265	42,171
WAYNE	21,715	3	1,670	709	24,097
Region 3 Total	963,295	37,827	327,103	135,248	1,463,472
State Total	2,616,014	1,876,779	1,162,627	483,118	6,138,538
* total wetland acreage adjusted with soils data					

Appendix II

County Profiles

Appendix II - County Profiles

This section provides a brief discussion of each Michigan county including an overview of the surface geology, soils, and native vegetation, then discusses significant trends in wetland acreages that have occurred since the 1800s. The surface geology for each county was summarized from Farrand & Bell (1982). Soils descriptions and association names were derived from all available county soil surveys (Soil Conservation Service, various dates) or the soils association map of Veatch (1953). Current forest acreage statistics referred to in the text were dreived from Leatherberry & Spencer (1996).

Region 1- County Profiles

Alger

The surface geology of Alger County includes a wide diversity of landforms, including sand lake plain, outwash plain, exposed bedrock ridges and cliffs, and moraines comprised of medium to coarse-textured material. Sand lake plain forms the surface features along the shoreline from Miners River east beyond Grand Marais. With post-glacial uplift, the sandstone bedrock of Pictured Rocks was exposed and the Grand Sable Dunes formed. Outwash deposits form much of flat landscapes at the east end and central portions of the county. Rolling to steeply sloping end moraines are concentrated at the eastern, inland extreme of the county, northeast of Munising, and southwest of Chatham. Recent geomorphological studies indicate that many of these moraines may actually be outwash deposits (Blewett & Rieck 1987). Soils of these landforms vary in texture, from sandy to loamy soils.

In the 1840s, upland forests of Alger County included northern hardwoods, often in combination with white pine and eastern hemlock throughout the moraine ridges and plains. Hemlock was often dominant or in combination with white pine and/or yellow birch on many portions of the less well drained outwash. White spruce, balsam fir, and cedar were found in small upland areas close to the Lake Superior shoreline. White pine, red pine, and jack pine, in varying combinations, dominated fire-prone outwash plains in the county. They were also common on the low dune ridges close to the Lake Superior shoreline. Small amounts of open jack pine barrens were located in the most frequently burned areas. Forested wetlands, mostly dominated by mixed conifers of northern-white cedar, tamarack, balsam fir, eastern hemlock, white pine, and black spruce characterized roughly 22% of Alger County. Most extensive swamps and open shrub- and black spruce-dominated muskeg were found on poorly drained outwash sands bordering Schoolcraft and Delta counties. On the moraines, swamps tended to be located in smaller pockets. Shrub swamp and wet meadow were mostly located along streams and in small depressions.

Comparison of historical map data with MIRIS data indicates a 21% loss in wetland acreage for Alger County. This represents a net loss of approximately 29,000 wetland acres. Most of the wetland loss resulted from the clearing and drainage of conifer swamp. Similar to statewide trends, statistics from conifer swamp and emergent wetlands indicate significant declines (44% and 38%, respectively) while lowland hardwoods and shrub swamps acreages increased. This latter trend resulting from the conversion of some conifer swamps to hardwood swamps after extensive logging.

Baraga

Glacial landforms in Baraga County include outwash plains, end and ground moraine, and extensive areas of thin glacial till over bedrock. Outwash deposits are concentrated on the Baraga Plains along the western border of the county. Soils of the plains vary from excessively drained Grayling and Rubicon sands to poorly drained soils of the Kinross-Au Gres-Croswell association. End and ground moraines extend over the southern townships of the county, as well as in townships along the Lake Superior shoreline. Poorly drained soils at the southern end of the county are mostly classified as the Carbondale-Greenwood-Witbeck association. Soils of the Skanee-Munising-Gay association vary considerable in drainage, and characterize many of the moraine ridges at the north end of the county. Poorly drained, silty soils of the Arnheim-Sturgeon-Moquah association are characteristic throughout the Sturgeon River gorge. The extensive granitic-bedrock outcrops, concentrated along the east-central portion of the county, are mapped as Champion-Michigamme-Rock outcrop association.

In the 1840s, upland forests of moraines in Baraga County were dominated by varying combinations of hemlock, sugar maple, yellow birch, and basswood. Jack pine barrens and mixed pine forests

characterized the outwash deposits of the Baraga Plains. About 19% of the county surface, totaling 111,000 acres, was wetland, mostly in mixed conifer swamp and shrub swamp. Mixed conifer swamp was prevalent in narrow channels between exposed bedrock ridges throughout the Craig Lake area. On the more gently rolling end and ground moraine to the southwest, the wetlands were generally larger, but still formed a complex upland/wetland landscape. A series of shallow emergent marshes and jack pine swamps were found in portions of the Baraga Plains. Cedar swamp and mixed hardwood swamp was found along much of the Sturgeon River, except near the north end of the county, where extensive muskeg was characteristic on peat deposits just east of the river. The ground moraines of the Abbaye Peninsula supported few wetlands, but Great Lakes marsh and muskeg were located along the Lake Superior shoreline in several sites.

MIRIS estimates of wetland extent in Baraga County were adjusted using soil survey data. Comparison of historical map data with these estimates indicated a net wetland loss of 4% for the county. There has apparently been a 48% reduction in lowland conifer acreage, with the most substantial shift in the direction of lowland hardwoods, which increased by roughly 23,000 acres.

Chippewa

A diverse set of glacial landforms, including clay lake plain, sand lake plain, outwash deposits, coarse-textured end moraine, and thin soils over bedrock characterize Chippewa County. Clay lake plain is most common from Sault St. Marie south into Mackinac County. Soils of the clay lake plain are very deep, level, and poorly drained. Most are classified as the Pickford-Rudyard-Ontonagon association. Sand lake plain is concentrated along the Lake Superior shoreline, east of Kinross, and in the southwest townships of the county. Soils of the sand lake plain vary in drainage characteristics, with most poorly drained soils classified as the Markey-Kinross-Croswell association. The sandy soils of Whitefish Point range from excessively drained to very poorly drained. Extensive peat and muck deposits are found on the lake plain along the drainages of the Tahquamenon River, and surrounding Munuscong Lake. The coarse-textured moraine and outwash deposits are mostly well drained to excessively drained. Shallow soils over dolomite bedrock characterize much of Drummond Island and adjacent mainland portions of the county. These areas are poorly drained in places, especially following spring snowmelt.

In the 1840s, upland forests of Chippewa County included northern hardwoods with various combinations of beech, sugar maple, hemlock, and yellow birch. These forests were predominant on end moraine. White spruce-balsam fir-cedar forest was also common, mostly associated with thin soils on and adjacent to Drummond Island. Mixed pine forest and open pine barrens occurred on excessively drained outwash deposits, especially around Raco Plains and at Whitefish Point. Based on historical map data, approximately 40% of the county, or roughly 427,000 acres, was wetland. Nearly 95% of the wetland acreage of Chippewa County was categorized as lowland conifer. The largest expanses of wetlands occurred on the poorly drained clay lake plain south of Sault Ste. Marie. Swamps in this area were predominantly a mixed conifer or mixed conifer-hardwood, with many pockets dominated by black spruce and/or tamarack. Tamarack swamp, jack pine swamp, and emergent marsh were part of a complex upland/wetland mosaic near Trout Lake. The extensive peat deposits along the Luce County border mostly supported mixed conifer swamp, although extensive, open peatland was characteristic east of Sheephead Lake.

Comparison of historical map data with MIRIS estimates indicate a 45% net wetland loss for Chippewa County, which attests to the extensive agricultural drainage that was concentrated on the clay lake plain. This is the only portion of the county where extensive wetland losses have taken place. Roughly 192,000 acres of wetlands were drained for agriculture in this portion of the county. This represents the largest total wetland acreage drained for any Michigan county. As with most counties in the region, in Chippewa County there was a significant amount of conversion from conifer swamp to hardwood- and shrub-dominated swamp. Nearly 73% of conifer swamp acreage was lost county-wide. Conversely, there has been an 8-fold increase in lowland hardwood acreage and a 9-fold increase in shrub swamp acreage. There were also increases in acreage for emergent wetlands. As with elsewhere in the Upper Peninsula, some of these increases may be explained by extensive fires that swept through some mixed conifer swamp during the logging era. Many of these swamps may have been opened up by fires and have yet to succeed back to swamp forest. Also, within

Chippewa County, extensive Great Lakes marsh associated with Munuscong Lake and the St. Mary's River may have been underestimated on historical maps, depending on the stage of Great Lake water level fluctuations at the time of the land surveys in the 1840s.

Delta

The landforms that characterize the surface of Delta County include outwash deposits, sand lake plain, thin soils over bedrock, and medium-textured ground moraine. Poorly drained soils of the outwash and sand lake plain are mostly classified as the Roscommon-Tawas association. Poorly drained areas where shallow soils overlay limestone bedrock are most concentrated in the Stonington Peninsula. These soils are classified as the Nahma-Ensley-Cathro association. Ground moraine, most concentrated along the western border of the county, contains loamy soils, most of which are poorly drained and classified as either the Charlevoix-Ensley-Anglica association or the Onaway-Charlevoix-Tacoosh association.

In the 1840s, upland forests of Delta County included northern hardwoods with varying amounts of hemlock and white pine intermixed, most concentrated on ground moraine, white spruce-balsam fir-cedar forest, on thin till over limestone bedrock, and mixed pine forest and pine barrens on dry, fire-prone outwash deposits. Based on historical map data, roughly 43% of the county surface, totaling 320,000 acres, was wetland. The vast majority of wetlands were mixed conifer swamp, with extensive swamps located on poorly drained portions of ground moraine among northern hardwood and hemlock hardwood forests throughout the western third of the county. On outwash and sand lake plain extensive swamps were located in a complex mosaic with mixed pine and hemlock-dominated dune ridges. Cedar swamp was common on the Garden Peninsula, Stonington Peninsula, and on the sand lake plain south of the city of Escanaba.

Comparison of historical map data with MIRIS estimates indicates a 24% net wetland loss for Delta County. This represents roughly a 77,000 acre loss county-wide. Much of the loss has taken place through drainage for agriculture west of Escanaba and Gladstone, but road construction throughout the county has probably also played a significant role. As with other counties statewide, there has been a significant decline in conifer swamp acreage, while all other wetland categories show acreage increases. Roughly 54% of lowland conifer acreage, totaling 156,000 acres have been either drained or converted to other wetland types. Aspen-dominated swamp has increased significantly in the county, along with other lowland hardwood types. Both shrub swamp and emergent wetland categories have increased in acreage by 90% and 52%, respectively.

Dickinson

The surface geology of Dickinson County includes a high diversity of landforms and soils. Landforms include medium and coarse-textured moraine, thin till over bedrock, and outwash deposits. Ground moraine with medium-textured soils dominates the eastern and northern townships of the county. Soils of the moraines tend to be loamy, with muck deposits common in poorly drained areas. In the south-central portion of the county, where thin till over bedrock predominates, poorly drained, mucky soils are found in narrow ravines. The outwash deposits are concentrated along the Menominee and Sturgeon rivers. Soils along the Menominee River are mostly well drained to excessively drained, while those along the Sturgeon River are moderately drained to poorly drained.

In the 1840s, upland forests the ground moraine in Dickinson County included sugar maple, basswood, yellow birch, hemlock, and white pine, in varying combinations. White pine was most often in combination with red pine on the outwash deposits along the Menominee River. Aspen-birch forest was characteristic of the Iron Mountain area. From historical map data, approximately 138,000 acres, or 28% of the county surface was wetland. Mixed conifer swamps were prevalent throughout the county, both in long narrow valleys between moraine ridges and in broad swamps on poorly drained ground moraine and outwash.

Comparison of historical map data with MIRIS estimates indicates an 8% net wetland loss for Dickinson County. This represents a loss of roughly 11,000 wetland acres, primarily from mining, urban development, and road construction. As with most northern counties, there has been a significant decrease in acreage of mixed conifer swamp (40% loss), with conversions to lowland hardwoods, shrub swamp, and emergent wetlands; all of which show net acreage increases. Aspen-dominated swamp probably accounts for much of the increase in lowland hardwood acreage in Dickinson County.

Gogebic

Coarse-textured end moraine and ground moraine dominate the glacial landforms of Gogebic County. There is also clay lake plain along the Lake Superior shoreline and bedrock outcrops along the Montreal River. The rolling end moraine along the Wisconsin border contains ice-contact deposits that support a series of kettle lakes and small wetland depressions. Soils of these landforms are mostly classified as the Gogebic-Hiawatha-Vilas-Iron River association. The northwest portion of the county contains gently rolling to flat ground moraine with soils of varying texture and drainage characteristics. Poorly drained pockets are common throughout the area. Outwash channels form the beds of several branches of the Presque Isle River. Basaltic outcrops with narrow, poorly drained ravines are common along the Montreal River. Soils of the clay lake plain, mostly classified as the Ontonagon-Watton-Bohemian-Au Train association, are drained by deeply cut trenches flowing into Lake Superior.

In the 1840s, upland forests of Gogebic County included sugar maple, hemlock, white pine, yellow birch, basswood, and American elm, in varying combinations. Sugar maple-hemlock and sugar maple-basswood forests were prevalent on the well drained portions clay lake plain and ground moraine, while hemlock-yellow birch forest and white spruce-balsam fir forest was more common where drainage was moderate to poor. Fire-prone pine forests of jack pine, red pine, and white pine were limited to outwash deposits south of Watersmeet. Based on historical map data, roughly 135,000 acres, or 18% of Gogebic County was wetland. Mixed conifer swamp with cedar, tamarack, balsam fir, and black spruce, dominated most of the county's wetlands. Shrub swamp totaled more than 15,000 acres, mostly concentrated along river margins. Ice-contact deposits along the Wisconsin border supported many small mixed conifer swamps among the many lakes and streams.

Comparison of historical map data with current MIRIS data is problematic for Gogebic County. There is clearly a significant over-estimation of current wetland extent in the MIRIS data, and no soil survey information is yet available. Given the relatively low level of development that has taken place in this large county, wetland loss for the county is probably less than 5%, with most of the losses coming from the Ironwood area, and from road construction county-wide. It is reasonable to conclude from existing data that, similar to other U.P. counties, there has been a significant conversion of conifer-dominated swamps to those dominated by hardwoods (especially aspens and balsam poplar) and to shrub swamps. Conifer swamp acreage appears to have declined by 22% county-wide.

Houghton

The surface geology of Houghton County includes end moraine and ground moraine, sand lake plain, clay lake plain, outwash deposits, and bedrock outcrop. Coarse-textured moraines are prevalent at the south end of the county. Somewhat poorly drained portions of these landforms are found where soils are classified as either the Graveraet-Misery-Ocqueoc association or the Skanee-Munising-Gay association. Clay lake plain is most common surrounding Kenton and along the Lake Superior shoreline. Poorly drained, silty portions of these landforms have soils classified mostly as the Rudyard-Froberg-Ontonagon association. Poorly drained soils along the Sturgeon River drainage are mostly classified as the Sturgeon-Arnheim-Pelkie association.

In the 1840s, uplands of Houghton County were predominantly sugar maple-hemlock, sugar maple-yellow birch, and sugar maple-basswood forests. Mixed pine, hemlock-white pine, hemlock-yellow birch, and white spruce-balsam fir-cedar forests were common on clay lake plain and outwash at the south end of the county. Based on historical map data, there were approximately 87,000 acres of wetlands. Most wetlands, totaling over 77,000 acres, were categorized as lowland conifer, with mixed conifer swamp, tamarack swamp, and cedar swamp comprising the most common types. Mixed hardwood swamp, alder-willow swamp, and emergent marsh were common at the north end of the Sturgeon River. The largest contiguous wetlands were found on sand lake plain and poorly drained outwash. On other landforms, wetlands were mostly found in small depressions and in narrow ravines.

Comparison of historical map data with MIRIS estimates is problematic for Houghton County. Total wetland acreage estimated by MIRIS totals 17% greater than total acreage recorded in historical maps. Further investigation is needed to reconcile historical and current wetland estimates. Wetland losses clearly have occurred in the Houghton-Hancock-Calumet area, but county-wide wetland loss probably has not exceeded 5%. It is clear from comparing these data that, similar to other counties, there has been a sig-

nificant conversion of conifer swamps to other wetland types in Houghton County. Nearly 65%, or roughly 50,000 acres of conifer swamp were apparently drained or converted to other wetland types. Extensive areas in southern portions of the county been converted to aspen-paper birch swamp. Lowland hardwoods, shrub swamp, and emergent wetland categories all indicate increased acreage, relative to historical estimates.

Iron

The surface geology of Iron County is dominated by coarse-textured ground and end moraine and outwash plains. The coarse end moraine is most concentrated at the northwest portion of the county. Soils of these landforms are mostly sandy loam or silt loam over coarse sands. Many wet depressions support swamps and many small lakes throughout this area. The ground moraine dominates most of the southwest and northeast sections of the county. Drumlins are found locally near Iron River. Soils of the ground moraine are generally loamy, with occasional bedrock outcrops scattered throughout. They are mostly classified as the Iron River-Gogebic-Amasa-Stambaugh soil association. Shallow depressions and small lakes are common on these landforms. Outwash deposits are concentrated in the southeast section of the county. Further west, the bed of the Iron River also is located in an outwash channel. Most of the outwash deposits are well drained to excessively drained, and classified as the Rubicon-Omega-Onamia association.

In the 1840s, upland forests on the moraines of Iron County consisted of sugar maple, yellow birch, hemlock, and white pine, in varying combinations. Upland forests of white spruce-balsam fir and aspen-birch were also found in several portions of the county. Outwash deposits also supported mixed pine forests, mostly in the southeast end of the county. Historical wetland area for the county is estimated at roughly 147,000 acres. Lowland conifer was the predominant wetland category. Mixed conifer swamp, with cedar, tamarack, black spruce, white pine, hemlock, and balsam fir were most common in the small depressions throughout the moraine and ice-contact topography. Black spruce swamp was somewhat more common on the end moraine and ice-contact features at the north end of the county, and alder-willow swamp was frequent along streams throughout the county.

Comparison of historical map data with MIRIS estimates indicates no net loss of wetlands for Iron County. Undoubtedly a some acreage has been lost due to mining activity, road construction, and urban development around the towns of Iron River and Crystal Falls. The damming of the Michigamme River also caused significant wetland losses, although much of the area flooded by the Michigamme Reservoir was described as upland forest by land surveyors. Although future investigation is needed to make a definitive assessment, actual wetland losses for Iron County are probably less than 5%. There has clearly been a significant conversion of mixed conifer swamp to other wetland types. An estimated 42% of lowland conifers, roughly 58,000 acres, have been either drained, flooded, or converted to other wetland types. Many conifer swamps in the north-central portion of the county have been converted to aspen-birch-balsam poplar swamp. All other wetland categories show relative increases in acreage over historical estimates.

Keweenaw

The surface geology of Keweenaw County, including Isle Royale, contains extensive bedrock outcrop, thin till over bedrock, sandy ground moraine, and sand lake plain. Bedrock outcrop, most abundant on Isle Royale, includes small, poorly drained ravines and wet pockets. Similar patterns of well drained bedrock knobs with poorly drained ravines and depressions characterize the northern half of mainland Keweenaw County. Sandy ground moraine dominates the interior portion of the county, forming a series of plateaus and benches, several of which contain poorly drained flats. Soils of the ground moraine are classified as the Munising-Skanee-Onota-Strongs association. The sand lake plain is concentrated along the southern shoreline of the county, as well as in the Eagle Harbor area. Most of the lake plain from Little Traverse Bay north to Lac La Belle is poorly drained, supported soils classified as the Eastport-Shelldrake association. High dune ridges separated by poorly drained swales characterize the lake plain at Eagle Harbor.

In the 1840s, upland forests of Keweenaw County was predominantly sugar maple-yellow birch-balsam fir forest and white spruce-balsam fir forest. Sugar maple-yellow birch-balsam fir forest was most prevalent in interior portions of mainland Keweenaw County and in a few isolated portions at the south end of Isle Royale. Aspen-birch forest was common along the north side of the mainland and in several isolated portions of the island. Red pine was dominant at Great Sand Bay and Five Mile Point. Histori-

cal estimates of wetland extent county-wide are nearly 75,000 acres, or roughly 21% of the county surface. Nearly all of historical wetland acreage was categorized as mixed conifer swamp, with relatively small areas described as shrub swamp, emergent wetlands, and lowland hardwoods. Black spruce and tamarack dominated coastal dune/swale complexes at Point Isabella, and bog was described for much of the embayment at Lac La Belle. Mixed conifer swamp and alder-willow swamp was found in narrow ravines throughout the county. Larger mixed conifer swamps were mostly limited to rolling ground moraines in central portions of the Keweenaw Peninsula.

Comparison of historical data with MIRIS estimates indicates a 3% net wetland loss for Keweenaw County. That represents a loss of about 2,200 wetland acres. Wetland losses are likely connected to road construction and past mining activity. As with other counties, there has been a significant amount of conversion of conifer dominated wetlands to other wetland types. About 42% of historical conifer swamp acreage, totaling some 30,000 acres, has been either drained or converted to lowland hardwoods, shrub swamps, or emergent wetlands, following intensive logging activity. All three of the latter wetland categories have increased in acreage, relative to historical estimates. A fair portion of this conversion probably took place on Isle Royale, where aspen and paper birch dominated wetlands are now quite common.

Luce

The surface geology of Luce County is dominated by sand lake plain, outwash plain, and sandy moraine. Much of the sand lake plain in Luce County is poorly drained, supporting extensive peat deposits. Better drained portions of the sand lake plain, closer to the Lake Superior shoreline, include sand dunes at the surface, but also contain a number of small lakes and wet pockets. The outwash plains are concentrated along the Schoolcraft County line. They are mostly dry Rubicon-Grayling sands, but they include small, poorly drained pockets. The sandy end moraine extends across the Alger County border into western Luce County. These landforms are generally flat to gently rolling, with a few lakes, streams, and small wet depressions found across the surface. Coarse-textured ground moraine is concentrated south and west of Newberry, with soils classified as the Blue Lake-Kalkaska-Trenary association. This gently rolling topography includes several lakes and flat, poorly drained depressions.

In the 1840s, forests of beech, sugar maple, yellow birch, hemlock, and white pine dominated most of the end and ground moraine, as well as portions of the sand lake plain of Luce County. Hemlock-yellow birch forest and white spruce-balsam fir-cedar forest was common in lower landscape positions on sand lake plain. White spruce-balsam fir forest was also found on portions of clay lake plain along the Lake Superior shoreline. Mixed pine forests and open pine barrens were found on excessively drained outwash along the Schoolcraft County line, and on the dune ridges along Lake Superior. Historical map data indicate that there were about 246,000 acres of wetlands, or roughly 41% of the county surface. Most wetlands of the county were described as mixed conifer swamp. Although cedar swamp, tamarack swamp, and black spruce swamp occurred throughout the county, most wetlands were distributed in such complex mosaics that they could not be adequately delineated with surveyor's information, and therefore, had to be lumped together on historical maps. Two wetland types of the shrub swamp category, patterned peatlands and black spruce muskeg, were also common wetlands found on the peat deposits of the sand lake plain, totaling 27,000 and 14,000 acres, respectively. Alder-willow swamp was common along the margins of the Tahquamenon and Two Hearted rivers. Emergent marshes and intermittent wetlands were found in many of the shallow depressions on outwash and otherwise well drained sand lake plain.

Comparison of historical map data with MIRIS estimates is problematic for Luce County. MIRIS estimates of current wetland extent are 10% greater than historical estimates. Further investigation with soils and detailed current wetland maps will be needed to clarify the total wetland status for Luce County. Wetland loss in the county has been mostly related to road construction, and is likely less than a 5%. As with other Michigan counties, it is clear that there has been significant conversions of mixed conifer swamp to other wetland categories, most notably lowland hardwoods. About 28% of lowland conifer swamp acreage, or roughly 51,000 acres, was either drained or converted to other wetland types. Both lowland hardwood and emergent wetland categories indicate increases in acreage over historical estimates. Shrub-dominated wetlands appear to have maintained relatively stable county-wide acreage.

Mackinac

A wide variety of landforms of glacial lacustrine origin characterize Mackinac County, including flat lake plain, deltaic deposits of sand, parabolic dune fields, and shallow embayments containing transverse dunes. Large areas consist of sand lake plain 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 county are diverse. Lacustrine soils are primarily sands, but there are small, local areas of lacustrine clays. The clays are mostly poorly drained. The sands are 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. Within the county, the soils of the ground moraine range from loamy sands to loams, and are often stony. Where bedrock is near the surface, soils are often calcareous and poorly drained. The most common soils within poorly drained portions of the county are in the Newton-Saugatuck-Rubicon association or the Eastport-Shelldrake complex.

In the 1840s, between Drummond Island and St. Ignace, much of the coastal area along northern Lake Huron, where thin soils overlay bedrock, was dominated by balsam fir-spruce-cedar forests and northern hardwoods. Thin soils over bedrock also characterize Mackinac Island and the area around St. Ignace. These soils supported several forest types, including northern hardwoods on better drained sites, and both balsam spruce-fir-cedar, and aspen-birch on poorly drained sites. Upland portions of Bois Blanc supported northern hardwoods, spruce-fir-cedar forest, and hemlock forest. Limestone ledges were encountered by surveyors throughout the inland forests north of St. Martins Bay. High bedrock ridges west of the straits area, and lower morainal ridges northeast of Brevoort Lake supported northern hardwood forests. Adjacent ground-moraine ridges were dominated by northern hardwoods, hemlock-beech, and hemlock-white pine forests. From Pointe Aux Chenes to Brevoort there are areas of low parabolic dunes on the sand lake plain of Lake Michigan. Near the Lake Michigan shoreline, the moist air, and higher precipitation resulted in most dunes being dominated by northern hardwood forest. In contrast, similar dunes located near Round Lake, several miles inland from Lake Michigan, supported forests dominated by red and jack pine, possibly indicating the lack of local micro-climatic influence bringing moisture from Lake Michigan. Northern hardwoods were common throughout the interior uplands at the west end of the county, except to the northeast of Millecoquins Lake, where mixed pine forest was common. Pines, as well as hemlock, and spruce-fir-cedar forest were common on the low dune ridges along the western Mackinac County shoreline.

Historical estimates of wetland extent for Mackinac County are about 304,000 acres, or 45% of the county surface. Mixed conifer swamp, cedar swamp, and tamarack swamp were overwhelmingly the dominant wetland types county-wide. Several dune/swale complexes occur along the Lake Huron shoreline. Just east of Ponchartrain Shores, the complex supported cedar swamp and those west of St. Martin Bay and in Horseshoe Bay, supported a mix of cedar, spruce, and paper birch. Marly pools were mentioned by the surveyors at Horseshoe Bay. Stunted cedar, tamarack, and white pine grew along the edges of these pools. Vast areas of organic soils located on lacustrine deposits just north of St. Ignace supported cedar and tamarack swamps, with scattered dune ridges. Sand lake plain along northern Lake Huron supported Great Lakes marsh in a number of protected coves in and around the Les Cheneaux Islands. The sand lake plain portions of Bois Blanc Island supported extensive cedar swamp and tamarack swamp. The vast dune/swale complex at Point Aux Chenes supported tamarack, aspen, birch, and spruce in the narrower swales, with emergent marsh and alder-willow shrub swamps in the wider swales. From Epoufette to the western end of the county, the shoreline was dominated by a chain of dune and swale complexes. Sand and clay lake plain extend into Luce and Chippewa counties. These extensive tracts of inland lacustrine deposits, which include some areas of deep organic soils, supported vast swamps dominated by cedar, spruce, and tamarack.

Comparison of historical map data with MIRIS estimates is problematic for Mackinac County. There is apparently a significant underestimation of current wetland extent in MIRIS data. The comparison of the two acreage estimates indicates a net wetland loss of 37%, or about 112,000 acres. While there clearly have been significant wetland losses, especially from

road construction, quarrying, and coastal development, this appears to be a significant overestimate of wetland loss. Further investigation is needed to clarify overall wetland status for Mackinac County. As with other Michigan counties, there has clearly been a net loss of conifer swamp acreage in the county, owing to drainage and conversion to other wetland types. Emergent wetlands also appear to have declined in acreage relative to historical estimates. Given the apparent distortions current acreage estimates, it is difficult to reach definite conclusions about the magnitude of these changes.

Marquette

Exposed bedrock knobs and areas with thin till over bedrock characterize large parts of northern Marquette County. Although bedrock generally controls topography in these areas, 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. 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 scattered throughout the county. The Yellow Dog and the Mulligan plains, two large outwash plains, separated by only a few miles, occur within the county. Extensive outwash plains are also located at Gwinn, and southwest of Ishpeming.

The soils of the county are generally sands. Local silt caps of aeolian origin covers some of the rock knobs. 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. Near Gwinn, there are numerous kettle lakes and depressions, some containing ponds and peat deposits. Farther to the south, the outwash slopes gradually to the southeast where acid peat deposits lay over sand or sandy loam. Poorly drained soils of the county are classified as the Angelica-Trenary-Onaway-Carbondale association, or the Newton-Saugatuck-Rubicon association.

In the 1840s, areas of thin soils over bedrock in Marquette County included extensive forests of hemlock, sugar maple, white pine, yellow birch, white spruce, and balsam fir, in varying combinations. Mixed pine forests were common on sandy outwash plains and sand lake plain. Sugar maple-basswood forest was found on ground moraine in the southwest portion of the county. Historical estimates of wetland extent for the county indicate that there were about 284,000 acres of wetlands comprising 24% of the county surface. Mixed conifer swamp, with varying amounts of cedar, tamarack, and black spruce were by far the dominant wetland type in the county. Mixed conifer swamp and alder-willow swamp was found in narrow ravines between bedrock ridges throughout the north half of the county. Great Lakes marsh and tamarack swamp were common in several embayments along the Lake Superior shoreline. Coastal dune and swale complexes 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 Big Bay was mostly bog and tamarack swamp, while the one at Salmon Trout Bay was dominated by cedar and white pine and bog inland, and alder-willow swamps closer to the shoreline. More extensive swamps of similar composition were found on extensive peat deposits at the southern end of the county. These swamps were typically dominated by balsam fir, tamarack, and black spruce.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 6% for Marquette County. That represents the drainage or inundation of about 17,000 wetland acres, mostly associated with the Dead River Storage Basin, the Silver Lake Basin, and other reservoirs, as well as with road construction and urban development around the City of Marquette. As with other northern counties, there has clearly been a significant conversion of mixed conifer swamp to other wetland types. Roughly 106,000 acres of conifer swamp has been drained or converted to other wetland types. Lowland hardwoods, shrub swamps, and emergent wetlands all show acreage increases, relative to historical estimates.

Menominee

The surface geology of Menominee County includes medium-textured ground moraine, sand lake plain, outwash deposits, and areas with thin till over bedrock. The ground moraine dominates the central portion of the county. This area contains the most extensive drumlin fields in the state. The soils of the drumlin fields vary in drainage characteristics based on topographic position. Moderate to steep slopes of the drumlins are mostly well drained, while the lowlands between the drumlins are poorly drained, supporting muck and peat deposits. Soils of the drumlin fields are classified as the Onaway-Lupton association. Sand lake plain is concentrated in a 1-5 mile band along the Lake Michigan shoreline. Soils of this flat landscape are generally poorly drained, classified

as either the Deford-Wainola-Rousseau or Solona-Pickford-Cathro association. Outwash deposits are concentrated along the Menominee River, and are poorly drained in places.

In the 1840s, upland forests of the ground moraine and drumlin fields in Menominee County were mostly hemlock, sugar maple, beech, white pine, balsam fir, and yellow birch, in varying combinations. Hemlock and white pine dominated most upland forests of the sand lake plain, and mixed pine forests, hemlock-white pine forests, and pine barrens were characteristic of the outwash deposits along the Menominee River. The historical estimate of wetland extent for the county is about 312,000 acres, or 46% of the county surface. Mixed conifer swamp was overwhelmingly the most common wetland type in the county. Although it was not possible to detect the pattern from land survey data, a typical pattern was characteristic of many swamp depressions between drumlin ridges. Cedar swamp most commonly was associated with the base of the drumlin ridge, with tamarack and black spruce gradually increasing in relative abundance in more acid, deep water environments towards the center of the wetland. Extensive cedar swamp was common throughout the sand lake plain, and mixed hardwood-conifer swamp was common in the floodplain of the Menominee River.

Comparison of historical data with MIRIS estimates indicates a 26% net wetland loss for Menominee County. That represents the drainage of about 81,000 acres. Although there has been significant wetland loss in the county, due to agricultural drainage and road construction, this appears to be an overestimate of wetland loss. Further investigation is needed for a more definitive sense of wetland status for Menominee County. There has clearly been a significant loss of mixed conifer swamp. About 152,000 acres of these swamps appear to have been either drained or converted to other wetland types. All other wetland categories appear to have increased in acreage, relative to historical estimates.

Ontonagon

Lake plain formed by glacial Lake Duluth forms much of the surface geology of Ontonagon County, but bedrock exposures and sandy ground moraine are also representative surface features. Bedrock exposures are most prominent in the Porcupine Mountains. Also, a narrow exposed ridge of volcanic bedrock extends from a few miles southwest of Victoria to the northeast into Houghton County. Rolling ground moraine is prevalent at the southwest and southern ends of the county. Poorly drained soils in this area are mostly classified as the Iron River-Skanee-Adolph-Watton association. Clay lake plain varies in drainage characteristics throughout the county. Clays are poorly drained where the lake plain is flat and on lower slopes. On the upper slopes of the dissected clay plain, soils are well drained. Close to the Lake Superior shoreline, the lake plain is dissected by numerous small rivers with straight, shallow valleys. Further inland, the lake bed is deeply dissected by the Ontonagon River. Poorly drained soils in the county are mostly classified as the Ontonagon-Bergland association or the Iron River-Gogebic-Ahmeek association.

In the 1840s, upland forests of the lake plain and ground moraine in Ontonagon County were predominantly hemlock with yellow birch and sugar maple. White spruce, balsam fir, white pine, and cedar were also common where drainage was too poor for sugar maple. The thin till over bedrock characteristic of the Porcupine Mountains supported sugar maple-basswood and sugar maple-yellow birch-balsam fir forests. Extensive aspen-birch forest was common along upper reaches of the Ontonagon River. Historically, there were about 44,000 acres of wetlands, comprising just 5% of the Ontonagon County surface. Mixed conifer swamp was the most abundant wetland type county-wide. These swamps were most frequent in poorly drained depressions in ground moraine along the southern border of the county. Black ash swamp and alder-willow swamp was common in floodplains along lower reaches of the Ontonagon River. Narrow, dune and swale complexes were located along Misery Bay, Sleeping Bay, and west of the Flintsteel River mouth. A diversity of conifers, including hemlock, cedar, spruce, fir, and alder dominated wet swales in these complexes. The complex at the Flint Steel River, the only large area of sand lake plain within the county, included shrub swamp and bog.

The initial comparison of historical data with MIRIS estimates indicated a major distortion in MIRIS data for this county. MIRIS data greatly overestimated current wetland extent, so soil survey information was utilized to make adjustments in county-wide wetland acreage. Unfortunately, the original draft soil survey from the 1920s was the only soils information available, but it at least reflects most wetland alterations that had already taken place in this county related to mining, railroad construction, and agriculture. Adjusted data, compared with 1840s

estimates indicate a net wetland loss of 12% for Ontonagon County. This represents the drainage of about 5,200 wetland acres. As with all northern counties, conifer swamps have decreased significantly in acreage. About 66% of conifer swamp acreage, roughly 21,000 acres of conifer swamps were either drained or converted to other wetland types. Emergent wetlands apparently decreased by about 7% from historical estimates. Both lowland hardwoods (mostly aspen swamp) and shrub swamp acreage increased significantly compared with historical estimates. Further comparisons with updated wetland maps are needed to more definitively assess the current wetland status of Ontonagon County.

Schoolcraft

Poorly drained sand lake plain and outwash deposits characterize much of the surface geology of Schoolcraft County. Sand lake plain occupies the central portions of the county, with outwash plains located southwest of Shingleton, and throughout the northern, Alger County border area. Medium-textured ground and end moraine is found along the eastern county line, north of Blaney Park, and to the west of Indian Lake. Thin till over dolomite bedrock is common close to Lake Michigan between Blaney Park and Manistique. Organic peats and mucks characterize most of the poorly drained area. Excessively drained sands are common on low beach ridges and parabolic dunes found throughout the surface of the lake plain among the poorly drained peat deposits.

In the 1840s, upland portions of sand lake plain and outwash plains supported jack pine barrens and mixed pine forest where wildfire was most frequent, and hemlock or mixed hemlock-northern hardwood forest where fire was uncommon. Ground moraine supported hemlock-sugar maple forest and beech-sugar maple forest. The thin till over bedrock close to Lake Michigan supported beech-sugar maple forest and white spruce-balsam fir-cedar forest. Coastal dunes included mixed pine forest and spruce-fir forest. Historically, wetlands comprised nearly 404,000 acres, or 52% of Schoolcraft County; second only to Alpena County in the wetland percentage of county surface area. Overwhelmingly, the most abundant wetland type was mixed conifer swamp, covering about 25% of the county. Northern white-cedar, tamarack, and black spruce, respectively, were most frequent dominant species. These swamps were common throughout poorly drained portions of all major landforms. Patterned peatland and muskeg dominated the north-central portions of the county on sand lake plain. Throughout these areas, excessively drained sands on dune ridges supported red pine, jack pine, and white pine. Poorly drained sand lake plain along Lake Michigan supported mixed conifer swamp and cedar swamp.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 18% for Schoolcraft County. That represents the drainage or flooding of almost 73,000 wetland acres. Much of the wetland loss was related to floodings established throughout the Seney National Wildlife Refuge, but also to quarrys near Lake Michigan, urban development around Manistique, and road construction county-wide. About 48% of conifer swamps have been either drained or converted to other wetland types. Shrub swamps, which include patterned peatlands and muskeg, appear to have decreased in acreage by 65%. Interpretation of aerial photographs explains much of this apparent acreage change. Many patterned peatlands and muskegs contain many pockets of herbaceous vegetation, and could easily have been classified as emergent marsh on MIRIS maps. This also explains the apparent increase in the emergent wetland category. Lowland hardwoods (primarily aspen-birch-balsam poplar) show significant increases in acreage over historical estimates, due to the conversion of other types.

Region 2 - County Profiles

Alcona

A wide combination of glacial landforms are found in Alcona County. The shoreline of the county is a series of low dune features overlain on sand lake plain. Excessively drained sand lake plain is common along the Iosco County border in southwest Mikado Township. Outwash sands are found along the Au Sable River drainage, southwest of Jewel Lake, and along streams draining into Hubbard Lake. Poorly drained soils of the sand lake plain and outwash deposits are mostly classified as the Rifle-Carbondale-Greenwood soil association. The remaining portions of the county northeast of Barton City are rolling ground moraine and steeply sloping ice-contact topography. The confluence of streams entering the Pine River south of Mikado flow across fine textured ground moraine, much of which is poorly drained and classified as the Bergland-Munuscong-Selkirk soil association. Medium to fine-textured soils are common on irregular topography of the Glennie moraine, which

dominates much of the southwest end of the county. Poorly drained depressions are common throughout this largely well drained landform.

In the 1800s, the uplands of Alcona County were almost entirely forested, with northern hardwoods in combination with white pine and hemlock dominating much of the ground moraine. The outwash deposits and adjacent end-moraine ridges throughout the county included forests of jack pine, red pine, and/or white pine in varying combinations. Wildfires originating from the dry outwash plains were apparently blown by the prevailing westerly winds resulting in the spread of pine forests onto adjacent ridges. Where fires were most frequent, as on the sand lake plain along the Iosco County border, open jack pine barrens were common. Poorly drained portions of the sand lake plain, mostly along the Lake Huron shoreline, supported mixed conifer swamp and cedar swamp. Cedar swamp was historically the most common wetland type in the county, totaling over 16% of the county surface area. These swamps were most common in poorly drained portions of outwash, with a large example extending south and west from Hubbard Lake. Cedar swamp also dominated the margins of the Au Sable River. Smaller swamps of cedar, tamarack, hemlock, and black spruce were also common among the ground moraines. Aspen swamp was common on the poorly drained ground moraine south of Mikado. Shrub swamp and emergent wetlands were not very common in the county, mostly limited to the margins of lakes and streams.

Comparison of historical map data with current MIRIS data indicates a net wetland loss of 26%, or roughly 31,000 acres in Alcona County. The wetland loss was most concentrated in the eastern-most townships of the county. Nearly all of the wetland loss came through the drainage of lowland conifer swamp, which decreased in acreage county-wide by 63%. All other wetland categories indicate an increase in acreage, owing to the conversion of conifer swamps.

Alpena

All of the Lake Huron shoreline, and much of the northeast quarter of Alpena County is sand lake plain and low dune features. A series of well drained beach ridges and wet swales form much of the coastal landscape south of Alpena. Most of the sand lake plain is moderate to poorly drained, with soils classified as Munuscong-Alpena-Detour-Rubicon and Newton-Saugatuck-Rubicon associations. Rolling, coarse-textured ground moraine dominates the central portion of the county. Drumlins are located on the ground moraine near Herron, and poorly drained portions in Wellington Township are dominated by extensive peatlands. Karst topography is found within the ground moraine of Long Rapids Township and on the sand lake plain surrounding Long Lake. Poorly drained outwash sands are common south of Fletcher Pond and along Wolf Creek in Ossineke Township. Muck soils in these areas are classified as the Rifle-Carbondale-Greenwood soil association.

In the 1830s, the uplands of Alpena County supported a variety of forests, most of which were a northern hardwoods in combination with hemlock and white pine. Red pine and white pine were common on the outwash and ground moraines in the southwest of the county. Historically, Alpena County contained a greater relative proportion of wetland (53%) than any other Michigan county; totaling nearly 200,000 acres. Most of the wetlands in Alpena County were conifer swamps, with nearly 115,000 acres of cedar swamp and 40,000 acres of tamarack swamp. These swamp forests were found in poorly drained portions of all glacial landforms, closely associated with the branches of the Thunder Bay River. Extensive peat deposits in Wellington Township supported cedar swamp intermixed with black ash swamp and hemlock-cedar forest. Mixed hardwood swamp was common in places along the South Branch of the Thunder Bay River.

Comparison of historical map data with current MIRIS data indicates an 18% net loss of wetland acreage county-wide. Most of the wetland losses were concentrated around the City of Alpena, in agricultural townships in the center of the county, and with the development of Fletcher Pond, which inundated extensive tamarack swamps. Reflecting statewide trends, nearly 66% of historical conifer swamp acreage has been lost in Alpena County; mostly through convertion to lowland hardwoods and shrub swamps. Both of the latter categories indicate significant increases in acreage since the 1800s.

Antrim

Two large end-moraine ridges with steeply sloping, well drained soils cut across eastern Antrim County in a northeast direction. Between the moraine ridges are well drained to excessively drained outwash sands. The northwest half of the county is a rolling landscape of sandy ground moraine with extensive drumlin fields forming the moraine surface. Soils of the moraine are well to moderately well drained. Sur-

rounding Torch Lake, Elk Lake, Lake Bellaire, and all along the Jordan and Intermediate River valleys is poorly drained outwash and sand lake plain. Soils in these valleys are of the Tawas-Ensley-Roscommon association. Along Grand Traverse Bay there are a number of coastal dune features extending from Elk Lake to the north. Soils in these areas vary from excessively drained to very poorly drained, and are mostly of the Deer Park-Roscommon association.

The uplands of Antrim County were historically dominated by northern hardwoods, with hemlock-white pine forest limited to small concentrations along Grand Traverse Bay. In the 1830s, a large block of aspen-birch forest was also located on outwash deposits at the southeast end of the county. Wetlands accounted for nearly 9% of the county surface, totaling around 30,000 acres. Most wetlands were cedar swamps located on sand lake plain in poorly drained valleys between steep moraine ridges. In poorly drained valleys between drumlin ridges at the northwest end of the county, mixed conifer swamp, alder-willow swamp, and emergent marsh were common. Black ash swamp was found in several locations along Grand Traverse Bay.

Comparison of historical map data with MIRIS estimates indicates a net wetland loss of 11% for Antrim County. Most of the wetland loss is associated with agricultural drainage and urban development near Grand Traverse Bay, and has come from the drainage of conifer swamp which shows a decrease in acreage by nearly 60%. This represents the conversion or drainage of approximately 15,600 acres of conifer swamp. The majority of this acreage was converted to lowland hardwoods through logging activity.

Arenac

Arenac County is dominated by landforms characteristic of sand and clay lake plain. Poorly drained soils of the sand and clay lake plain are variously classified as the Munuscong-Ogemaw-Bergland, the Bergland-Munuscong-Selkirk, the Colwood-Wauseon-Berrien, and the Carlisle-Rifle soil association. Fine-textured end moraine extends in a 1 to 3 mile-wide band from the southwest extreme of the county northeast into Ogemaw County near Maple Ridge. Fine-textured ground moraine is found in the northwest extreme of the county. Large, relict sand dunes are found at the southwest end of the county just inland of the end moraines. More recent lake-deposited dune ridges are found along the shoreline from Point Au Gres north.

Historically, extensive swamps dominated by tamarack, cedar, or a mixture of black ash and other lowland hardwoods were common throughout the clay lake plain near Point Lookout and Point Au Gres. An extensive cedar swamp was located along the shoreline near Saganing. There was also extensive Great Lakes marsh along the shoreline at the mouth of the Pine River. Lake plain prairie was located along the shoreline near the Bay County border. A large hemlock-dominated swamp was located just southwest of Standish. Upland forests on the clay lake plain included northern hardwoods and hemlock types. The sand lake plain included a number of small swamps dominated by cedar, tamarack, black ash, or other combinations of lowland hardwoods. Upland forests on the sand lake plain were mostly dominated by white pine and hemlock. The fine-textured end and ground moraines were dominated by northern hardwoods, hemlock, hemlock/beech, and hemlock/white pine forests. The small wetlands included in the morainal features were dominated by tamarack, cedar, spruce, and black ash. The relict dunes at the west edge of the county were mostly dominated by red pine surrounded by extensive tamarack swamp on the adjacent sand lake plain. The more recently deposited beach ridges along the Saginaw Bay shoreline supported extensive dune and swale complexes, with tamarack and mixed lowland hardwoods in the swales, and red pine dominating the shoreline ridges.

Historically, wetlands accounted for approximately 50% of Arenac County, totaling nearly 119,000 acres. Agricultural development has taken place on up to 46% of the county land surface. This has occurred throughout the fine-textured moraines and on much of the clay lake plain, including extensive swamps close to the Saginaw Bay shoreline, which were drained for this purpose. As a result, there has been a net wetland loss of approximately 38% since the 1830s in Arenac County. Extensive logging at the turn of the century, and subsequent farming, have dramatically changed the character of adjacent uplands, with approximately 37% of the upland forest acreage present in the 1800s remaining today. These forests contain much less white pine and hemlock than was characteristic of the historical condition.

Bay

Bay County contains glacial landforms similar to those of Arenac County. Clay lake plain characterizes much of the county. Poorly drained soils in these areas are mostly classified as the Munuscong-Ogemaw-Bergland or Kawkawlin-Conover-Brookston soil associations. Narrow channels of sand lake plain, relict sand dune features, and a mile-wide ridge of fine-textured end moraine extend in a north-south direction from the shoreline at Nayanquing Point inland for 3-4 miles. The Saginaw River flows through a 2-3 mile-wide channel of sandy lake plain into Saginaw Bay. Poorly drained soils in this area are mostly classified as the Thomas-Wisner-Bono-Toledo soil association. Fine-textured end and ground moraine dominates the southwestern end of the county. Scattered relict dunes are also found along the western border of the county.

Historically, approximately 27% of the county surface, or nearly 78,000 acres, was wetland. Much of the clay lake plain within the county contains moderately well drained soils. Upland forest of eastern hemlock mixed with white pine and scattered hardwoods was most characteristic of this area. The small wetlands found on these landforms were typically dominated by black ash, elm, and maple. The sand lake plain more commonly supported cedar and tamarack swamp. The sand lake plain along the Saginaw River supported extensive emergent marsh and lake plain prairie. The prairies were most common along the Saginaw Bay shoreline, but also extending several miles up the Quanicassee River. Upland forests on the sand and clay lake plain at the southern end of the county contained much beech, sugar maple, and basswood. The fine-textured end moraines tended to support hemlock-dominated forest, with relatively few, small wetlands. These wetlands were dominated by tamarack or lowland hardwoods.

A comparison of historical map data with current MIRIS data indicates the tremendous impact agricultural and urban development have had on Bay County's natural landscape. With agricultural activities effecting up to 74% of the county, and urban development effecting 9%, there has been approximately a 49% net loss of wetland acreage since the 1830s. While lowland hardwood acreage appears to have remained somewhat stable, conifer-dominated swamps have been virtually eliminated from this county's landscape. The exploitation of conifer swamps for lumbering probably caused many to convert to shrub-dominated wetlands, a wetland category which has become more common over time. Emergent marsh, Great Lakes marsh, and lake plain prairie are all wetland types that have dramatically declined, from approximately 9% of the county's surface area in the 1830's to 1% today, as a result of agricultural development.

Benzie

Much of central and eastern Benzie County is an extensive outwash plain with moderate to well drained soils. Isolated, flat-topped moraines with coarse-textured soils are scattered throughout the eastern half of the county. Larger expanses of ground moraine are located west of Weldon and on either side of Crystal Lake. Fine-textured, but well drained, end moraine dominates the shoreline south of Elberta. Sand lake plain, most of which is poorly drained, forms the basins of the Herring lakes, the Platte lakes, and near-shore portions of the Betsie River. Poorly drained sand lake plain is also centered around Thompsonville, along the upper reaches of the Betsie River. Soils in these poorly drained areas are mostly classified as the Newton-Saugatuck-Rubicon or Eastport soil associations. Coastal dunes, mostly including excessively drained soils, are prominent along much of the Benzie County shoreline north of Elberta.

Historically, much of the upland forests of Benzie County were northern hardwoods or beech-hemlock forest. Along the Lake Michigan shoreline there were open dunes, hemlock-white pine forest, and mixed pine forests at Platte Bay. About 10% of the county surface, totaling roughly 23,000 acres, was wetland. Most wetlands in the county were mixed conifer swamp and cedar swamp. Cedar swamp was prominent surrounding Grass Lake, which was described by surveyors as much larger than it appears today. Cedar-rich mixed conifer swamp was also common along the Betsie River and along the margins of Upper Herring Lake and Crystal Lake. Tamarack and black ash swamp were most common surrounding the Platte lakes.

Comparison of historical map data with MIRIS data is problematic in Benzie County. A direct comparison of available data indicates a 37% increase in wetland acreage. Unfortunately, no soil survey data is available to adjust MIRIS estimates of current wetland extent. Interestingly, a portion of the apparent increase can be explained by the current extent of Grass Lake, which was described by surveyors as encompassing well over 1500 acres. It's current,

much more modest dimensions are now surrounded by more forested wetland than was historically described. Perhaps the only conclusion that could be made for Benzie County is that overall wetland extent is probably similar to the 1800s. Also, following statewide trends, conifer swamps have been converted in large measure to mixed hardwood and shrub swamps.

Charlevoix

Similar to Antrim County to the south, Charlevoix County contains a distinct set of landforms and associated soils extending from the shoreline inland. Sand lake plain and coastal dunes dominate the entire shoreline. Soils along the western portion of the shoreline are mostly well drained. Further east along the shoreline, soils of the Detour-Kiva association are somewhat poorly drained to well drained. Sand lake plain forms the basins of Lake Charlevoix and its immediate surroundings. Uplands adjacent to the lake are well drained. Coarse-textured ground moraine forms the majority of western Charlevoix County, with some of the most extensive drumlin fields in Lower Michigan. Most of the drumlin fields surrounding Lake Charlevoix are well drained. Further east, somewhat sandier soils are more common. Outwash sands form the basins of Walloon Lake, Hoffman Lake, and Deer Lake, as well as the channels of Boyne River, Collins Creek, and Spring Creek. Poorly drained portions of these outwash deposits have soils of the Carbondale-Lupton-Tawas association. Coarse-textured end moraine forms much of the southeast extreme of the county and supports steeply sloping, well drained soils. Beaver, High, Hog, and Garden islands are made up mostly of sand lake plain and dune features. Soils on the islands range from those that are poorly drained and classified as the Roscommon-Charlevoix-Mackinac association, to well drained soils of the Deer Park-Dune land-Eastport association.

In the 1840s, much of the upland of Charlevoix County was northern hardwood forest. Upland forest of white spruce, balsam fir, and cedar was common on High Island. Based on historical maps, roughly 17% of the county surface, or nearly 48,000 acres, was wetland. Wetlands of Charlevoix County were overwhelmingly conifer swamps, with most of those being cedar dominated. Cedar swamps were found on poorly drained sand lake plain surrounding most of the lakes, between drumlin ridges, and along much of the mainland shoreline. Mixed hardwood swamp, conifer-hardwood swamp, and emergent marsh was more characteristic of wetlands on the islands, although hemlock swamp was noted in southern Beaver Island.

Comparison of historical map data with MIRIS data is problematic in Charlevoix County, with estimates of modern acreage 15% higher than historical estimates. Additional data are needed to more definitively assess the wetland status of this county. There clearly has been a modest amount of wetland loss in the county, especially associated with urban and agricultural development in western townships, but this is not accounted for by our acreage comparison. Conifer swamps have declined in acreage by roughly 55%, representing the drainage or conversion of roughly 25,000 acres of predominantly cedar swamp.

Cheboygan

Much of the northern half of Cheboygan County is sand lake plain with surficial dunes and beach ridges. Soils of the lake plain range from very poorly drained to excessively drained. Poorly drained soils are of the Roscommon-Charity-Au Gres association, the Detour-Brevort association, or the Tawas-Lupton association. These soils are most common along the Lake Huron shoreline, or along Burt Lake, Mullet Lake, and Black Lake. Extensive peat deposits are found on the sand lake plain north of Douglas Lake. Coarse-textured ground moraine forms broad ridges between Douglas and Mullett lakes, and between Mullett and Black lakes. Another area of rolling ground moraine extends east from the town of Afton. Drumlin fields form the surface of the ground moraine along the eastern county line. Poorly drained soils of the ground moraines are mostly classified as the Detour-Brevort association. Soils on well drained to excessively drained portions of ground moraine are classified as the Cheboygan-Blue Lake association or the Fairport-Onoway association. Outwash and ice-contact deposits form much of the south end of the county, with soils similar to those of the adjacent, sandy ground moraine.

In the 1840s, the uplands of Cheboygan County included a variety of forests, from northern hardwoods on much of the ground moraine and ice-contact deposits, to mixed pine forest on more fire-prone outwash and sand lake plain. Hemlock-white pine forest and mixed white spruce-balsam fir-cedar forest was also common close to the Lake Huron shoreline. From historical map data, approximately

23% of the county surface, or 119,000 acres was wetland. Cedar swamp was by far the most common wetland type in the county, found throughout poorly drained portions of ground moraine and outwash deposits, especially on the margins of rivers and lakes. Extensive muskeg was characteristic of the Dingman Marsh complex. Bogs, alder-willow swamp, and emergent marsh were more common on poorly drained portions of sand lake plain.

Comparison of historical map data with MIRIS data indicates a net wetland loss of 4% for Cheboygan County. Much of that loss was associated with the town of Cheboygan and coastal development in the immediate surroundings. Following statewide trends, nearly 63% of conifer swamp acreage has been drained or converted to other wetland types. Much of the cedar swamp of Cheboygan County has been converted to aspen-dominated wetlands. Lowland hardwoods, as a general wetland category, have increased by roughly 50,000 acres, or 25 times their estimated 1840 acreage.

Clare

The surface geology of Clare County is predominantly sandy outwash plains and coarse-textured moraines. A large, steeply sloping end moraine extends from Harrison to the west and south. Soils of this moraine are mostly well drained to excessively drained, and classified as the Graycalm-Montcalm association. Well drained and moderately well drained soils of this moraine are mostly of the Montcalm-Menominee-Nester association. The outwash plains included excessively drained Grayling sands with inclusions of poorly drained sands of the Rubicon-Croswell-Au Gres association. Medium-textured end and ground moraine characteristizes Sheridon and Grant townships in the southeast extreme of the county. Soils vary from excessively drained to poorly drained in this area, and are mostly classified as the Nester-Kawkawlin-Sims association.

Circa 1830, the uplands of Clare County included significant acreages of beech-hemlock forest and hemlock-white pine forest, most concentrated on sandy moraines. Outwash plains supported a variety of mixed pine forest, oak-pine forest, and open pine-oak barrens. Based on historical map data, there were approximately 67,000 acres of wetlands county-wide, amounting to roughly 18% of the county surface. Cedar swamp and mixed conifer swamp were the two most abundant wetland types recorded. On poorly drained portions of ground moraine, relatively large swamps of cedar or black ash were common. On outwash deposits, wetlands were generally smaller and more isolated, or located as linear features along rivers and streams. Mixed hardwood swamp and conifer-hardwood swamp was common throughout the floodplain of the Muskegon River.

Comparison of historical map data with MIRIS estimates indicates a net wetland loss of 4% for Clare County. The majority of wetland loss has come from agricultural drainage centered in the southeast end of the county. Nearly 80% of historical acreage in conifer swamp has been drained or converted to other wetland types. That represents a loss of roughly 43,000 acres of these wetland types. Emergent wetlands have also declined in acreage by 43%. Conversely, both lowland hardwood and shrub swamp categories significantly increased in acreage for Clare County, owing to the conversion of other wetland types.

Crawford

The glacial landforms of Crawford County fall into two general categories of extensive outwash plains and moderate to steeply sloping ice-contact/end moraine topography. Outwash deposits are most concentrated in the southern half of the county, containing the channels where the Manistee and Au Sable river beds are located. Well drained to excessively drained Grayling sands are most common on the outwash deposits, while poorly drained inclusions on the outwash plains support Rifle peat. Similarly well drained to excessively drained Rubicon sands are more common on steeper ice contact and end moraine features. The end moraine centered on Maple Forest Township includes Coventry loams and Kalkaska sandy loams.

Circa 1850, the uplands of Crawford County included a diverse mosaic of vegetation driven in large part by the frequent fires that burned across the county prevailing west and southwest winds. Jack pine barrens were common where fires were most frequent, mostly on extensive outwash plains and west-facing slopes of ice-contact deposits. Mixed pine, oak-pine, and white pine-hemlock forests were common elsewhere on the outwash and ice-contact deposits. Northern hardwoods dominated the ridges of Maple Forest Township, where wildfire was clearly least frequent in the county. Based on historical map data, there were approximately 36,000 acres of wetlands, representing 10% of the county surface. Mixed conifer swamp, cedar swamp, tamarack

swamp, and conifer-hardwood swamp were most common wetland types, mostly concentrated along river floodplains and in a large swamp complex surrounding the City of Grayling and Lake Margrethe.

Comparison of historical map data with MIRIS estimates indicates a 7% net wetland loss for Crawford County. This loss represents approximately 2,500 acres, mostly concentrated around Grayling or associated with road construction throughout the county. Similar to region-wide trends, lowland conifer acreage has declined by 50%, mostly through conversion to aspen-dominated lowland hardwoods and shrub swamp, both wetland categories that have increased significantly. Emergent wetlands have also declined significantly, by roughly 68%, or 1,300 acres. Part of this may be explained by the suppression of wildfires that historically may have kept some emergent wetlands from succeeding to shrub swamps. Other losses have undoubtedly come through road construction and urban growth.

Emmet

Emmet County includes a high diversity of glacial landforms and soils. High, flat topped ground moraines dominate the landscape south of Petoskey and north of Little Traverse Bay. Soils of the moraines are mostly deep, well drained sands classified as the Blue Lake-Leelanau association. Between sections of ground moraine are outwash deposits, most of which are also well drained sands. A poorly drained portion of outwash south of Larks Lake supports a mixture of organic and sandy soils classified as the Carbondale-Tawas-Roscommon association. Sand lake plain is characteristic of much of the eastern and northern-most townships of Emmet County. A mixture of poorly drained and well drained soils similar to those found on nearby outwash deposits are found throughout the sand lake plain. Dune formations are characteristic along Sturgeon Bay and Trail's End Bay. The largest dunes support deep, well drained sand, but also includes poorly drained flats between dune ridges. Soils in these areas are mostly classified as the Deer Park-Dune land soil association.

Circa 1840, most of the uplands of Emmet County were dominated by beech-sugar maple forest with varying amounts of hemlock, yellow birch, red oak, and white pine intermixed. Hemlock was co-dominant with beech on sand lake plain north of Pellston. White pine dominated many of the high sandy ridges along the northern shoreline. Based on historical map data, there were approximately 72,000 acres of wetlands, or roughly 23% of the county surface. Nearly all of those wetlands were conifer swamp, with mixed conifer swamp and cedar swamp the prevalent wetland types. Cedar swamp was most common on outwash and sand lake plain in the southern and eastern portions of the county. The extensive swamp in the valley south of what is now Larks Lake was mostly cedar swamp, with tamarack, hemlock, and balsam fir also intermixed. On poorly drained sand lake plain along the northern shore, it was a highly complex wetland mosaic with cedar, tamarack, white pine, black spruce, black ash, balsam fir, paper birch, and hemlock, all noted as charactersitic species.

Comparison of historical map data with MIRIS estimates indicates a 45% net wetland loss for Emmet County. This represents roughly a 32,000 acre wetland loss county-wide. Most of the losses have occurred through agricultural drainage and urban development in the southern end of the county. As with other counties in the region, there has been a significant decrease in acreage of conifer swamp which has decreased by 78%. This represents the drainage or conversion of roughly 56,000 acres, most of which were converted to aspens and other lowland hardwoods, or to shrub swamp; two categories that have seen dramatic relative increases in acreage. Part of the acreage loss for conifer swamp is also explained by Larks Lake, which was entirely described as conifer swamp by land surveyors in the 1840s. Emergent wetlands, although not encompassing large acreages overall, appear to have increased relative to historical estimates.

Gladwin

Gladwin County contains a variety of glacial landforms, with sand lake plain being most common along most upper branches of the Tittabawassee River. Soils of the sand lake plain vary considerably in drainage and are classified as the Croswell-Au Gres-Rubicon and the Iosco-Brevort associations. Clay lake plain is located in the southern end of the county, along the Tobacco River (just southeast of Beaverton), and further north in the county along the lower reaches of the Sugar River. Soils of the clay lake plain are mostly poorly drained, classified as the Sims or the Allendale-Pickford-Pinconning association. Several large blocks of fine-textured ground moraine also dominate this county's landscape. One portion extends from just east of Wooden Shoe Village to the northeast corner of the county; and another lies along

the western border of the county. End moraines of both fine-textured and course-textured soils are located just north and west of Gladwin, in the northwest corner of the county at Skeels, and in the southeast at Rhodes. Soils of the moraines are classified as Nester-Kawkawlin-Iosco association, and vary considerably in their drainage characteristics.

Based on historical map data, there were approximately 114,000 wetland acres, representing roughly 35% of the county surface. Numerous wetlands were found throughout the sandy lake plain. Most wetlands, which varied considerably in size, were dominated by cedar, tamarack, mixed conifer, and various lowland hardwoods. Upland forests on the sandy lake plain were dominated by eastern hemlock, American beech, and white pine. The clay lake plain in Gladwin County was generally poorly drained, with wetlands dominated by cedar and black ash being most common. Upland forests on the clay lake plain were predominantly hemlock. The finer-textured moraines supported swamps of tamarack, cedar, black spruce, and black ash. Wetlands on the ground moraine tended to be much larger than those located on the more irregular topography of the end moraines. Upland forests on moraines were dominated by hemlock, beech, and white pine. The course-textured end moraines at the northwest end of the county also supported numerous small cedar swamps and shrub swamps.

Agricultural development, which over time has occupied up to 33% of the county, has had a less significant impact on Gladwin County than it has had on many adjacent counties further south. Currently, approximately 55% of the county's upland forest acreage present in the 1800s remains. However, given the amount of white pine and hemlock-dominated forest that was once characteristic of this county, these species are not nearly as abundant in today's forests as they once were. There has been approximately a 23% loss of the wetland acreage since the 1800s. Conifer swamps have declined in acreage by 97%. The conifer swamps were heavily exploited for lumbering, with many converted to mixed hardwood and shrub-dominated wetlands. Both of these latter categories have increased significantly in relative abundance. Total acreage for emergent wetlands have remained relatively stable within the county.

Grand Traverse

The landforms of Grand Traverse County are predominantly sandy outwash plains and steep sloping end moraine. Soils of the outwash plains are classified as the Rubicon-Grayling association and the Kalkaska-Mancelona association. The end moraines are mostly well drained sandy loams and loamy sands in the McBride-Montcalm and Emmet-Leelanau associations. At the mouth of the Boardman River and the south end of Grand Traverse Bay there is sand lake plain. Sand lake plain also forms a narrow band along the margins of the Mission Peninsula. Soils of the sand lake plain vary widely in the drainage characteristics. Poorly drained portions are classified as the Lupton-Roscommon association. The remainder of the Mission Peninsula is ground moraine with sandy loam and loamy sand soils.

In the 1840s, upland forests of Grand Traverse County included northern hardwoods on many of the moraine ridges, with white pine-hemlock forest, mixed pine forest, oak-pine forest, and open pine barrens more common on the sandy outwash deposits. Based on historical map data, roughly 32,000 acres, or 17% of the county, were described as wetland. Most wetlands were described as conifer-dominated swamp, with the majority of those dominated by cedar. Cedar swamp, mixed hardwood swamp, and shrub swamp were common along the Boardman River. Mixed conifer swamp, hemlock swamp, and cedar swamp were common throughout the Interlochen and Weldenhamer Swamp areas.

Comparison of historical map data with current MIRIS data indicates a net wetland loss of 10% for Grand Traverse County. That represents about 3,100 wetland acres county-wide, with losses probably most concentrated surrounding Traverse City. Nearly 94% of conifer swamp acreage has been drained or converted to other wetland types. That represents the loss or conversion of nearly 27,000 acres of conifer swamp. All other wetland categories show increases over historical acreage, with shrub swamp and lowland hardwoods increasing the most.

Huron

Most of the landforms of Huron County are associated with from clay lake plain, sand lake plain, and medium-textured moraine. Soils of the clay lake plain are somewhat poorly drained to poorly drained, and classified as the Shebeon-Kilmanagh association. The end and ground moraine, on the southern border of the county, vary from well drained Guelph-Londo-Parkhill soils, to poorly drained soils of the Grindstone-Kilmanagh association. A series of dunes and beach ridges are found along the Saginaw Bay shore-

line. Soils of these features vary from poorly drained sands of the Sanilac-Bach association to soils of variable drainage in the Covert-Plainfield-Tobico association.

In the 1830s, the uplands of clay lake plain in Huron County supported mostly hemlock-dominated forest. Over a thousand acres of aspen-birch forest was associated with recent blowdowns on portions of the clay lake plain. On the moraines the southern townships, beech-hemlock and beech-sugar maple-basswood forest were most characteristic. Based on historical map data, there were approximately 218,000 acres of wetlands, totaling roughly 41% of the county surface. Swamps of mixed hardwoods, mixed conifers, black ash, and cedar were most common over large expanses of the clay lake plain. Smaller swamps of similar composition were characteristic between moraine ridges. Along the Lake Huron and Saginaw Bay shoreline, cedar swamp and Great Lakes marsh were the most common wetland types. Extensive dune and swale complexes are found from Point Aux Barque west to Bay Port. Swamps of cedar, tamarack, and black ash, along with emergent marsh and lake plain prairie were found in the swales between the white pine and oak-dominated ridges. Lake plain prairie, Great Lakes marsh, cedar swamp, and black ash swamp were common wetlands among oak, white pine, and hemlock-dominated beach ridges along the western Huron County shoreline and on the Wildfowl Bay Islands.

Comparison of historical map data with MIRIS estimates indicates 78% net wetland loss for Huron County. That represents the drainage of roughly 170,000 wetland acres; the second greatest wetland acreage loss for Michigan counties (second to Chippewa County). Based on MIRIS data, nearly all of the 132,000 acres of conifer swamp from Huron County has been drained or converted. Lowland hardwood acreage has decreased by 47%, probably resulting both from losses through drainage and slight gains through the conversion of conifer swamp. Emergent wetlands, most notably Great Lakes marsh and lake plain prairie, have decreased in acreage by 66%. Of the 2,200 acres of lake plain prairie historically known from the county, all but 44 acres has been drained or converted to shrub swamp (Comer et.al. 1995c).

Iosco

The landforms of Iosco County are derived from sand lake plain, clay lake plain, and fine textured moraine. Sandy outwash deposits form the channel that contains the Au Sable River, which is now cut over 100 feet into these deposits. These outwash deposits extended onto the sand lake plain in a delta-like formation in northern Iosco County. In the southeastern portion of the county much of the sand lake plain is poorly drained, variously classified as the Newton-Saugatuck-Rubicon and Eastport soil associations. Fine-textured till forms gently rolling hills all along the western border of the county. A similar end moraine ridge forms an arc generally oriented to the northeast through Grant, Tawas, and Wilber townships. Most of the moraines have moderately well drained to well drained soils.

In the 1830s, upland forests of moraines of Iosco County were dominated by hemlock, white pine, and beech. Outwash deposits and excessively drained portions of sand lake plain supported forests of jack pine and red pine, and open jack pine barrens. Mixed pine forest and beech-sugar maple forest was found on dune deposits along the Lake Huron shoreline. Total wetland acreage is estimated to have been about 100,000 acres, or roughly 28% of the county surface. Nearly 80,000 acres were lowland conifers. Mixed conifer swamp, cedar swamp, and black ash swamp were common in the active floodplain of the Au Sable River. Extensive cedar swamp and mixed conifer swamp were located on poorly drained sand lake plain north of Tawas Lake. Poorly drained portions of clay lake plain near Alabaster supported black ash, mixed hardwoods, and tamarack swamp.

Comparison of historical map data with MIRIS estimates indicates a net wetland loss of 27% for Iosco County. That represents the drainage of roughly 27,000 wetland acres, most concentrated in southern townships, and from urban development around the City of Tawas. An estimated 77% of conifer swamp acreage, totaling roughly 61,000 acres, have been either drained or converted to other wetland types. All other wetland categories show increased acreage over historical estimates.

Isabella

The surface geology of Isabella County is characterized by a series of end moraine ridges and gently rolling ground moraine which are north to south trending features. The eastern-most ridges contain fine textured soils, with those further west more coarse in texture. Between the ridges are a series of outwash channels, through which flows the Chippewa River and its tributaries. Soils of the outwash chan-

nels vary in drainage from excessively drained to very poorly drained mucks, and are classified as the Coloma-Pinnebog association. The Chippewa River flows east onto a large block of sandy lake plain that extends east into Midland County. Soils of the sand lake plain are mostly poorly drained and classified as the Pipestone-Kingsville association. At Mount Pleasant, and directly north and east, clay lake plain is the dominant landform, with poorly drained loamy soils in the Londo-Parkhill-Wixom association .

Many of the moraines in this county had upland forests dominated by American beech, sugar maple, and hemlock. The sandier soils on the moraines at the western border of the county supported mixed forests of white pine and American beech. Based on historical map data, there were approximately 50,000 acres of wetlands, comprising 13% of the county surface. The moraines supported numerous small wetlands dominated by tamarack, cedar, and lowland hardwoods. Several large hemlock-dominated swamps were located on the more level ground moraine. The clay lake plain supported several large mixed hardwood and cedar swamps. Large cedar swamps and black ash swamps were located on the sandy lake plain at the northeast edge of the county.

By comparing historical land cover data to current cover types, it is clear that agricultural development (up to 69% of the county) has replaced most of the upland forests (down from 86% to 19% of the county). There has been a 40% net wetland loss county-wide, representing the drainage of 20,000 wetland acres. Lowland conifer swamp types have declined by 86%, or roughly 28,000 acres. After heavy logging, many conifer swamps converted to shrub swamps, hardwood swamps, or emergent wetlands. All three of these types appear to have increased in total acreage in this county.

Kalkaska

The glacial landforms of Kalkaska County fall into four main categories; outwash plains, sandy ice-contact topography, coarse-textured end moraine, and sand lake plain. Sand lake plain is limited to the northeast extreme of the county surrounding Lake Skegemog. Most of that area is very poorly drained, supporting muck and peat. The end moraines form two parallel ridges extending in a northeastern direction across the western half of the county. The ice-contact features are concentrated in the eastern-most townships of the county. Soils of these steeply sloping landforms are well drained to excessively drained, and classified as Grayling or Rubicon sands, or Blue Lake sandy loam. The outwash deposits of Kalkaska County are located between the end moraine and ice-contact ridges and contain the stream channels for the Manistee and Boardman rivers. These deposits vary widely in their drainage characteristics. Poorly drained outwash supports Rifle peat and Lupton mucks, while well to excessively drained portions were classified as Grayling and Rubicon sands, and Kalkaska sandy loam.

In the 1840s, the coarse-textured moraines and outwash throughout the central portion of Kalkaska County supported forests of beech, sugar maple, yellow birch, hemlock and white pine. Open pine barrens, mixed pine forest, hemlock-beech forest were common on outwash deposits southwest of the town of Kalkaska, while oak-pine forests were common on ice-contact features at the southeast end of the county. Historical estimates of total wetland acreage for the county are nearly 49,000 acres, or 13% of the county surface. Most of the wetland acreage for the county was categorized as lowland conifer, with cedar swamp and mixed conifer swamp most abundant. Cedar swamp, followed by black ash swamp, were most common along river floodplains. Cedar swamp dominated the east end of Lake Skegemog. Tamarack swamp, hemlock swamp, shrub swamp, and emergent marsh formed a complex wetland mosaic above the confluence of many streams with the Manistee River near the town of Sharon.

Comparison of historical map data with MIRIS estimates indicates a net wetland loss of 28% for Kalkaska County. That represents the drainage of nearly 14,000 wetland acres, distributed throughout the county. About 78% of lowland conifer acreage, totaling roughly 36,000 acres, has been either drained or converted to other wetland types. Lowland hardwoods, shrub swamps, and emergent wetlands all show increases in acreage over historical estimates.

Lake

The glacial landforms of Lake County are predominantly outwash plains and coarse-textured end moraines. The outwash is poorly drained along portions of the Little Manistee River and the Baldwin River. Soils in these areas are classified as the Tawas-Croswell-Lupton association. Most of the outwash deposits surrounding the Pere Marquette River are well drained to excessively drained. The end-moraine ridges contain steep slopes and are also well drained to excessively drained sands. Soils on both

the excessively drained outwash and end-moraine ridges are classified as the Kalkaska, Grayling-Graycalm, or Rubicon-Montcalm-Graycalm associations.

In the 1840s, much of the upland vegetation of Lake County was determined by the relative frequency and intensity of wildfire. Jack pine barrens and oak-pine barrens were common on outwash deposits that burned most frequently. Mixed pine and pine-oak forests commonly surrounded barrens on outwash plains and adjacent end moraines. White pine-beech-maple forest, hemlock-white pine forest, and beech-sugar maple forest were found on end moraines where wildfire was relatively least frequent. Historical estimates of wetland extent for Lake County are about 38,000 acres, or 10% of the county surface. About 33,000 acres of wetlands were categorized as lowland conifers. Conifer-hardwood swamp was dominant in the floodplain of the Pere Marquette River. Large tamarack and cedar swamps were also found on poorly drained portions of the outwash deposits in the headwaters of both the Baldwin River and the Little Manistee River. Small emergent marshes were found in pockets on the end moraine surrounding Bass Lake.

Comparison of historical data with MIRIS estimates for Lake County is problematic. MIRIS data indicates 15% more wetland acres today than historical estimates. Unfortunately, soils survey data are not yet available for Lake County to help rectify MIRIS estimates. There have probably been modest wetland losses from road construction, agricultural drainage, and urban development, most concentrated in south-central and southeast portions of the county. There has clearly been a significant amount of conversion from conifer swamp to other wetland types. Roughly 80% of historical lowland conifer acreage was either drained or converted to other wetland types. That represents the loss of about 27,000 acres of cedar, tamarack, and mixed conifer swamp. Shrub swamp, lowland hardwoods, and emergent wetland categories have all increased in acreage, relative to historical estimates.

Leelanau

The glacial landforms and soils of Leelanau County are quite diverse, including moraines, sand lake plain, outwash deposits, and dune features. Coarse-textured end and ground moraine forms the majority of the county. The end moraines form a series of rolling hills extending across the southern half of the county. Soils of these ridges are well drained. Ground moraine extends northward forming most of the Leelanau Peninsula and is also the predominant landform on the Manitou islands. Drumlin fields are a prominent surface feature of the ground moraine on either side of Lake Leelanau. The basins of Lake Leelanau, Glen Lake and Lime Lake, as well as the Grand Traverse Bay shoreline, are all formed by sand lake plain. Outwash deposits form the southern half of townships along the Benzie County line. Soils of both landform types vary in their drainage characteristics from well drained to poorly drained. The East Lake-Eastport-Lupton association is characteristic on much of lake plain, while the Kalkaska-Mancelona association is characteristic of the outwash. Sand dunes are prominent surface features throughout the Lake Michigan shoreline of the Peninsula and the Manitou islands. Sand dunes are perched on top of the sandy end moraines near Empire. Soils of the dunes are predominantly well drained sands of the Deer Park-Dune land association.

In the 1840s, nearly all of the uplands of Leelanau County were dominated by beech, sugar maple, yellow birch, white pine, and hemlock. White pine and hemlock were common on sand dunes at Glen Arbor and Good Harbor Bay. Historical estimates of wetland extent county-wide are nearly 18,000 acres. Nearly all wetlands from the county were categorized as lowland conifer, with most of those being cedar swamp. Cedar swamp was characteristic along the Grand Traverse Bay shoreline, and along the shoreline of Lake Leelanau. Hemlock swamp and emergent marsh were common at the tip of the peninsula, and on North Manitou Island.

Comparison of historical data with MIRIS estimates for Leelanau County is problematic. MIRIS estimates 5% more wetland acres than historical estimates. It is safe to say that a small percentage of wetland acreage, probably less than 5% has been lost in the county, due primarily to road construction. As with other counties, there has been a significant conversion of cedar swamps to other wetland types resulting from intensive logging and hydrological alterations. About 7,700 acres, or 47% of lowland conifer acreage was either drained or converted. Lowland hardwoods and shrub swamps both increased significantly in acreage, relative to historical estimates, while emergent wetlands decreased only slightly.

Manistee

Predominant glacial landforms in Manistee County are outwash plains, sand lake plain, coarse-textured end moraine, medium-textured moraine, ice-contact topography, and sand dunes. Outwash plains characterize the southern tier of townships in the county, as well as the basin including Bear Lake. The outwash deposits tend to be well drained to excessively drained sands. Sand lake plain was deposited in an elongated post-glacial embayment that extended from the town of Manistee east for 15 miles, then north along the Bear Creek drainage. Muck soils characterized much of the poorly drained sand lake plain, especially along the river floodplains. Sandy, coarse-textured end moraines form north-south ridges in the eastern-most townships of the county. Medium-textured end and ground moraine is concentrated in the coastal townships of Manistee County, and is mostly characterized by well drained, sandy loam soils. The Udell Hills are characteristic of the steep, sandy, ice-contact ridges found at the southern end of the county. Sand dunes in the county are limited to a small area at the town of Manistee, and a series of perched dunes rest on end moraines that extend from Bar Lake north beyond Portage Point.

In the 1840s, northern hardwoods dominated most of the uplands of Manistee County. Hemlock-beech forest was common on upland portions of sand lake plain and end moraines close to Lake Michigan. Hemlock-white pine forest was found around the town of Manistee. Mixed pine forests and open pine barrens were common throughout the outwash deposits along the southern county border. Historical estimates of wetland extent are about 48,000 acres, or 13% of the county surface. Mixed conifer swamp was the most abundant wetland type, most concentrated as a large wetland expanse on the sand lake plain forming the headwaters of Bear Creek. Black ash swamp and Great Lakes marsh were located at Arcadia, and at Bar Lake swamp. Great Lakes marsh was also common near the mouths of the Manistee and Little Manistee rivers. Mixed hardwoods, cedar swamp, and hardwood-conifer swamp dominated much of the active floodplain of the Manistee River.

Comparison of historical data with MIRIS estimates is problematic in Manistee County. MIRIS data indicates 14% more wetland acreage than historical estimates. It is likely that most distortions occur in the sand lake plain area of Bear Swamp. In these landscapes it was difficult for surveyors to distinguish uplands from wetlands, leading to distortions on historical maps, and because of the extent of conversion from conifer swamp to aspen-birch swamp, distinguishing the current condition from aerial photos is most challenging. There clearly have been wetland losses in Manistee County, due to agricultural drainage, road construction, and urban development. Tippy Dam also flooded a significant amount of wetland. Further investigation is needed to clarify the wetland status for the county. Based on existing information, there clearly has been a shift in wetland acreage from mixed conifer swamp to other wetland types. MIRIS data indicate that 92%, or about 31,000 acres, of mixed conifer swamp has been either drained or converted to other wetland types. All other wetland categories appear to have increased in acreage relative to historical estimates.

Mason

A wide diversity of glacial landforms characterize the surface of Mason County, including outwash plains, sand lake plain, sand dunes, coarse-textured end moraine, and fine-textured end and ground moraine. The outwash deposits are most concentrated in the northeastern townships of Meade and Freesoil, as well as along the eastern reaches of the Pere Marquette River further south. Soils of the outwash plains range from excessively drained sands to very poorly drained soils of the Kerston-Carlisle-Glendora association. The latter type is prominent along the Pere Marquette River. The sand lake plain is most concentrated closer to the Lake Michigan shoreline along major river drainages. Soils of the lake plain are variable in drainage characteristics, and are mostly classified as the Covert-Pipestone-Saugetuck association. The sand dunes, most prominent at Big Sable Point, have excessively drained sands of the Dune land-Nordhouse association. The coarse-textured moraines are most concentrated in the southeast extreme of the county. The sandy soils in this area range from excessively drained to poorly drained. The fine-textured end and ground moraine is concentrated in central portions of the county, with somewhat poorly drained soils of the Ithaca-Arkona and Coloma-Spinks-Fern associations being most common.

In the 1830s, the upland forests on ground moraine and sand lake plain throughout the central portions of the county were dominated by beech, sugar maple, and hemlock. Hemlock-white pine forest dominated much of the sand lake plain and sand dunes along the Lake Michigan shoreline. Mixed pine forest, oak-pine forest, and pine barrens were

common on the fire-prone outwash deposits along the Lake County border. The historical estimate of wetland extent for the county is about 49,000 acres, or 15% of the county surface. Cedar swamp was the most abundant wetland type in the county, frequently associated with river floodplains and poorly drained outwash deposits. Conifer-hardwood swamp and black ash swamp were also common on the floodplains of the Big Sable and Pere Marquette rivers. Great Lakes marsh was found near the mouths of these two rivers and the Lincoln River. Tamarack swamp, cedar swamp, and alder-willow swamp was common in small depressions in end moraine around Pleiness Lake. Black ash and cedar swamps were common on ground moraine southwest of Gun Lake.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of just 4% for Mason County. That represents the drainage of about 1,900 wetland acres, most concentrated west of Round Lake, and surrounding the Oxbow lakes. There has clearly been significant conversion of lowland conifers to other wetland types. About 90% of lowland conifer acreage, roughly 34,000 acres, have either been drained or converted to other wetland types. Lowland hardwoods, shrub swamps, and emergent wetland categories all show increases in acreage, relative to historical estimates.

Midland

The surface geology of Midland County is dominated by clay lake plain and sand lake plain, which includes relict sand dune features at the surface. Sand lake plain is most common in the west-central portion of the county, significant portions of which are poorly drained. Soils in these areas are mostly classified as the Newton-Saugatuck-Rubicon or Munuscong-Ogemaw-Bergland soil associations. Clay lake plain is most common in the northwest, northeast, and southern parts of the county. The city of Midland is also located on clay lake plain. Much of the clay lake plain in Midland County contains moderately well drained soils. Relict sand dunes with moderate to well drained soils are common throughout the county, but are most concentrated toward the eastern border townships .

In the 1830s, upland portions of the sand lake plain supported forests of hemlock and white pine. Poorly drained portions supported large swamps dominated by tamarack, black ash, or mixed hardwood swamp. Aspen was also found on the sand lake plain, especially where windthrows were most common. The relict sand dunes in this area supported upland forests dominated by white pine and/or hemlock. In the southern half of the county, well drained lake plain supported forests with common dominants such as beech, sugar maple, and white oak. The historical estimate of wetland extent is about 78,000 acres, or 23% of the county surface. Poorly drained portions of the clay lake plain supported large expanses of mixed hardwood swamp. These swamps were also characteristic of river floodplains. The sand lake plain supported more tamarack and mixed conifer swamp. Black ash also dominated some swamps of the sand lake plain.

Comparison of historical data with MIRIS estimates is problematic for Midland County. Current wetland acreage was adjusted using hydric soils estimates from the soils survey, but the comparison still indicates significantly greater wetland acreage than historical estimates. Historical maps appear to underestimate wetland extent on portions of the sand lake plain in north-central and southwestern Midland County. Current statistics for total wetland acreages are distorted by the amount of acreages of upland aspen forests incorrectly designated as swamp. Because leaf-on aerial photographs were used to determine current cover types, there was confusion between upland and wetland areas dominated by aspen (Hollander pers. comm. 1993). It is, therefore, not possible to indicate the total wetland losses for Midland County until more accurate information on both historical and current wetland acreages can be obtained. There clearly has been wetland losses and conversions throughout Midland County. Agricultural drainage was most significant along the eastern and southern county border, and Sanford Lake flooded significant acreages of floodplain forest. Other trends in wetland acreages follow those of adjacent counties. Conifer swamps were nearly eliminated during and after the logging era. Many conifer swamps were converted to aspen-birch swamp, shrub swamps, and emergent wetlands, with these wetland categories apparently increasing in county-wide acreage.

Missaukee

Missaukee County includes a diversity of glacial landforms, including outwash plains, ice-contact topography, coarse-textured end and ground moraine, and fine-textured ground moraine. Outwash deposits characterize much of the eastern half of the county. Extensive, poorly drained outwash supports peat and

muck soils in the Dead Stream Swamp, which extends from northeast Missaukee County into adjacent Roscommon County. Sandy, steep-sloping ice-contact ridges are found along the Kalkaska County border in the north, and in south-central portions of the county. Well drained to excessively drained portions of the outwash and ice-contact deposits have soils classified as the Rubicon-Montcalm-Graycalm association or the Kalkaska association. Gently rolling, coarse-textured end moraine and ground moraine is concentrated in the southwest end of the county near McBain, and in the northwest at Morey. Fine-textured ground moraine is concentrated southeast of Lake Missaukee and surrounding the town of Merritt. The soils of the end and ground moraines are mostly classified as the Emmet-Montcalm or Nester-Kawkawlin-Manistee associations.

In the 1840s, upland portions of the outwash deposits in Missaukee County were predominantly mixed pine, oak-pine, and white pine-hemlock forests. Northern hardwoods and beech-hemlock forests were more common on end and ground moraine. The historical estimate of wetland extent for the county is about 86,000 acres, or 23% of the county surface. The overwhelming majority of wetlands were mixed conifer swamps, with varying amounts of cedar, tamarack, hemlock, balsam fir, white pine, and black spruce. These swamps were mostly found on poorly drained outwash and ground moraine, and characterized much of the Dead Stream Swamp and Haymarsh Swamp. Cedar swamp was common along the upper reaches of the Muskegon River's west branch, and was found among smaller pockets of tamarack swamp, black spruce swamp, and alder-willow swamp in the Clam River drainage near the town of McBain.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 30% for Missaukee County. That represents the drainage of about 26,000 wetland acres. Most wetland losses in the county have come from agricultural drainage in the south-central portion of the county, and from road construction county-wide. As with most northern counties, there has been a significant amount of drainage and conversion of conifer swamps. About 76%, or 57,000 acres of lowland conifers were either drained or converted to other wetland types. The wetland categories of lowland hardwoods and shrub swamp both show significant increases in acreage over historical estimates. Emergent wetlands appear to have remained relatively stable in county-wide acreage.

Montmorency

The surface geology of Montmorency County is a complex mosaic of outwash plains, narrow outwash channels, sandy ground moraine, medium-textured end moraine, and fine-textured ground moraine. Most extensive outwash deposits are concentrated around Twin Lakes near Lewiston, surrounding Black and Canada creeks further north, and near Avalon and Grass Lake in the northeast end of the county. Most of the soils in these large outwash plains are well to excessively drained sands. Coarse-textured ground moraines with well drained, sandy soils form rolling hills throughout much of the central and southeast portions of the county. Sandy loam soils are characteristic of the medium-textured end moraine extending across the southwest quarter of the county. Fine-textured ground moraine is limited to the Hillman area along the eastern border of the county.

In the 1840s, uplands on the outwash deposits were predominantly mixed pine forests, with jack pine, red pine, and white. Open jack pine barrens were found in a few locations where wildfires burned most frequently. Ground moraine and end moraine throughout the county mostly supported northern hardwood forests. In the northeast extreme of the county, hemlock-beech and hemlock-cedar forest was common on ground moraine. Historically, there were about 77,000 acres of wetlands, comprising 21% of the county surface. Conifer swamp was clearly the most abundant wetland type, with cedar swamp occupying roughly 43,000 acres and tamarack swamp 26,000 acres. Extensive cedar swamp and tamarack swamp were characteristic of the Hunt Creek area in the southeast of the county, and the Green Swamp in the west. Tamarack swamp was more characteristic of the Tomahawk Lakes area along the northern county border.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 12% for Montmorency County. That represents the drainage of about 9,200 wetland acres, probably due to road construction and agricultural drainage along the northeast county border. As with most northern counties, there was a significant amount of conversion of conifer swamps to other wetland types. About 44%, or 32,000 acres of historical conifer swamp acreage has either been drained or converted to other wetland types. Lowland hardwood (mostly aspen-dominated

swamp), shrub swamp, and emergent wetlands all increased significantly in acreage, relative to historical estimates.

Ogemaw

A wide variety of glacial landforms are found in Ogemaw County including sand lake plain, outwash plain, ice-contact topography, and end moraine and ground moraine with medium to fine textured soils. Sand lake plain, much of which is poorly drained, is concentrated at the south-central border of the county. Soils of the sand lake plain are classified as the Rubicon-Au Gres-Roscommon association. Well drained to excessively drained soils of the Graycalm-Grayling association are most characteristic of the outwash deposits and steep-sloping ice-contact topography. These landforms dominate the western and northern townships of the county. The rolling end and ground moraine with fine-textured soils are concentrated in central portions of the county, extending northeast of West Branch up through Rose City. Soils of the Nester-Kawkawlin association are characteristic of these landforms.

In the 1840s, hemlock-white pine forest dominated much of the lake plain, though jack pine and red pine were found in the droughtiest portions. Similarly, hemlock intermixed with beech and/or white pine dominated much of the fine-textures moraines, with sugar maple becoming more frequent on the well drained slopes in central portions of the county. The outwash and ice-contact deposits to the northwest experienced frequent wildfire and were predominantly mixed pine forest, jack pine forest, and pine barrens. Historically, there were about 68,000 acres of wetlands comprising 19% of the Ogemaw County surface. The most abundant wetland type was cedar swamp, which was frequent throughout the sand lake plain and ground moraine, and dominated the floodplain of the Rifle River. Other swamps dominated by hemlock, tamarack, and black ash were common throughout the southeast half of the county.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 45% for Ogemaw County. That represents the drainage of about 31,000 wetland acres, with most drainage related to agriculture and road construction in eastern and central portions of the county. As with most northern counties, there has been significant drainage and conversion of conifer swamps in this county. Based on MIRIS estimates, about 90% of conifer swamp acreage, totaling 56,000 acres, were either drained or converted to other wetland types. Lowland hardwoods, shrub swamp, and emergent wetlands all show increases in acreage over historical estimates.

Osceola

Gently rolling end and ground moraine makes up most of the surface geology of Osceola County. For the most part, soils of these moraines are well drained sands and sandy loam classified as the Chelsea-Rubicon-Montcalm association. Ground moraine with loamy soil forms gently rolling to level topography in the northeast extreme of the county around the town of Marion. Similar landforms and soils are concentrated around Sears. Outwash deposits with soils varying from poorly drained to excessively drained are concentrated along the tributaries and main branch of the Muskegon River. These soils are mostly classified as the Rubicon-Croswell-Au Gres association.

In the 1840s, much of the upland of Osceola County was dominated by northern hardwood forests. Hemlock-beech and white pine-beech-red maple forest were also common on sandier end moraine and outwash. Hemlock-white pine forest, mixed pine forests, and jack pine barrens were located on outwash deposits along the eastern county border. Historically, there were about 49,000 acres of wetlands comprising 13% of the Osceola County surface. Mixed conifer swamp and cedar swamp accounted for the majority of wetland acreage in the county. Large swamps were associated with outwash deposits along the Muskegon and Pine rivers. Emergent marsh, tamarack swamp, alder-willow swamp, black ash swamp, and mixed conifer swamp was found in depressions scattered across the surface of the sandy end and ground moraine throughout central and northern portions of the county.

Comparison of historical data with MIRIS estimates is problematic in Osceola County. Probably due to the high number of small, isolated wetlands, total wetland extent is probably underestimated on historical maps. There has also been significant conversion of upland and forested wetland to aspens, so distortions in MIRIS data should be assumed as well. Based on existing information, about 65% of conifer swamps was either drained or converted to other wetland types. Further investigation is needed to more definitively assess the wetland status of this county.

Oscoda

The surface geology of Oscoda County is dominated by extensive, excessively drained outwash plains and sandy ice-contact topography. The Au Sable River cuts deeply into outwash channels extending west to east across the middle of the county. A large, fine-textured end moraine extends across the southeast end of the county beginning just south of Mio. The surface soils of this moraine, however, are quite sandy and well drained in most places. Clay lake plain is located just southwest of Fairview. Similar to the above mentioned moraine, it has sandy soils at the surface, but is mostly poorly drained. Soils in this area are classified as the Berrien-Tuscola-Lacota-Brookston soil association.

In the 1850s, frequent wildfires that continually swept across this sandy landscape had created a mosaic of forest and open savanna. Most of the outwash deposits throughout the southern and western portions of the county supported forest of jack pine and/or red pine, and open jack pine barrens. Northern pin oak and bigtooth aspen were common components of these upland systems. hemlock-white pine forest and red pine-white pine forest were common on outwash throughout the northeast portion of the county. End and ground moraine supported forests of beech, sugar maple, white pine, and hemlock in places where wildfire was much less frequent and intense than on adjacent outwash plains. Historically, there were about 30,000 acres of wetlands comprising roughly 8% of the county surface. The most common wetland types were cedar swamp, tamarack swamp, and mixed conifer swamp. These were concentrated on poorly drained outwash, mostly associated with the Au Sable River and major tributaries. Several large, poorly drained areas of outwash supporting cedar, black spruce, and tamarack swamps were located several miles to the north and south of the Au Sable River, north of the town of Luzerne.

Comparison of historical data with MIRIS estimates is problematic for Oscoda County. MIRIS estimates greater current wetland acreage than historical estimates. Further investigation is needed to clarify the current wetland status for the county. It is likely that aspen-dominated uplands were counted as wetlands in the MIRIS maps. There has likely been some minor wetland losses associated with road construction throughout the county. Approximately 40% of conifer swamp acreage has either been drained or converted to other wetland types.

Otsego

A variety of glacial landforms are found in Otsego County, including outwash plains, ice-contact topography, coarse-textured end and ground moraine, and medium-textured end moraine. Sandy outwash plains and steep-sloping ice-contact features dominate the southern half of the county. Upper reaches of the Au Sable and Manistee rivers drain poorly drained portions of these outwash deposits. Other portions of outwash deposits at the northeast end of the county are poorly drained as well. The end moraines extend from northwest to southeast across the county. Most of these moraines form gentle to steep, north-facing slopes with well drained soils.

In the 1840s, the majority of upland forest in Otsego County was dominated by northern hardwoods. Beech-hemlock forest and hemlock-white pine forest were common on outwash and ice-contact deposits at both the north and south ends of the county. Aspen-birch forest, mixed pine forests and jack pine barrens were found on outwash within the Pigeon River State Forest and in the southeast corner of the county. Historically, wetlands accounted for about 33,000 acres, comprising 10% of the county surface. The most common wetland types were cedar swamp, mixed conifer swamp, and tamarack swamp, all concentrated on outwash deposits in the Pigeon River drainage and along rivers draining into both the Au Sable and Manistee rivers at the southern end of the county. Small, isolated conifer swamps, bogs and emergent marshes were located on end moraine north of Johannesburg.

Comparison of historical data with MIRIS estimates indicates that overall wetland acreage appears to be stable for Otsego County. It is possible that small acreages of wetland have been lost due to road construction and agricultural drainage. There has clearly been a significant amount of conversion of conifer swamps to other wetland types. Roughly 32%, or nearly 10,000 acres, of conifer swamp has been either drained or converted to other wetland types. Lowland hardwoods, shrub swamp, and emergent wetland categories all show increases in acreage over historical estimates.

Presque Isle

The surface geology of Presque Isle County includes many different landforms, including coarse-textured ground moraine, outwash plains, sand lake plain, and sand dunes. Extensive drumlin fields are located throughout ground moraines which are concentrated

in the southwest and central portion of the county. Most drumlin ridges are well drained along their slopes and soils are poorly drained between the ridges. Outwash deposits, most of which are well to excessively drained, are concentrated around Lake Ella. Sand lake plain extends along all of the coastal townships of the county. Large lakes, such as Black Lake, Grand Lake, and Long Lake are located in these deposits. Poorly drained soils of the sand lake plain are mostly classified as either the Munuscong-Ogemaw-Bergland or the Munuscong-Detour-Alpena-Rubicon soil association. The sand lake plain is often quite thin over dolomite in portions of Presque Isle County, especially surrounding Grand Lake. Large portions of these thin soils are poorly drained. Sand dune features and low beach ridges are concentrated at Hammond Bay, extending east beyond Rogers City.

In the 1840s, ground moraine throughout Presque Isle County supported either northern hardwood forests or mixed pine forests in the uplands, depending on the relative frequency of wildfires that spread from adjacent outwash plains. Outwash and sand lake plain throughout the county supported mixed pine forests and jack pine barrens. Where sand lake plain is thin over limestone bedrock, upland forests of white spruce, balsam fir, cedar, and aspen were common. Historically, wetlands accounted for about 162,000 acres, or 37% of the county surface. Most wetlands were categorized as lowland conifer, with cedar swamp by far the most abundant wetland type at roughly 108,000 acres. Cedar and tamarack swamps were dominant in poorly drained depressions between drumlin ridges, on poorly drained outwash, and in extensive poorly drained areas of sand lake plain. The large coastal dune and swale complex at Hammond Bay supported cedar swamp and conifer-hardwood swamp in its wet swales.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 34% for Presque Isle County. That represents the drainage of about 55,000 wetland acres, mostly due to agricultural drainage, quarrying, and road construction throughout the county. About 66% of lowland conifer acreage, totaling 101,000 acres, was either drained or converted to other wetland types. Aspen-balsam poplar swamp now probably account for a large proportion what was formerly cedar swamp. There has been a 43% decrease in emergent wetland acreage, a loss totaling about 1,300 acres. Both lowland hardwoods (primarily aspen-birch), and shrub swamps, show significant increases in acreage over historical estimates.

Roscommon

The surface geology of Roscommon County is almost entirely dominated by outwash deposits and ice-contact topography. Most of the outwash deposits, especially concentrated in central portions of the county, are poorly drained, with peat and muck soils. These peats and mucks are generally classified as either the Rifle-Carbondale-Greenwood association or the Newton-Saugatuck-Munuscong-Bergland-Rifle Peat association. The ice-contact topography is most concentrated at the southeast extreme of the county and is characterized mostly by moderate to well drained, sandy soils.

In the 1850s, much of the upland of Roscommon County supported mixed pine, oak-pine, and hemlock-white pine forests. Northern hardwoods and hemlock-beech forest was also common on ice-contact topography. Historically, wetlands accounted for about 105,000 acres, comprising 28% of the county surface. Lowland conifers were by far the dominant wetland category, with mixed conifer swamp and conifer-hardwood swamp accounting for most acreage. Mixed conifer swamp, conifer-hardwood swamp, and tamarack swamp dominated poorly drained outwash to the east of Houghton Lake. Mixed conifer swamp of black spruce and tamarack characterized much of the Dead Stream area. Cedar swamp was common with emergent marsh and shrub swamps in smaller depressions throughout the ice-contact features in the southeast end of the county. Extensive bog and muskeg dominated poorly drained outwash to the west of Houghton Lake.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 8% for Roscommon County. That represents the drainage of about 8,400 wetland acres, mostly related to road construction and urban development around Houghton Lake. As with other northern counties, there has clearly been significant conversion of conifer swamp to other wetland types. About 59%, or 52,000 acres of conifer swamps were either drained or converted to other wetland types. Lowland hardwoods, with a significant proportion in aspen and balsam poplar, shrub swamp, and emergent wetlands all show increases in acreage over historical estimates.

Saginaw

The surface geology of Saginaw County is comprised of large expanses of flat, clay and sand lake plain, whose soils are mostly classified as either the Parkhill-Wixom or Sloan-Zilwaukee-Misteguay associations. Clay-rich end moraine and ground moraine are common in the northeastern townships of the county. The Saginaw River drains to the north through a portion of sand lake plain which splits two broad, flat end and ground moraine features. The ground moraines have large areas of poorly drained soils, mostly classified as the Tappan-Londo association. Relict sand dune features are most common in the southwest portion of the county in the Shiawassee River drainage.

In the 1830s, the clay lake plain of Saginaw County supported upland forests of American beech, sugar maple, and basswood locally inter-mixed with hemlock. Poorly drained portions of the clay lake plain supported emergent marsh, mixed hardwood swamp, and tamarack swamp. Upland portions of the sand lake plain supported forests of white pine and hemlock, while poorly drained portions supported extensive emergent marsh and, less commonly, lake plain prairie. The relict sand dune features supported forests of white pine intermixed with white oak and/or beech. The clay-rich moraines supported forests of beech, sugar maple, and basswood, but contained few wetlands. The fine-textured ground moraine supported large swamps dominated by tamarack and black ash.

The comparison of historical data with current MIRIS estimates indicates a net wetland loss of 50% for Saginaw County. That represents the drainage of about 60,000 wetland acres. After extensive conversion to agriculture, just 9% of the upland forests present in 1830 remain in some form today. Although conifer swamps were never abundant in the county (2%), only 15 acres out of 9,200 remain today. Emergent marsh and lake plain prairie have also dramatically declined in overall acreage; from a combined total of 28,578 acres down to 1,274 acres today. Acreages of forested wetlands dominated by lowland hardwoods have declined less dramatically than other wetland types. However, some of the areas described as lowland hardwoods today probably were wet prairies and emergent marshes that were drained for agriculture, and later abandoned. Partially for this same reason, shrub swamp shows increased acreage over historical estimates.

Sanilac

The surface geology of Sanilac County is among the most complex of any county in Lower Michigan. It includes sand and clay lake plain, dune features, outwash deposits, and ground and end moraines with coarse to medium-textured soils. Clay lake plain forms a three-mile wide band along the Lake Huron shoreline and along the Black River drainage in the southern end of the county. Much of the coastal lake plain has moderately drained soils and many deeply cut streams draining into Lake Huron. The soils of the lake plain are classified as London, Iosco, and Saverine series. Poorly drained sand lake plain extends from the north-central end of the county south along the Black River drainage. Much of the sand lake plain and outwash channels support extensive peats and mucks. Peat development over large areas in Sanilac County reach their southern-most extreme in the Great Lakes region. The remainder of the county is gently rolling moraine with soils of variable drainage that are classified as Parkhill, Capac, Guelph, and London series.

In the 1830s, the upland portions of moraines and clay lake plain in Sanilac County supported beech-sugar maple-basswood forest and hemlock-beech forest. Upland portions of sand lake plain and outwash supported hemlock and/or white pine forest. Historically, wetlands accounted for about 199,000 acres, or 32% of the county surface. Mixed hardwood swamp, black ash swamp, mixed conifer swamp, tamarack swamp, cedar swamp, and black spruce swamp were the most abundant wetland types. The extensive peat deposits over sand lake plain in the Minden Bog area supported black spruce swamp and tamarack swamp. Mixed hardwood swamp, black ash swamp, and cedar swamp were located in smaller pockets around the larger peatland complex. Mixed conifer swamp, and black ash swamp were common along the Cass River and its tributaries. Mixed conifer swamp and mixed hardwoods swamp was abundant on ground moraine throughout the southwest end of the county.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 77% for Sanilac County. That represents the drainage of 153,000 wetland acres, ranking Sanilac County among the top three Michigan counties in wetland acreage drained. As with other Michigan counties, conifer swamp was largely drained or converted to other wetland types. Of the estimated 124,000 acres of conifer swamp historically known from the county, none remain.

Apparently extensive fires, probably associated with the logging era passed through much of the Minden Bog area, removing the black spruce and tamarack and leaving leatherleaf and other shrubs as dominants. Succession in these low-productivity wetlands is likely very slow, so much of this area remains shrub-dominated. This explains in part the county-wide increase in acreage for shrub swamps over historical estimates. County-wide, lowland hardwoods have decreased by 48%, or 34,000 acres, and emergent wetlands have decreased by 88%, or 1,300 acres.

Tuscola

The surface geology of Tuscola County is characterized by sand and clay lake plain, end and ground moraines, relict sand dunes, and outwash plains; all, for the most part, oriented in bands trending from southwest to northeast across the county. The sand lake plain and low dunes dominate the Tuscola County shoreline along Saginaw Bay. Soils of this area are mostly classified as the Essexville-Aquents-Tappan association. Further inland, the clay lake plain occurs in 3-5 mile-wide bands, with soils classified as the Tappan-Londo-Avoca association. Low ridges of fine-textured end moraine are found from Reese northeast to Unionville and Colling, while a narrow band of fine-textured ground moraine extends from Tuscola northeast to Cass City. The Cass River flows southwest through a 3-4 mile-wide band of sand lake plain, which includes numerous relict sand dunes scattered across its surface. The southeast edge of the county is predominantly medium- and fine-textured end moraine, with a concentration of outwash deposits near Wilmot and East Dayton.

Historically, wetlands comprised about 149,000 acres, or 29% of the Tuscola County surface. In characterizing the extensive marshes, swamps, and prairies of the Saginaw Bay shoreline in the 1830s, land surveyors described the area as "unexcelled habitat for ducks, geese, and fur bearers." The Great Lakes marsh and wet lake plain prairie extended inland 2-3 miles at Fish Point, and for several miles up the Quanicassee River. The beach ridges found scattered throughout the shoreline area supported open oak savanna or closed-canopy oak-dominated forests. The sand and clay lake plain further inland supported upland forests of beech, sugar maple, and basswood in well drained portions, and swamps of tamarack or hardwoods in poorly drained portions. Black ash swamps were most commonly found on poorly drained portions of the sandy lake plain. The end-moraine ridges throughout the county supported upland forests with eastern hemlock and white pine and small shrub swamp, emergent marsh, and conifer-dominated swamps. The outwash deposits tended to support upland forests dominated by American beech and hemlock.

Acreage comparisons of historical and current wetland types indicate the extent of the impact that agricultural activities have had on the landscape of Tuscola County. Only 10% of the acreage of upland forests present in the 1830's remains today. Due to an extensive drainage system established throughout the county, there has been a net wetland loss of 49% for the county. That represents the drainage of about 73,000 wetland acres. Marsh and wet prairie have declined dramatically (by 88%) due to agricultural development. Conifer swamps have also seen dramatic declines, with fewer than 1% of the 1830's acreages remaining. The logging and conversion of conifer-dominated swamps, along with the drainage of some of the coastal wet prairies, resulted in the relative increase in acreages of lowland hardwoods (up 51%) and shrub swamps (up 376%).

Wexford

Sandy end moraine and outwash plains dominate the surface geology of Wexford County. Soils of the end moraines are predominantly well drained. The outwash deposits are poorly drained in portions, especially along the upper reaches of creeks draining into the Manistee River northwest of Manton. Sand lake plain forms the basins of Lake Mitchell and Lake Cadillac. Most of the sandy soils in this area are poorly drained, classified as the Tawas-Croswell-Lupton association.

In the 1840s, uplands throughout much of the county supported beech-sugar maple forests with varying amounts of white pine and/or hemlock. Hemlock-white pine forest was common on outwash along major rivers. Mixed pine forest and jack pine barrens were found on outwash at the southwest extreme of the county. Historically, wetlands accounted for about 27,000 acres, or just 7% of the county surface. Conifer swamps of cedar, tamarack, or a mix of the two, were the most common wetland types in the county. They were most abundant on poorly drained ground moraine supporting streams feeding into the Manistee River, and on sand lake plain west of Lake Mitchell.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 17% for Wexford County. That represents the drainage of about 4,700 acres, mostly due to agricultural drainage and road construction throughout the county. The flooding at Hodenpyl Dam inundated several hundred wetland acres. Conifer swamps have decreased in acreage by 71%, or almost 17,000 acres. Other wetland categories indicate increases in acreage relative to historical estimates, resulting from the conversion of conifer swamps during the past century.

Region 3 - County Profiles

Allegan

The surface geology of Allegan County includes sand lake plain, sand dunes, outwash plains, and moraines of fine- and coarse-textured material. Sand lake plain dominates the west-central portion of the county. The bed of the Kalamazoo River cuts deeply through these thick, sandy deposits, flowing to the northwest. Sand dunes within the county are limited to the well drained, steep slopes of the Saugatuck Dunes. Outwash deposits are concentrated in the eastern townships of the county, either as extensive plains, or as channels containing the Rabbit River located between end moraine ridges. Soils of the sand lake plain and outwash deposits are mostly well drained to excessively drained, but poorly drained soils are classified as either the Morocco-Newton-Oakville or the Glendora-Adrian-Granby associations. Moraines extend in a northeasterly direction across the east-central portion of the county, and from the southwestern shoreline north and east through Overisell Township. Soils of the moraines are generally loamy, with many poorly drained inclusions. They are mostly classified as the Capac-Rimer-Pipestone association or the Marlette-Capac-Metea association.

In the 1830s, uplands of Allegan County included a variety of forests and barrens. American beech, sugar maple, and basswood forest was common throughout the moraines. Oak-hickory forest was common on outwash deposits in the southeast end of the county. Beech was co-dominant with eastern hemlock on portions of the sand lake plain close to Lake Michigan. Much of the sand lake plain now included within the Allegan State Game Area was a mosaic of forest and barrens dominated by white oak and white pine. Frequent fires on the droughtiest portions resulted in open oak-pine barrens. Historically, wetlands accounted for nearly 82,000 acres, or 155 of the county surface. Large swamps dominated by tamarack and/or black ash and silver maple were common on poorly drained outwash and sand lake plain. Wet prairie, emergent marsh, and elm-ash swamp were found along the Gun River. Most of the Kalamazoo and Rabbit river floodplains were dominated by mixed hardwood swamp and conifer-hardwood swamp. A large bog was located among extensive tamarack swamp south of Fenville. On the moraines, smaller pockets of wetlands were more common. These included tamarack swamp, mixed hardwood swamp, emergent marsh, and occasionally shrub swamp.

Comparison of historical map data with current MIRIS data indicates a net wetland loss of 16% for Allegan County. This represents a loss of roughly 13,000 wetland acres. Most of the losses came from the drainage of conifer swamp and emergent wetlands, which declined by 98% and 22%, respectively. Nearly all of the 33,000 acres of conifer swamp was either drained or converted to lowland hardwoods and shrub swamp, both of which increased in acreage.

Barry

The surface geology of Barry County includes extensive outwash deposits as well as moraines with soils that vary from sandy to loamy textures. Outwash plains are concentrated in Barry Township and Yankee Springs Township. More narrow outwash channels contain the beds of the Thornapple River and its tributaries extending across much of the northern third of the county. Poorly drained areas of outwash are most concentrated in river floodplains and contain muck soils classified as the Houghton-Sloan association. Sandy end moraine dominates the central and southeast part of the county, most of which is well drained. Moraines with loamy soils are concentrated in the northeast quarter of the county, with somewhat poorly drained areas containing soils classified as either the Marlette-Capac or the Perrington-Ithaca-Marlette associations.

Circa 1820, much of the uplands of Barry County were a complex mosaic of oak savanna, oak-hickory forest, and beech-sugar maple forest, depending on soil moisture conditions and the frequency of wildfires. The oak savanna was most concentrated on the outwash deposits at the southern and western ends of the county. White oak-white pine forest was also located around the north end of Gun Lake. Wetlands represented roughly 11%, or nearly 40,000 acres of the county surface, according to the historical maps.

Lowland conifer swamp and mixed conifer-hardwood swamp were the most common wetland types, totaling more than 21,000 acres county-wide, with most dominated by tamarack with mixed hardwoods. These swamps, along with many small depressions supporting emergent marsh and wet prairie, were characteristic of the outwash deposits. Larger wetlands, predominantly tamarack swamp, and mixed hardwood swamp, were characteristic of poorly drained portions of the end and ground moraine in the northeastern portion of the county. Mixed hardwoods were predominant in the active floodplain of the Thornapple River.

The comparison of historical map data with current MIRIS data is problematic in Barry County. Soil survey data were utilized in this county when it became clear that there was significantly greater wetland acreage estimated for the current condition than for the historical condition. Even with this adjustment there remains a significant distortion in the data sets for making this comparison. It is possible that, with the number of small isolated wetland areas throughout the county, that overall historical wetland extent was significantly underestimated, but further investigation is needed in this county. Perhaps the only conclusion that can be made concerning wetland trends in Barry County is the near elimination of tamarack swamp. Over 16,000 acres of tamarack swamp was noted by land surveyors in the 1820s. Very few occurrences of this wetland type remain in the county. Additionally, of the 950 acres of wet prairie known to exist in the county from the historical maps, there remains only one known example, just northeast of Gun Lake.

Berrien

Berrien County includes a high diversity of glacial landforms, including sand and clay lake plain, sand dunes, outwash and ice-contact deposits, and moraines comprised of fine-, medium-, and coarse-textured material. Sand lake plain is most concentrated in a 3-5 mile-wide band extending north from Baroda through Benton Harbor. Clay lake plain is concentrated at the southwest end of the county including much of the Galien River's basin. Outwash plains and ice-contact deposits, most of which are well drained, are concentrated around Niles. The outwash channel containing the floodplain of the St. Joseph River further north, however, is somewhat poorly drained and swampy. Poorly drained soils of the lake plain and outwash deposits are classified as the Morocco-Thetford-Granby, Shoals-Cohocton-Abscota, or Pella-Kibbie associations. Fine- and medium-textured moraines are most concentrated in the south-central portion of the county. Coarse-textured moraine dominates the northeast end of the county. Most of the moraines in Berrien County are at least moderately well drained, but somewhat poorly drained portions contain soils classified as the Blount-Rimer association.

Circa 1820, much of the upland surface of Berrien County was dominated by beech-sugar maple-basswood forest, oak-hickory forest, and in the southeast end of the county, oak savanna and tallgrass prairie. Historical wetland extent is estimated to have been 11% of the county surface, or roughly 40,000 acres. Extensive floodplain forest of mixed hardwoods and silver maple swamp were characteristic along lower reaches of the St. Joseph and Paw Paw rivers. Great Lake marsh was found in the "drowned" river mouths of both of these rivers and the Galien River. Black ash swamp was common along portions of the Galien River. Extensive wetland complexes, including emergent marsh, tamarack swamp, bog, black ash swamp, and elm swamp were characteristic southeast of the town of Three Oaks, and surrounding the town of Baroda. Lake plain prairie was common near Hinchman.

Comparison of historical map data with MIRIS estimates indicates a 31% county-wide wetland loss. That represents a net wetland loss of about 12,000 acres. This may be a conservative estimate, considering the amount of wetland drainage that has taken place along the St. Joseph River and in the above mentioned areas around Three Oaks and Baroda. Today, approximately 75% of Berrien County has been converted for agriculture or urban land use. The roughly 5,000 acres of tamarack swamp and mixed tamarack-hardwood swamp historically noted for Berrien County appear to have been eliminated entirely.

Branch

Sandy ground moraine and outwash deposits dominate the glacial geology of Branch County. On the surface of the ground moraine, numerous low drumlin ridges are oriented from northeast to southwest. The drumlins, which are sometimes separated by narrow outwash deposits, are low and broad. The soils on the end moraine and ground moraine are typically sandy loam or loamy sand, and most are well drained. Poorly drained portions of the

ground moraine contain soils classified as the Hatmaker-Locke-Barry, Locke-Barry-Hillsdale, or Morley-Locke-Houghton associations. Most of the outwash deposits have well or moderately well drained sands and loamy sands. Very poorly drained soils are common in the narrow outwash channels between drumlins and in ice-block kettles or abandoned stream channels. These poorly drained soils are classified as the Fox-Houghton-Edwards and Matherton-Sebewa-Branch associations. Lakes are common on the outwash plain, where they occupy ice-block kettles or abandoned channels. Small streams are numerous; many originating from wetlands on the outwash plain.

Circa 1820, most of the uplands of Branch County were a mosaic of beech-sugar maple-basswood forest, oak-hickory forest, white oak savanna, black oak barrens, and tallgrass prairie. Beech-sugar maple-basswood forest was concentrated on the ground and end moraines, while the outwash deposits, which are drier and more fire-prone, supported the oak forests, savannas, and prairies; all systems maintained by fire. Total wetland acreage, as estimated from historical maps, was approximately 57,000 acres, or roughly 17% of the county surface. Lowland hardwoods and emergent wetlands were the most common wetland categories in Branch County. On the ground moraine, mixed hardwood swamp and tamarack swamp were common between drumlin ridges. Similar wetland types characterized large expanses of poorly drained outwash and surrounded lakes, such as Coldwater Lake. Mixed hardwood swamp was common throughout the active floodplains of the Coldwater and St. Joseph rivers.

Comparing historical map data to MIRIS estimates, there has been a 15% net wetland loss in Branch County. That represents the drainage of about 8,600 wetland acres. This appears to be an underestimate of wetland loss county-wide, and further investigation is needed to more definitively assess this county's wetland status. Today, roughly 80% of the county surface has been converted for agriculture or urban development. Similar to statewide trends, lowland conifer and emergent wetlands both saw significant declines in acreage, while lowland hardwoods and shrub swamps increased in acreage. This reflects the logging and conversion of conifer swamps, resulting in a shift in dominant species. Many emergent wetlands, especially wet prairies and some emergent marshes, were relatively easy to drain for agriculture.

Calhoun

The surface geology of Calhoun County is comprised mostly of outwash deposits and moraines of coarse- and medium-textured material. Outwash channels formed around island-like uplands of end and ground moraine include the beds and floodplains of major rivers such as the Kalamazoo and St. Joseph rivers and Battle Creek. More extensive outwash plains are located south of Marshall, and in the southwest corner of the county near Athens. The outwash channels along major rivers include extensive floodplain, with poorly drained soils mostly classified as the Macomb-Allendale-Berrien association. Wetlands on the more extensive outwash plains are found mostly in small potholes, with soils classified as the Fox-Osthemo-Plainfield association. Most of the coarse-textured moraines in the county are well drained. Medium-textured moraines are concentrated at the northeast extreme of the county. These areas include small, somewhat poorly drained depressions with loamy soils. Very poorly drained areas include muck soils classified as the Carlisle-Rifle association.

Circa 1825, the uplands of Calhoun County included extensive oak savannas with smaller inclusions of tallgrass prairie, both maintained by frequent wildfire. Other less frequently burned uplands included oak-hickory forest and beech-sugar maple-basswood forest. Historical estimates of wetland extent are about 86,000 acres, or 19% of the county surface. Emergent marsh, tamarack swamp, mixed hardwood swamp, and wet prairie were among the most common wetland types in the county. Most wetlands were found in poorly drained outwash deposits between moraine ridges. Mixed hardwood swamp and wet prairie were common in the floodplain of the Kalamazoo and St. Joseph rivers. Mixed hardwood swamp, tamarack swamp, and emergent marsh was common in poorly drained portions of ground moraine in the northwest part of the county.

Comparison of historical map data with MIRIS estimates indicates a net wetland loss of 9% for Calhoun County. Given the extensive agricultural drainage that has occurred throughout the eastern half of the county, this appears to be an underestimate. Further investigation is needed to establish the current wetland status of Calhoun County. There has clearly been a significant decrease in acreage for both lowland conifers and emergent wetlands. About 98% of tamarack and conifer-hardwood swamp acreage, and 88% of emergent wetland acreage appears to have been drained or converted to other wetland types.

Both shrub swamps and lowland hardwood categories indicate relative increases in acreage over historical estimates.

Cass

The surface geology of Cass County is dominated by outwash plains, sandy ice-contact deposits, and coarse-textured ground moraine. The ice-contact deposits form moderate to steeply sloping ridges extending from southwest to northeast across the county. Ground moraine is concentrated in long, linear bands near Dowagiac and Nicholsville, and in a township-size area south of Calvin Center. Outwash plains are most concentrated in the southeast and northwest quarters of the county. Poorly drained soils on the outwash deposits are most commonly associated with river floodplains and old glacial lake beds. Soils in these areas are classified as either the Glendora-Adrian-Cohoctah association or as Houghton mucks.

In the 1820s, the uplands of Cass County supported a mosaic of tallgrass prairie, oak savanna, oak-hickory forest, and beech-sugar maple-basswood forest. The prairies and savannas were most concentrated on outwash plains where wildfires frequently swept across large areas. Oak-hickory forest and beech-sugar maple-basswood forest were more commonly on ground moraine and ice-contact topography where wildfire was less frequent. The historical estimate of wetland extent for the county is about 46,000 acres, or 14% of the county surface. Emergent marsh and wet prairie were among the most common wetland types, along with mixed hardwood swamp, and tamarack swamp. Emergent marsh and wet prairie were most common surrounding lakes and in drainages throughout the outwash deposits. A large wet prairie was located just east of Niles. Extensive mixed hardwood swamp formed much of the headwaters of the Dowagiac River.

Comparison of historical data with MIRIS estimates indicates a 16% net wetland loss for Cass County. This represents the drainage of about 7,400 wetland acres. Given the extensive agricultural drainage that has taken place in the county, this may be an underestimate of actual wetland loss. Future investigation is called for to establish a more definitive wetland status for this county. It is clear from available data that tamarack swamp and emergent wetlands have decreased significantly relative to historical estimates. Nearly 10,000 acres of tamarack swamp, and 15,000 acres of emergent marsh and wet prairie were either drained or converted to other wetland types. Both lowland hardwoods and shrub swamp appear to have increased in acreage over historical estimates.

Clinton

The surface geology of Clinton County consists of gently rolling to flat ground moraine, outwash channels, and sand lake plain. Ground moraine dominates the southern two thirds of the county. Poorly drained depressions are common throughout this landscape of predominantly loamy soils. Poorly drained portions of the ground moraine include soils classified as the Houghton-Gilford-Adrian association. The outwash deposits from the stream channels and floodplains of major rivers draining the county, including the Looking Glass River, Stony Creek, and the Maple River. Poorly drained loams in these areas are mostly classified as the Sebewa-Matherton-Boyer or Sloan-Houghton-Cohoctah associations. Sand lake plain is limited to the northeast extreme of the county, only portions of which are poorly drained.

In the 1830s much of the upland of Clinton County was beech-sugar maple-basswood forest. Oak-hickory forest and oak savanna were common in the southeast quarter of the county, and along the northeastern county border. From historical map data, there were approximately 57,000 acres of wetlands county-wide, representing roughly 16% of the county surface. Mixed hardwood swamp was the most common wetland type, most concentrated in river floodplains. Mixed conifer swamp, tamarack swamp, and even a few black spruce swamps were located throughout poorly drained portions of ground moraine. Wet prairie was also common in Bath Township.

Comparison of historical map data with MIRIS estimates indicates a 43% net wetland loss for Clinton County. This represents the loss of approximately 27,000 wetland acres. All wetland categories except shrub swamps show significant declines in acreage. All of roughly 17,000 acres of conifer swamps historically represented in the county have been either drained or converted to other wetland types. Lowland hardwoods, as a wetland category have declined in acreage by 19%; roughly 4,700 acres. Emergent wetlands have declined in acreage by 71%, or roughly 8,000 acres.

Eaton

The surface geology of Eaton County consists of gently sloping ground and end moraine broken by several large outwash channels. The end-moraine ridges, which cross-cut the ground moraine, typically do not form single, well-defined ridges but rather groups of low ridges and swampy depressions. There are a few small lakes, both kettle lakes on the end moraines and lakes occupying more linear depressions on the ground moraine. Poorly drained soils also occupy small depressions in the uplands; most are classified as either the Capac-Parkhill or Marlette-Capac-Owosso associations. Outwash channels form the stream channels and floodplains of Battle Creek and the Thornapple River. Poorly drained mucks in these drainages are classified as either the Boyer-Cohoctah-Houghton, or Houghton-Gilford-Adrian soil associations.

Circa 1830, upland portions of the ground and end moraines in Eaton County were overwhelmingly dominated by beech-sugar maple-basswood forest. Some of the drier end-moraine ridges at the southern end of the county supported oak-hickory forest and oak savanna. Based on historical data, there were approximately 60,000 acres of wetland county-wide. Throughout most of the fine-textured moraines and poorly drained outwash, large swamp forest was often configured within long linear depressions, or along major river floodplains. Mixed hardwood swamps were common in the river floodplains, and were dominated by American elm, black ash, red ash, silver maple, and swamp white oak. Tamarack swamp, mixed tamarack-hardwood swamp, willow-button bush swamp, and emergent marsh were among the common wetland types throughout the ground moraine and outwash deposits. Wet prairie was also found on poorly drained ground moraine in the southeast extreme of the county.

Comparison of historical map data with MIRIS estimates indicates a 45% net wetland loss for Eaton County. That represents the loss of about 27,000 wetland acres. None of the estimated 35,000 acres of conifer swamp remain in the county today. They were apparently drained or converted to lowland hardwoods, a wetland category that increased in acreage by 44%, or 8,300 acres. Both shrub swamp and emergent wetland categories also declined in acreage, by 5% and 28%, respectively.

Genesee

The surface geology of Genesee County is quite complex; including rolling end and ground moraines with medium-and fine- textured soils, clay lake plain, sand lake plain, and outwash channels. End and ground moraine dominates the north-central and southeast portions of the county. Somewhat poorly drained portions have soils classified as the Conover-Brookston association. The townships of Flushing, Vienna, and Montrose are located on sand lake plain, with some inclusions of clay lake plain. The City of Flint is also located on a clay lake plain, which extends for several miles to the northeast and south. Soils of the clay lake plain are somewhat poorly drained clays of the Del Rey-Lenawee association. Both the Flint River and the Shiawassee River pass through outwash deposits in the northeast and southern portions of the county. Poorly drained portions of outwash and sand lake plain contain soils classified as the Boyer-Spinks-Ceresco-Cohoctah association. The concentrations of lakes in Argentine and Fenton townships are located on outwash and moraine landforms.

Historically, much of the sand lake plain in the northwest townships of Genesee County supported upland forests of American beech, sugar maple, white oak, and basswood. There were also upland forests close to the Flint River with white pine as a co-dominant. Based on historical map data, there were approximately 43,000 acres of wetlands, totaling 10% of the county surface. A large lake plain prairie was located just north of the Flushing. Other poorly drained portions of the sand lake plain supported mixed hardwood swamp. The end moraines in the northeast portion of the county supported oak-dominated forests on the uplands, with tamarack, and small hardwood-dominated swamps. The rolling moraines at the southern end of the county supported oak-dominated savannas with numerous small wet prairies, tamarack swamps, and lowland hardwood swamps.

Urban and agricultural land use, which currently occupy as much as 81% of the county's surface area, has transformed the natural landscape of Genesee County. Upland forests and savannas on rich soils were exploited for agriculture. Genesee County today contains 13% of the forested acreage that existed in the 1820s. Some of today's forests are probably in areas that were described as "poor, sandy barrens" by surveyors. These savannas were maintained open by periodic fires, which swept across this landscape.

Since European settlement, wildfires have been virtually eliminated from this landscape. The savannas that were located on poor soils, often after one or more attempts at farming, were abandoned and have grown into closed-canopy forests. Approximately 56% of the presettlement wetland acreage has been lost in Genesee County. All wetland categories except for shrub swamps have declined dramatically. Almost no acreage of conifer swamps remain today, while just 44% of the acreage in hardwood-dominated swamps remain. Of the historical acreage in emergent wetlands, just 53% remain.

Gratiot

The surface geology of Gratiot County includes sand lake plain, clay lake plain, outwash channels, and moraine composed of fine-, medium-, and coarse-textured materials. Sand lake plain dominates the southeast townships of the county, surrounding the towns of Ashley and Bannister. Much of the sand lake plain consists of sand overlain on loam or clay subsoil. Clay lake plain is predominant in the northeast quarter of the county, and surrounding the town of Middleton. Poorly drained portions of the lake plain contain soils classified generally within the Macomb-Brookston association. The outwash channels include the stream channels as floodplains of the Pine Creek. Poorly drained soils within these deposits are generally classified as the Vestaburg-Tedrow-Boyer association. While much of the plains and ridges of the moraines in the county are at least moderately well drained, poorly drained flats are occasionally present.

In the 1830s much of the upland forest of Gratiot County was dominated by beech, sugar maple, and basswood. White pine, hemlock, and white oak-white pine forests were common on the sand lake plain along the east edge of the county. Based on historical map data, there were approximately 73,000 acres of wetland, or roughly 20% of the county surface. Most wetlands were categorized as lowland hardwoods, with black ash swamp and mixed hardwood swamp most common. Mixed hardwood swamp, tamarack swamp, and emergent marsh were characteristic of what is now the Gratiot-Saginaw State Game Area, and mixed hardwood swamp dominated the active floodplain of the Maple River. Extensive mixed hardwood and tamarack swamp and a large wet prairie were noted to the east and west of Ithaca.

Comparison of historical map data to MIRIS estimates indicates 38% loss in wetland acreage for Gratiot County. That represents a loss of approximately 28,000 wetland acres. Given that agricultural land use occupies roughly 76% of the county surface, and large wetland areas were clearly drained for agriculture, this estimate may actually be conservative. All wetland categories but shrub swamps show significant declines in acreage. Nearly 96% of conifer swamp acreage, totaling roughly 15,300 acres, has been either drained or converted to other wetland types. Lowland hardwoods declined in acreage by 21%, or 11,300 acres. Emergent wetlands declined by 82%, or 1,800 acres.

Hillsdale

The surface geology of Hillsdale County includes outwash plains, coarse-textured end moraine, and medium-textured end and ground moraine. Outwash deposits are predominant between end moraine ridges in the northwest half of the county. The stream channels and floodplains of the St. Joseph River are located within these outwash channels. Poorly drained soils in the outwash deposits are generally classified as the Fox-Osthemo-Plainfield association. Sandy end moraine is also concentrated in the northwest half of the county, with poorly drained soils generally uncommon. End moraine and gently rolling ground moraine dominate the southeast half of the county. Poorly drained soils are most common in the drainage of the St. Joseph River's East Branch in Wright and Ransom townships. Soils in this area are mostly classified as the Conover-Miami-Brookston association.

In the 1820s, much of the upland of Hillsdale County included beech-sugar maple-basswood forest on most medium-textured moraine ridges, with oak-hickory forest, white oak savanna, and dry black oak barrens on sandier moraines and outwash. Based on historical map data, there were approximately 51,000 wetland acres comprising 13% of the county surface. Most of the wetland acreage was distributed among mixed hardwood swamp, tamarack swamp, and emergent marsh; types that were common on all glacial landforms. Buttonbush-willow swamp and wet prairie were common in small depressions throughout the sandy end moraine and outwash deposits. Mixed hardwoods were predominant among the active floodplains of the St. Joseph River.

Comparison of historical map data with MIRIS estimates is problematic in Hillsdale County. There clearly has been extensive wetland drainage, but MIRIS estimates indicate more current wetland acre-

age than those recorded from historical maps. Further investigation is needed to establish current wetland estimates for this county. Regardless of ambiguities in total wetland acreage, it is clear that nearly all of the 14,000 acres of tamarack swamp historically characteristic of the county have been drained or converted to other wetland types. Similarly, 62% of the emergent wetland acreage, including 7,000 acres of historical wet prairie, has been drained or converted to shrub swamp or lowland hardwoods.

Ingham

The surface geology of Ingham County is dominated by gently rolling till plain traversed by narrow east-west oriented end moraine ridges. The surface of the till plain includes a series of cobbly eskers generally oriented north-south. Soils of the till plain vary in their drainage characteristics. While most are moderately well drained, somewhat poorly drained to poorly drained inclusions are found on flats and narrow valleys. Outwash deposits contain the stream channel and floodplains of the Grand River in the southern end of the county. Poorly drained portions of outwash include mucks of the Houghton-Palms-Edwards association. There is also a concentration of sandy outwash deposits near the town of Bunker Hill. Poorly drained portions of this plain contain soils classified as the Oshtemo-Riddles-Houghton association.

In the 1820s, most of the upland of Ingham County was beech-sugar maple-basswood forest. Oak-hickory forest and white oak savanna were found along the Red Cedar River, and surrounding Lake Lansing. Oak-hickory forest, dry black oak-white oak forest, and oak savanna were common on the outwash and ground moraines across the southern townships of the county. Based on historical map data, there were approximately 78,000 acres of wetland in the county. The most common wetlands were tamarack swamps, which totaled nearly 25,000 acres. These swamps were common in poorly drained valleys between moraine ridges. Mixed hardwood swamp was common in active river floodplains. Outwash deposits at the south end of the county supported wet prairie, emergent marsh, tamarack swamp, and button-bush-willow swamp.

Comparison of historical map data with MIRIS estimates indicate a net wetland loss of 45% for Ingham County. That represents a loss of roughly 35,000 wetland acres. Based on MIRIS data, 99% of the lowland conifer swamp of Ingham County has been either drained or converted to other wetland types. About 72% of emergent wetland acreage has been similarly effected. Lowland hardwood and shrub swamp categories increased in acreage by 80% and 61%, respectively; reflecting the large-scale conversion of other types.

Ionia

The surface geology of Ionia County is predominantly medium-textured moraine and coarse-textured outwash deposits. The gently rolling surface of the moraines is formed by end moraine ridges alternating with flat ground moraine. The ridges are generally oriented in a north-south direction. The outwash channels are deeply cut, perpendicular to the moraine ridges, and form the stream bed and floodplain of the Grand River and its major tributaries. The loamy soils of the moraines vary in their drainage characteristics. Poorly drained soils are most concentrated in the south-central portion of the county and are generally classified as the Conover-Brookston association. Poorly drained portions of the outwash channels are most concentrated along the Grand River. These soils are generally classified as the Carlisle-Cohoctah-Sloan association.

In the 1830s, the uplands of Ionia County were a mosaic of beech-sugar maple-basswood forest, oak-hickory forest, and oak savanna. Oak forest and savanna was most closely associated with outwash deposits along major rivers. Based on historical map data, there were nearly 46,000 wetland acres in the county, with lowland hardwoods being prevalent. Mixed hardwood swamp was most common in active river floodplains, along with wet prairie, buttonbush-willow swamp, and emergent marsh. Large swamps of mixed hardwoods, black ash, and tamarack were common on poorly drained portions of ground moraine throughout the county. Smaller swamps and marshes were common on outwash and ground moraine east of the town of Belding.

Comparison of historical map data with MIRIS estimates indicates a net wetland loss of 19% for Ionia County. Given the extensive wetland drainage that occurred in south-central townships, that may be a conservative estimate of wetland loss. That represents a loss of roughly 8,700 wetland acres county-wide. Based on MIRIS data, none of the estimated 16,000 acres of tamarack swamp historically represented remain in the county. All were apparently drained or converted to other wetland types. Nearly 92% of emergent wetland acres, totaling roughly

3,800 acres were similarly effected. Lowland hardwoods and shrub swamps increased in acreage by 24% and 145%, respectively.

Jackson

The surface geology of Jackson County includes outwash and ice-contact deposits, as well as sandy end and ground moraine. Outwash plains are most extensive in the townships east of the city of Jackson, but the stream channels and floodplains of all major rivers, including the Grand, Kalamazoo, St. Joseph, and River Raisin, are contained within outwash channels located throughout the county. Shallow outwash deposits are in some places underlain by bedrock or fine-textured till and lacustrine deposits, causing poor or very poor drainage conditions. Poorly drained soils in the outwash deposits are generally classified as the Boyer-Oshtemo-Houghton association. Northeast of Jackson, steep, sandy kettle-kame topography is common. Ice contact deposits form kettle lakes, kames, eskers. Poorly drained areas, often located at the base of steep slopes, or on lake margins, contain soils generally classified as the Houghton-Palms-Henrietta association. West of Jackson, the topography is more gentle, with broad, coarse-textured ridges surrounded by deposits of outwash sand. The soils of these moraines are typically well drained to excessively drained.

In the 1820s, the uplands of Jackson County supported a mosaic of oak savanna, black oak-white oak forest, and oak-hickory forest. Wildfire played a dominant role in shaping the mosaic of upland vegetation in the county, with oak savanna, mixed oak forest, and oak-hickory forest all experiencing fire, but with relatively lower frequency, respectively. Based on historical map data, there were approximately 100,000 acres of wetland county-wide. Most wetland acreage, totaling nearly 68,000 acres were emergent wetlands. Nearly 50,000 acres in Jackson County were described by land surveyors as wet prairie. These wetlands were common throughout the county, but were most concentrated in narrow drainages on outwash and ice-contact deposits. Tamarack swamp comprised 20,000 acres of wetland in Jackson County, and like the wet prairies, was most common on poorly drained outwash and ice-contact deposits in the eastern half of the county. Mixed hardwood swamp was common in the active floodplain of the Grand River and along many small streams throughout the county.

Comparison of historical map data with MIRIS estimates indicates a net wetland loss of 12% for Jackson County. That represents the loss of 12,000 acres. Given the amount of agricultural development in Jackson County, that estimate of wetland loss appears to be conservative. But given the irregular topography of the county, it is likely that many wetlands were too difficult to drain. Wetlands throughout Jackson County have certainly changed in character. Based on MIRIS data, 95% of tamarack swamps and 95% emergent wetlands of the county have been either drained or converted to other wetland types. Of the estimated 50,000 acres of wet prairie, only one eight-acre prairie remnant is known to remain (MNFI database). Both lowland hardwood and shrub swamp categories show significant increases in acreage over historical estimates.

Kalamazoo

Outwash plains, ice-contact ridges, medium-textured ground moraine with drumlin fields, and coarse-textured end moraine characterize the surface geology of Kalamazoo County. Flat to gently rolling outwash deposits dominate the central portions of the county, while more steeply sloping ice-contact topography extend along north-south ridges in the western-most townships of the county. Soils of these landforms are mostly well drained, but poorly drained areas are found among soils classified as the Kalamazoo-Schoolcraft, Coloma-Spinks-Oshtemo, or Thetford-Gilford-Granby associations. The medium-textured ground moraine is concentrated in the southeastern townships of the county on either side of the Little Portage River. The loamy soils of the drumlin fields are generally well drained, but poorly drained areas are common between drumlin ridges.

In the 1820s, the uplands of Kalamazoo County supported a mosaic of tallgrass prairie, oak savanna, oak-hickory forest, and beech-sugar maple-basswood forest. Black oak barrens, white oak and bur oak savanna, and tallgrass prairie, were prevalent on the outwash and ice-contact deposits throughout the western half of the county. Beech-sugar maple-basswood forest dominated the drumlin fields in the southeastern portion of the county. Historical map data indicate that approximately 58,000 acres of wetlands were found in the county, comprising 16% of the county surface. Mixed hardwood swamp and tamarack swamp were dominant in the floodplain of the Kalamazoo River. Mixed hardwoods, tamarack swamp, and emergent marsh were common in smaller

pockets throughout other portions of the outwash deposits, and between drumlin ridges on the ground moraine.

Comparison of historical map data with MIRIS estimates indicates a net wetland loss of 51% for Kalamazoo County. That represents the drainage of roughly 29,000 wetland acres. Wetland loss has occurred throughout the county, but has been concentrated around the City of Kalamazoo and adjacent portions of the Kalamazoo River floodplain. All wetland categories but shrub swamp show significant declines from historical acreage estimates. About 97% of lowland conifer acreage, including some 15,000 acres of tamarack swamp were either drained or converted to other wetland types. About 84% of emergent wetland acreage, and 62% of lowland hardwood acreage were similarly effected.

Kent

The surface geology of Kent County includes outwash channels of varying width as well as moraine ridges and till plains of coarse, medium, and fine texture. The outwash channels occupy the bottoms of steeply sloping valleys formed by adjacent moraines. The stream channels and floodplains of the Grand River, Rogue River, Flat River, and Thornapple River are all included in these channels. Poorly drained soils of the outwash channels are directly associated with the rivers and are generally classified as mucks in the Houghton-Cohoctah-Ceresco association. Medium-textured moraine dominates much of the north and southeast ends of the county. Coarse-textured moraine within the county is limited to the Montcalm-Ionia county border. While much of the coarse- and medium-textured moraines are well drained, poorly drained portions tend to include soils of the Marlette-Capac-Metamora association, and the Capac-Parkhill-Marietta association. Fine-textured moraine is concentrated from just east of Grand Rapids extending south to the county border. Poorly drained soils in this area tend to be classified as the Ithaca-Rimer-Perrington association.

In the 1820s, the uplands of Kent County supported a diverse mosaic of forest and savanna. Beech-sugar maple-basswood forest, white pine-beech-maple, and oak-hickory forests were all common on moraine ridges. Black oak barrens, white oak savanna, and bur oak savanna were more common on outwash deposits west of Grand Rapids. Historical estimates of wetland extent county-wide are nearly 66,000 acres, or roughly 16% of the county surface. Lowland hardwoods made up the most abundant wetland category, with mixed hardwood swamp dominating much of the floodplain of both the Rogue River and Grand River. Tamarack swamp, mixed hardwood swamp, buttonbush-willow swamp, and emergent marsh were common in small pockets throughout the east-central portion of the county on end and ground moraine. A similar mosaic of small wetlands was common throughout the moraine and outwash deposits north of Sparta.

Comparison of historical map data with MIRIS estimates indicates a net wetland loss of 15% for Kent County. That represents the drainage of roughly 9,100 wetland acres. Wetland losses were likely distributed throughout the county, from agricultural drainage, road construction, and urban development. Approximately 97% of historical conifer swamp acreage, and 64% of emergent wetland acreage was either drained or converted to other wetland types. That represents the drainage or conversion of 15,300 acres of conifer swamp and 5,400 acres of emergent wetlands. Both the lowland hardwoods and shrub swamp categories increased relative to historical acreage estimates.

Lapeer

The surface geology of Lapeer County includes a high diversity of glacial landforms, including clay lake plain, outwash deposits, and moraine comprised of both medium- and coarse-textured material. Clay lake plain is found both at the northern end of the county in Rich Township and to the southeast of the city of Lapeer. Poorly drained portions of the clay lake plain have soils mostly classified as either the Roselms-Paulding or Carlisle-Lupton-Tawas soil association. The outwash deposits in Lapeer County contain the stream channels and floodplains of the Flint River and its tributaries. Poorly drained soils in these channels are mostly classified as the Chelsea-Sloan-Cohoctah association. Most of the coarse-textured moraines, which are concentrated in central and southern portions of the county, contain moderate to steep slopes that are well drained. The medium-textured moraines, which are mostly concentrated in the northeast extreme of the county, contain a mixture of well drained and poorly drained conditions. The soils of these landforms range in texture from sandy loam to clay loam. Poorly drained soils are mostly classified as the Capac-Belding-Brookston association. Fine-textured end moraine is limited to several north-south oriented ridges located just east of Imlay

City. Soils of these landforms are poorly drained and classified as the Conover-Blount-Brookston association.

In the 1820s, the uplands of Lapeer County supported a diverse array of forests and savannas. Oak savanna and oak-hickory forest were common on moraines and outwash deposits in the southern and southwestern portions of the county. The clay lake plain and end moraine throughout central and northern portions of the county supported beech-sugar maple-basswood forest, and forests with varying combinations of white pine, beech, red maple, and hemlock. Historical estimates of total wetland extent are about 83,000 acres, or 18% of the county surface. Lowland hardwoods and lowland conifers were evenly split with roughly 40,000 acres represented in each category. Mixed hardwood swamp was common in the floodplain of the Flint River and its tributaries. Mixed conifer swamp, cedar swamp, and tamarack swamp were common throughout the outwash, end moraine, and clay lake plain, and also in small depressions throughout the Metamora-Hadley area.

Comparison of historical map data with MIRIS estimates indicates a net wetland loss of 40% for Lapeer County. That represents the loss of about 33,000 wetland acres. Agricultural drainage, road construction, and urban development account for most wetland losses. Most significant wetland losses have been in the category of lowland conifers, which have apparently decreased in acreage by 97%, or about 37,000 acres. Lowland hardwoods decreased by 25%, or about 10,000 acres. A fair portion of these swamps were likely converted to shrub swamp and emergent wetlands; both categories having increased in acreage relative to historical estimates.

Lenawee

The surface geology of Lenawee County includes clay lake plain, sand lake plain, outwash deposits, and moraine composed of coarse-, medium-, and fine-textured materials. The clay lake plain dominates the southeastern 40% of the county. This level, poorly drained landscape contains clay-rich soils that are generally classified as the Nappanee-Hoytville-Pewamo association. Sand lake plain was formed as sandy outwash was deposited over the surface of the clay lake plain, then re-worked by the wave action of proglacial lakes. The stream channel and floodplain of the River Raisin, where it crosses the lake plain, is located within these deposits. The poorly drained soils of this area are generally classified as the Macomb-Allendale-Berrien association. Outwash deposits are found adjacent to sandy end moraine along the Jackson County border and forming the channel occupied by the northwestern portions of the River Raisin. Poorly drained portions of these deposits are limited to several river floodplains and margins of lakes. Fine- and medium-textured end and ground moraine extends from the southwest corner of the county across to the northeast. Soils of the these landforms range in texture from sandy loam to clay loam, with poorly drained portions classified mostly within either the Brady-Sebewa or Blount-Pewamo-Nappanee association.

In the 1820s most of the upland portions of lake plain and fine-textured moraine in Lenawee County

supported beech-sugar maple-basswood forest. Oak-hickory forest, black oak-white oak forest, white oak savanna, and black oak barrens were common on sand lake plain around the town of Morenci, surrounding the River Raisin floodplain near Tecumseh, and throughout outwash and sandy moraine at the northwest end of the county. Wetlands accounted for about 124,000 acres, or 26% of the county surface. Lowland hardwoods were the predominant wetland category, followed by emergent wetlands, lowland conifers, and shrub swamps. Mixed hardwood swamp and black ash swamp encompassed large expanses of the clay lake plain. A large lake plain prairie, encompassing about seven square miles, was located between Deerfield and Britton along the Monroe County border. Mixed hardwood swamp dominated the floodplain of the River Raisin. Tamarack swamp, mixed hardwood swamp, wet prairie, and emergent marsh were common in small pockets and narrow drainages throughout the northwest end of the county.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 69% for Lenawee County. That represents the drainage of about 86,000 wetland acres, primarily due to agricultural activities. All of the estimated 9,700 acres of tamarack swamp, about 14,000 acres (77%) of emergent wetlands, and 65,000 acres (68%) of lowland hardwoods historically recorded from Lenawee County have been drained or converted to other wetland types. Shrub swamps have increased by about 2,800 acres, due mostly to the conversion of other wetland types.

Livingston

The surface geology of Livingston County includes end and ground moraine, outwash plains, and ice-contact topography. The northwest half of the county is predominantly moraine forming gently rolling hills with medium-textured soils. Poorly drained portions of these areas have soils classified as either the Miami-Conover or Miami-Brookston association. The southeastern portion of the county includes sandy end moraine, outwash plains, and ice-contact deposits. While most of these landscapes are well drained, poorly drained soils are common along river floodplains and around lake margins. These muck soils are classified primarily as the Fox-Boyer-Oshtemo-Houghton association.

In the 1820s, the uplands of Livingston County supported a mosaic of oak-hickory forest, black oak-white oak forest, oak savanna, and beech-sugar maple-basswood forest. The beech-sugar maple-basswood forest was limited to the western edge of the county on ground moraine. Further east, wildfires, probably originating from adjacent sandy outwash and end moraine swept across the county more frequently, maintaining the oak forest and savanna. The historical estimate of wetland extent for Livingston County is about 80,000 acres, or 21% of the county surface. Wet prairie, tamarack swamp, and mixed hardwood swamp were the most abundant wetland types in the county. Wet prairie and tamarack swamp were common throughout the outwash deposits along the Huron River drainage, and on poorly drained portions of ground moraine. Mixed hardwood swamp was most common in river floodplains. Black spruce swamp was found in isolated depressions at the north end of the county.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 28% for Livingston County. That represents a 22,000 acre wetland loss, due primarily to agricultural drainage, road construction, and urban development. Based on MIRIS data, 98% of tamarack and black spruce swamp acreage, totaling some 24,000 acres were either drained or converted to other wetland types. About 85%, or 34,000 acres of wet prairie and other emergent wetlands were similarly effected. Both wetland categories of lowland hardwoods and shrub swamp show significant acreage increases, relative to historical estimates.

Macomb

The surface geology of Macomb County is dominated by clay lake plain and sand lake plain, but medium-textured end moraine and outwash deposits are also characteristic of the county as a whole. A long, narrow end moraine ridge extends from the northeast Wayne County up nearly to the town of Richmond. Somewhat poorly drained soils of this feature are classified as the Conover-Parkhill-Locke association. Surrounding this ridge is clay lake plain, which characterizes the entire Lake St. Clair shoreline. Soils of the clay lake plain are mostly poorly drained, especially along the Lake St. Clair shoreline and in some inland, southern townships. These soils are mostly classified as either the Toledo-Paulding or Lenawee-Corunna-Lamson association. Similarly classified soils are found throughout the sand lake plain, through which flows the Clinton River. Predominantly well drained end-moraine ridges and outwash channels characterize portions of Bruce and Washington townships, at the northwest end of the county.

In the 1820s, most well drained portions of lake plain in Macomb County supported beech-sugar maple-basswood forest. Oak savannas, black oak-white oak forest, and oak-hickory forest dominated the outwash and end moraine along the northwest border of the county. Historical estimates of wetland extent are about 76,000 acres, or 25% of the county surface. Mixed hardwood swamp was found over large expanses throughout the poorly drained portions of clay lake plain. The largest expanses of mixed hardwood swamp were found in the northeast end of the county along the St. Clair County border, and along the Lake St. Clair shoreline at Anchor Bay. Lake plain wet prairie also occurred in the southwest end of the county, extending into adjacent Oakland County. Great Lakes marsh was characteristic at the mouth of the Clinton River and at St. Clair Shores.

Comparison of historical data with MIRIS estimates indicates a 74% net wetland loss for Macomb County. That represents the drainage of roughly 57,000 wetland acres. All wetland categories except shrub swamp show significant county-wide acreage decreases. 71% of mixed hardwood swamp, or roughly 41,000 acres were either drained or converted to other wetland types. Lowland conifers, although historically representing only 5,300 acres, have been nearly eliminated. Emergent wetlands decreased in acreage by over 11,000 acres. Of the 6,800 acres of lake plain prairie once located in the

county, none are known to remain (Comer et al. 1995c).

Mecosta

Outwash plains and sandy moraines characterize much of the surface geology of Mecosta County. Large outwash channels extend from north to south through the county, containing the stream beds and floodplains of the Muskegon and Little Muskegon rivers. Within the outwash deposits, poorly drained soils are most concentrated along the Little Muskegon River on soils mostly classified as the Coloma-Covert-Thetford association. Houghton-Adrian mucks are common in the Hughes Swamp area. Surrounding the outwash deposits are extensive end moraines of mostly sandy soils on rolling to steeply sloping hills. Poorly drained soils on these landforms are limited to the margins of lakes and streams.

In the 1830s, upland forests of the sandy outwash and moraines in Mecosta County were dominated by sugar maple, beech, hemlock, and white pine, in varying combinations. Oak-pine forest and open barrens were located on outwash at the southwest extreme of the county. The historical estimate of wetland extent is nearly 47,000 acres, or 13% of the county surface. Mixed conifer swamp was the most common wetland type, found with extensive cedar swamp on poorly drained outwash. Smaller conifer swamps, mixed hardwood swamps, and alder-willow swamps were common throughout the surface of the end moraine in the northern half of the county. Intermittent wetlands were scattered among tamarack swamps in small depressions on outwash at the southwest end of the county.

Comparison of historical data with MIRIS estimates is problematic for Mecosta County. MIRIS estimates 32% more wetland acreage than historical estimates. It is likely that aspen-birch forest surrounding several floodings in the county account for overestimates in MIRIS data. Further investigation is needed to more definitively assess the wetland status of the county. There has clearly been wetland losses, due in part to extensive floodings at Haymarsh Lake, Martiny Lake, and the Canadian Lakes areas. Most of these floodings inundated tamarack and conifer-hardwood swamp, partially explaining the 72% decrease in lowland conifers county-wide. Other wetland categories show increases in acreage relative to historical estimates.

Monroe

The surface of Monroe County is a flat glacial lake plain. The lacustrine deposits extend into Ohio along the western end of Lake Erie. Within the broad clay lake plain, there are several broad sand channels, created when sand was deposited into the shallow proglacial lakes by meltwater streams. These sand channels can be several miles wide, but the sand in them is generally only five to ten 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 that in the swales is poorly or very poorly drained. Least well drained soils of the clay lake plain, mostly classified as the Lenawee and Lenawee-Del Rey associations, are most concentrated along the Lake Erie shoreline.

Around 1800, the vegetation of the clay lake plain and sand lake plain often differed. The majority of the clay lake plain supported closed-canopy forest, either upland or wetland. In contrast, the sand lake plain supported oak savannas on the uplands and wet prairies or marshes in the lowlands. The forests of the clay lake plain responded to slight differences in slope class and drainage. Beech-sugar maple-basswood forest occurred on those portions of the clay lake plain where drainage conditions were best, generally in those areas where streams had resulted in improved drainage conditions. These mesic forests also included American elm, hickory, and black walnut. The beach ridges and low dunes of the sand lake plain supported savannas of white and black oak. These areas were known as lake plain "oak openings." Small areas of tallgrass prairie probably occurred on the ridges, but were much less prevalent than savannas.

The historical estimates of wetland extent for Monroe County is about 136,000 acres, or 38% of the county surface. On the flat portions of the clay lake plain or in shallow basins or depressions, mixed hardwood swamp was prevalent. In the closed depressions, black ash was dominant, along with American elm and basswood. Cottonwood, sycamore, trembling aspen, and red or silver maple were other common wetland species of the clay lake plain. Large expanses of these swamps were common throughout the western border of the county. Depressions and flat portions of the sand lake plain were often poorly drained, and supporting wet, lake plain

prairie and emergent marsh. The upland-wetland mosaic of oak opening and wet prairie was most concentrated in central portions of the county. Pin oak swamp probably occurred among the wet prairies in the south-central portion of the county. Pin oak, presently a common species within the swamps of the sand lake plain, may have been mistakenly called black oak by land surveyors. It is also possible that pin oak was much less prevalent prior to drainage of the wet prairies and fire exclusion. Extensive Great Lakes marsh occurred along most of the Lake Erie shoreline. 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 Raisin. Inland of the marshes there was typically a broad zone of swamp forest, but locally along Lake Erie, 1-3 miles wide expanses of wet prairie occurred.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 87% for Monroe County. That represents the drainage of about 118,000 wetland acres, and is the highest relative wetland loss for any county statewide. Both categories of lowland hardwoods and emergent wetlands have decreased significantly in acreage, relative to historical estimates. About 80%, or 53,000 acres of lowland hardwoods, and 97%, or 65,000 acres of emergent wetlands, have either been drained or converted to other wetland types. Of the estimated 56,158 acres of wet prairie known to occur historically in Monroe County, only 24 acres remain (Comer et.al. 1995b). While nearly all of these wetlands were drained, about 1,000 acres converted to shrub swamp, which show an increase in acreage, relative to historical estimates.

Montcalm

The surface geology of Montcalm County is dominated by sandy moraines and outwash plains, but also includes moraines of fine-textured material. Sandy end moraine forms a series of ridges generally oriented north to south through the county. Immediately adjacent to the ridges are broad, gently sloping areas of sandy ground moraine, most of which is well drained. Finer-textured moraine is located in the west end of the county including the towns of Pierson and Amble, as well as in the southeast end of the county around the Crystal Lake and Sheridon areas. Outwash channels are located between moraine ridges throughout the county. The stream beds and floodplains of most major rivers are located within the outwash channels. Poorly drained soils are mostly limited to the fine-textured moraines and outwash channels and are classified as either the Mancelona-Gladwin-Epoufette or Rifle-Epoufette-Roscommon soil association.

In the 1830s, the upland portions of the end moraines throughout Montcalm County supported forests of beech, sugar maple, basswood, yellow birch, white pine, and red maple, in varying combinations. Outwash deposits supported a mosaic of vegetation significantly influenced by wildfires at varying frequencies and intensities. These areas included oak savanna, dry oak and oak-pine barrens, oak-pine forest, and oak-hickory forest. Historically, there were about 76,000 acres of wetlands, or 16% of the Montcalm County surface. Tamarack swamp and mixed hardwood swamp were the most common wetland types in the county. Relatively large tamarack swamps were located on poorly drained ground moraine throughout the northwest end of the county, and in many small pockets among emergent marshes throughout the south-central townships. Mixed hardwood swamp was common along streams such as Fish Creek, and on ground moraine near Westville.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 7% for Montcalm County. That represents the drainage of about 5,300 wetland acres, most concentrated in Bloomer Township in the southeast and the four northwestern townships of the county. As with other Michigan counties, there was a significant amount of conversion of conifer swamps to other wetland types. About 80% of conifer swamps, roughly 32,000 acres, were either drained or converted to other wetland types. Other wetland categories indicate increases in acreage relative to historical estimates.

Muskegon

Sand lake plain, sand dunes, outwash plains, and fine-textured moraine characterize the surface geology of Muskegon County. Sand lake plain dominates the west half of the county, reaching its inland extreme along the Newaygo County border. The sand lake plain includes a wide range of drainage conditions, from excessively drained to very poorly drained. Poorly drained areas are concentrated along the lower reaches of the Muskegon and White rivers where muck soils are classified as the Carlisle-Tawas association. Other poorly drained soils are found in shallow depressions in Dalton and Fruitland townships. Sand dune, most of which support upland vegetation are concentrated along the Lake Michigan

shoreline. Relict dunes are also scattered over the sand lake plain east of Cloverville. Outwash plains dominate the northeast quarter of the county. While most of the outwash is well drained to excessively drained, small lakes and seasonally wet depressions are also common. Moraines with fine-textured soils form a ridge extending north and west from Muskegon Lake through Montague Township. These landforms are also found at the eastern end of the county, dominating Casnovia and Ravenna townships. Poorly drained soils on these landforms are mostly classified as either the Nester-Ubly-Sims or Montcalm-Nester-Belding-Kawkawlin soil association.

In the 1830s, much of the upland portions of sand lake plain, outwash plain, and sand dunes north of Black Creek supported white oak-white pine forest. Oak-pine barrens were common on outwash in the Blue Lakes area. Hemlock-beech forest and white pine-beech-red maple forest was characteristic south of Black Creek. Hemlock-beech forest, and beech-sugar maple-basswood forest was common on fine-textured moraines throughout the county. Historically there were about 57,000 acres of wetlands comprising 17% of the Muskegon County surface. Conifer-hardwood, mixed conifer, and mixed hardwood swamp, and emergent marsh were the most common wetland types. Mixed hardwood swamp, black ash swamp, and tamarack swamp were all common in the floodplains of the Muskegon and White rivers. Emergent marsh was also common at the mouths of these rivers. Extensive conifer-hardwood swamps were common on poorly drained lake plain throughout the southern townships of the county. Small intermittent wetlands were characteristic of outwash deposits in the Blue Lake area.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 56% for Muskegon County. That represents the drainage of roughly 32,000 wetland acres, with most extensive drainage and hydrological alterations occurring in east-central portions of the county. Shrub swamp is the only wetland category that does not indicate significant acreage decreases from historical estimates. About 90%, or 21,000 acres of conifer swamp, 75%, or 8,600 acres of emergent wetlands, and 26%, or 5,600 acres of lowland hardwoods have either been drained or converted to other wetland types.

Newaygo

The surface geology of the Newaygo County includes extensive outwash plains and sandy end moraine. Many of the end moraine deposits were either eroded by meltwater channels or partially covered by outwash deposits. They are mostly steep sloping, typically rising 100-200 ft. above the surrounding flat outwash plain. The topography of the outwash plain is flat, but localized features, such as ice-block kettles and kames can have slopes as steep as 30%. The greater part of the outwash plain has excessively drained sands that contain very little organic material in surface horizons. Broad areas of poorly drained sand occur along the numerous rivers of the county. Organic soils are restricted to channels and ice-block kettles on the outwash. Poorly drained soils in Newaygo County are mostly classified as the Toogood-Boyer, Adrian-Carlisle-Martisco, or Pipestone-Covert-Kingsville soil association.

In the 1830s, the outwash plains mostly supported hemlock-white pine forest, white oak-white pine forest and oak-pine barrens. Several tallgrass prairies were located on outwash in southern Newaygo County. The mosaic of upland vegetation on outwash was undoubtedly shaped by the frequency and intensity of wildfire. Forests of sugar maple, hemlock, beech, white pine, and red maple, in varying combinations, dominated sandy end moraines throughout the county. Historically, there were about 83,000 acres of wetlands comprising 15% of the Newaygo County surface. Poorly drained outwash deposits supported swamps with a mixture of hardwood and conifer species, including white pine, American elm, red and black ash, red maple, hemlock, trembling aspen, and paper birch. Emergent marsh and intermittent wetlands were found in small depressions throughout the outwash deposits. Most extensive conifer-hardwood swamps were found in the northwest end of the county.

Comparison of historical data with MIRIS estimates indicate a net wetland loss of 42% for Newaygo County. That represents the drainage of about 35,000 wetland acres. Although significant wetland drainage has taken place, especially in southern townships of Newaygo County, this may be an overestimate of county-wide wetland loss. Further investigation is needed to more definitively assess the wetland status of Newaygo County. There has clearly been significant drainage and conversion of both conifer swamps and emergent wetlands in this county. Based on MIRIS data, 94% of conifer swamps and 83% of emergent wetlands were either drained or converted to other wetland types, while both lowland hardwoods and shrub swamps increased in acreage, relative to historical estimates.

Oakland

The surface geology of Oakland County is a complex mosaic of outwash deposits, coarse- medium-, and fine-textured moraine, clay lake plain, and sand lake plain. Outwash plains and sandy end moraine dominates the central portion of the county. This area includes many lakes and headwaters for several river systems. Poorly drained soils are concentrated surrounding lakes and along river floodplains, and are mostly classified as the Oshtemo-Spinks-Houghton association. Medium- and fine-textured moraines extend from southwest to northeast across the county, most prominently from Northville up through Goodison. Poorly drained portions of these landforms have soils classified as either the Marlette-Capac or Riddles-Marlette-Houghton soil associations. The sand and clay lake plain dominate the largely urbanized portion of southeast Oakland County. These soils are mostly described as somewhat poorly drained.

In the 1820s, the uplands of the outwash and sandy moraines of Oakland County were dominated by white oak savannas, black oak barrens, black oak-white oak forest, and oak-hickory forest. Beech-sugar maple-basswood forest was prevalent on the loamy moraines and clay lake plain in the southern portion of the county. Historically, there were about 114,000 acres of wetlands, comprising 20% of the Oakland County surface. Tamarack swamp, mixed conifer swamp, and wet prairie were common in narrow drainages and surrounding lakes throughout the outwash and sandy moraines of the county. Mixed hardwood swamp was common along streams, and in large expanses on the flat lake plain in the southeast end of the county. Lake plain prairie was also common in this part of the county, totaling about 3,000 acres.

Comparison of historical data with MIRIS estimates indicate a net wetland loss of 46% for Oakland County. This represents the drainage of about 52,000 acres, most concentrated in the Pontiac area. All wetland categories but shrub swamps show significant declines in acreage relative to historical estimates. About 96%, or 37,000 acres of conifer swamps, 41%, or 18,000 acres of lowland hardwoods, and 45%, or 13,000 acres of emergent wetlands have either been drained or converted to other wetland types. Of over 24,000 acres of wet prairie historically described as occurring in Oakland County, none are known to remain (Comer et. al. 1995c).

Oceana

The surface geology of Oceana County includes extensive outwash deposits, sand lake plain, sand dune, and coarse and fine-textured moraine. Outwash deposits are located between sandy end moraines throughout the county. Outwash channels include the stream beds and floodplains of most major river systems. Poorly drained peat and muck soils on these landforms are mostly associated with swamp along river drainages and are classified as the Carlisle-Rifle association. Sand lake plain and sand dunes are concentrated close to Lake Michigan, with sand lake plain surrounding both Stony Lake and Silver Lake. Poorly drained soils are limited to the lake plain and are mostly classified as the Newton-Saugatuck-Rubicon association. Most of the end moraines throughout Oceana County are gently rolling and moderately well drained to well drained. The fine-textured end moraine is concentrated in Claybanks Township, with loam and clay-loam soils classified as the Kent-Allendale-Isabella association.

In the 1830s, much of the upland of Oceana County was forest of beech, sugar maple, white pine, hemlock, yellow birch, and red maple, in varying combinations. White pine was abundant along Lake Michigan from Little Sable Point north. White pine-white oak forest and oak-pine barrens were found on outwash deposits along the White River. Historically, there were about 46,000 acres of wetlands, comprising 13% of the Oceana County surface. Cedar swamp was the most abundant wetland type. These swamps were common throughout the Pentwater River drainage, at Knox Swamp, and within the complex wetland mosaic of tamarack, black spruce, and black ash swamps in the Beaver Creek area. Mixed hardwood swamp was most common in the floodplains of the White River.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 9% for Oceana County. That represents the drainage of about 4,100 wetland acres, most concentrated in Leavitt and Grant townships. As with most other counties, there has been significant conversion of conifer swamps to other wetland types. About 93%, or 31,000 acres of conifer swamps have either been drained or converted to other wetland types. Lowland hardwoods, shrub swamps, and emergent wetlands all show significant acreage increases relative to historical estimates.

Ottawa

The surface geology of Ottawa County includes sand lake plain, sand dunes, outwash deposits, and fine-textured end moraine. Sand lake plain is predominant throughout the western half of the county. Sand dunes are concentrated along the entire Lake Michigan shoreline, with a few relict dunes located on the sand lake plain further inland. Poorly drained sands associated with the lake plain typically overlay a clay-rich sub-soil a few feet below the surface. Outwash deposits are found between moraine ridges in the eastern townships of the county, containing the stream beds and floodplains of the Grand River and its major tributaries. Poorly drained soils in the outwash deposits are primarily associated with steams draining into the Grand River or Lake Macatawa, and are classified as either Richter-Gilford-Gladwin or Sloan-Adrian-Houghton soil association. Moraine ridges with loam to clay-loam soils are located throughout eastern Ottawa County. These soils vary in drainage characteristics, with those that are least well drained classified within either the Nester-Kawkawlin-Sims or Kawkawlin soil association.

In the 1820s, Beech-sugar maple-basswood forest dominated many of the end moraine ridges and much of the outwash throughout the east half of the county. Hemlock-beech forest was dominant on the sand lake plain and dune features closer to Lake Michigan. Oak-pine forest was common on both sand lake plain and outwash close to the Grand River. White oak savanna was found in these areas along the eastern county border. Historically, nearly 59,000 acres of wetland accounted for 16% of the county surface. Mixed lowland hardwoods and black ash swamp were common throughout the floodplains of the Grand River and Black River. Extensive Great Lakes marsh and alder-willow swamps dominated the lower reaches and mouth of the Grand River. Extensive swamps of tamarack, white pine, hemlock, black ash, mixed hardwoods, and willow dominated poorly drained lake plain and ground moraine in central portions of the county.

Comparison of historical data with MIRIS estimates indicates a 65% net wetland loss for Ottawa County. That represents the drainage of about 38,000 wetland acres, most concentrated in central portions of the county. Of the 17,000 acres of conifer swamps historically known from the county, none remain. There has been a 42% decrease in lowland hardwood acreage (10,400 acres), a 66% decrease in shrub swamp acreage (7,200 acres), and a 65% decrease in emergent marsh acreage (3,700 acres).

Shiawassee

The surface geology of Shiawassee County includes moraines of medium- and coarse-textured material, sandy outwash channels, sand lake plain, and clay lake plain. Moraines dominate the southern three quarters of the county, with gently sloping till plains alternating with end moraine ridges oriented roughly east to west. Soils of most moraines in the county are loamy, and somewhat poorly drained. They are classified as either the Conover-Brookston or Miami-Conover-Brookston soil association. Coarse-textured till is found between end-moraine ridges in the southwest end of the county. Poorly drained soils in this area are mostly classified as the Boyer-Wasepi-Spinks association. Outwash channels are located between moraines throughout the central and southeast portions of the county. Portions of the stream beds and floodplains of the Shiawassee and Maple rivers are located within these channels. Poorly drained muck soils are concentrated along the river drainages and are mostly classified within the Carlisle-Gilford-Tawas association. Sand and clay lake plain are concentrated in the northern townships of Shiawassee County. Soils of these landforms are somewhat poorly drained to poorly drained and mostly classified as either the Brookston-Berville-Conover or Kibbie-Colwood-Lenawee soil association.

In the 1830s, uplands throughout the north half of the county supported beech-sugar maple-basswood forest. Oak-hickory forest was limited in the north to outwash deposits along the Shiawassee River, but was common throughout the ground moraine and outwash in southern townships. Black oak-white oak forest and oak savanna were also common in the uplands throughout the southern townships. Historically, wetlands accounted for about 73,000 acres, or 21% of the county surface. Mixed hardwood swamp, tamarack swamp, and wet prairie were the most common wetland types in the county. Swamps were most common on poorly drained outwash and sand lake plain, but were also found in depressions on the ground moraine. Wet prairie was probably more common among the ground moraines than on outwash deposits. A large black spruce swamp was located just west of the town of Henderson.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 60% for

Shiawassee County. That represents the drainage of about 44,000 wetland acres. As with other counties statewide, tamarack and black spruce swamp was almost entirely eliminated from the county, either through drainage or conversion to other wetland types. Similarly emergent wetlands have decreased by about 74%, or 12,000 acres. No wet prairies are known to remain in Shiawassee County. Lowland hardwoods decreased in acreage by 35%, or nearly 13,000 acres. Shrub swamps appear to have increased in acreage relative to historical estimates.

St. Clair

The surface geology of St. Clair County is dominated by clay lake plain, but also includes sand lake plain, sand dunes, outwash plain, end moraine, and ground moraine. Clay lake plain is predominant throughout the county and almost entirely characterizes the southern-most townships. Poorly drained soils are characteristic of much of the clay lake plain, many of which are classified as either the Allendale-Latty or Latty soil association. Sand lake plain typically results from the deposition of sandy glacial runoff over the clay lake plain. In St. Clair County, it is limited to areas surrounding Port Huron and Marine City. Soils in these areas are mostly poorly drained, and classified as the Paulding-Wasepi association. Sand dune features are most common along the Lake Huron shoreline. Poorly drained portions of these landforms have sandy soils mostly classified as the Eastport-Wanola-Tobico association. Outwash deposits are limited to the northwestern-most townships of the county, with poorly drained soils classified as the Bach association. End-moraine ridges ranging from one to five miles-wide extend across the county generally oriented from north to south. The loamy soils of these moraines vary in their drainage characteristics from well drained to somewhat poorly drained.

In the 1820s, nearly all of the uplands of St. Clair County supported beech-sugar maple-basswood forest. Oak-hickory forest and oak savanna was common on low dune features and ground moraine in the St. Clair Flats area, oak forests were common at Port Huron, and hemlock-dominated forest was located on end moraine just west of Port Huron. Historically, wetlands accounted for about 140,000 acres, or 28% of the county surface. Great Lake marsh, lake plain prairie, mixed hardwood swamp, and tamarack swamp were the most abundant wetland types in the county. Great Lakes marsh, lake plain prairie, and white oak-bur oak savanna formed a mosaic that characterized most of the St. Clair Flats area. Lake plain prairie and mixed hardwood swamp extended north along the St. Clair River through what is now the Marine City Drain. Extensive mixed hardwood swamp of black ash, American elm, and red maple dominated the clay plain and end moraine throughout the Macomb County border area. Mixed hardwood swamp, tamarack swamp, and shrub swamp dominated the poorly drained soils southwest of Port Huron.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 73% for St. Clair County. That represents the drainage of about 104,000 wetland acres, mostly converted for agriculture. Of the estimated 29,000 acres of conifer swamp known from the county, none remain today. About 83% of emergent wetland acreage, totaling 24,000 acres has also been lost. While extensive cattail marsh remains in the St. Clair Flats, only small remnants of lake plain prairie remain in and around Algonac State Park. Lowland hardwood acreage has decreased by 61%, or nearly 48,000 acres. Shrub swamp appears to have decreased in acreage by 28%, or 1,000 acres.

St. Joseph

The surface geology of St. Joseph County is dominated by outwash plains, but also includes sandy ice-contact deposits, sandy end moraine, and ground moraine with drumlin features. Outwash deposits throughout the county are mostly well drained, but poorly drained portions are concentrated along the St. Joseph River and its major tributaries, or in isolated depressions. Soils in these areas are mostly classified as either the Sebewa-Cohoctah or Adrian-Granby soil association. The sandy end moraines are concentrated south and east of Centerville and are, for the most part, well drained. The medium-textured ground moraine is concentrated in the northeastern townships of the county on either side of Portage Creek. While the loamy soils of the drumlin fields are generally well drained, poorly drained areas are common between drumlin ridges.

Around 1820, the uplands of St. Joseph County supported a complex mosaic of beech-sugar maple-basswood forest, oak-hickory forest, oak savanna, and tallgrass prairie. Rivers and wetlands played an important role as natural fire breaks, shaping the frequency of wildfires that swept throughout the county, and therefore, the resulting upland vegetation. His-

torically, wetlands accounted for about 49,000 acres, or 15% of the county surface. Emergent marsh, mixed hardwood swamp, and wet prairie were among the most abundant wetland types. Emergent marsh, wet prairie, and occasionally, tamarack swamp, were common on poorly drained outwash plains. Mixed hardwood swamp, occasionally purely dominated by black ash or silver maple, dominated the floodplains of the St. Joseph River and its tributaries.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 46% for St. Joseph County. That represents the drainage of about 35,000 wetland acres. Of the 6,000 acres of tamarack swamp known historically from the county, only 7% remain. Similarly, 91%, or nearly 29,000 acres of emergent marsh and wet prairie were drained or converted to other wetland types. Lowland hardwoods have decreased in acreage by 26%, or 2,800 acres. Shrub swamp appears to have increased in acreage relative to historical estimates.

Van Buren

The surface geology of Van Buren County is complex and diverse, including outwash plains, ice-contact topography, coarse-, medium-, and fine-textured moraines, sand lake plain, sand dunes. The southeast third of the county is predominantly outwash plain and sandy ice-contact topography. Most of these landforms are gently rolling and well drained. Poorly drained portions are concentrated along the main branch and west branch of the Paw Paw River, where soils are classified as either the Gilford or Adrian-Edwards-Houghton soil association. Moraine of coarse- and medium-textured soils extend across the central portion of the county, generally oriented to the northeast. While much of this area has gently rolling hills that are well drained, poorly drained flats and depressions are common. Fine-textured moraines are most concentrated in western the townships of Covert, Geneva, and South Haven. Soils of the moraines are classified mostly in the Capac-Riddles-Selfridge association. Sand lake plain and sand dunes are most concentrated along the Lake Michigan shoreline and along the Black River drainage. Poorly drained soils are mostly on the sand lake plain and are classified as the Kingsville-Covert-Pipestone association.

In the 1830s, much of the uplands of western Van Buren County supported forests of beech, sugar maple, basswood, and hemlock. On outwash and sandy end moraines further east, oak-pine forest, oak-hickory forest, and white oak savanna were prevalent. Historically, wetlands accounted for about 75,000 acres, or 19% of the county surface. Mixed hardwood swamp, black ash swamp, and tamarack swamp were most abundant wetland types. Mixed hardwood swamp and black ash swamp were characteristic of the Paw Paw River and Dowagiac River floodplains. Tamarack swamp was common on poorly drained outwash and ground moraine.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 51% for Van Buren County. That represents the loss of about 38,000 wetland acres, mostly due to agricultural drainage in the upper reaches of the Paw Paw and Dowagiac river basins. Of nearly 27,000 acres of tamarack swamp historically known from the county, only 72 acres remain. About 42% of lowland hardwood acreage, roughly 19,000 acres, were either drained or converted to other wetland types. Both shrub swamp and emergent wetland categories indicate increased acreage over historical estimates.

Washtenaw

The surface geology of Washtenaw County is quite diverse and complex, including clay lake plain, sand lake plain, fine-, medium-, and coarse-textured moraine, outwash deposits, and ice-contact topography. The lake plain is concentrated at the southeast end of the county including all or portions of Augusta, Ypsilanti, York, and Saline townships. Clay lake plain formed from the sediments of proglacial lakes. Sand lake plain formed when sands were later deposited over the clay surface and reworked by retreating lake waters to form sandy beach ridges and shallow sand deposits over a clay subsoil. Soils of the clay and sand lake plain are somewhat poorly drained to poorly drained. Fine- and medium-textured end moraine ridges extend to the northeast across the central portion of the county. These gently sloping features contain poorly drained inclusions with soils classified mostly within the Miami-Conover-Brookston or St. Clair-Nappanee-Hoytville soil association. Between end moraine ridges are a series of outwash channels that include the stream channels and floodplains of the Huron River and River Raisin. Poorly drained soils in these areas are mostly classified as the Boyer-Fox-Sebewa association. Larger outwash plains and ice-contact topography is concentrated in the northwest end of Washtenaw County, and to the west of the town of Manchester. These features are mostly well drained,

but poorly drained sands and mucks are common around lake margins and along streams.

In the 1820s, the end and ground moraine supported oak-hickory forest and dry, mixed oak forests. White oak appeared to be the most common species of the oak-hickory forest. Oak barrens, with white and black oak, occurred along outwash channels and on adjacent moraine ridges, where fires from the outwash could be frequently carried by westerly winds. Mixed white and bur oak savanna was limited to outwash and end moraine at the southwest end of the county. Beech, sugar maple, and basswood forest was mostly restricted to silt loams and clay loams, and was concentrated along the northern and southern county borders. Historically, wetlands accounted for about 98,000 acres, or 21% of the county surface. Mixed hardwood swamp, wet prairie, and tamarack swamp were the most abundant wetland types. Mixed hardwood swamp was common in lower slope positions on both ground and end moraine, and over large expanses of the clay lake plain. Common species in the swamps included black ash, red maple, American elm, swamp white oak, bur oak, and basswood. On major river floodplains, silver maple, hackberry, red elm, red ash, and American elm were common. Tamarack swamp and wet prairie were associated with poorly drained outwash and ground moraine. Emergent marsh and willow-buttonbush swamp were also noted in small depressions throughout the ice-contact and outwash deposits.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 57% for Washtenaw County. That represents the drainage of about 56,000 wetland acres. Wetland losses can mostly be attributed to agricultural drainage, but urban development and road construction have certainly played a role. Only 2% of roughly 13,000 acres of tamarack swamp remains in the county. Wet prairie and other emergent wetlands have decreased by 90%, or about 37,000 acres. Mixed hardwood swamps have decreased by 44%, or about 18,000 acres. Shrub swamp appears to have increased in acreage, relative to historical estimates, primarily due to the conversion of other wetland types.

Wayne

The surface geology of Wayne County is dominated by clay and sand lake plain which was formed by the sediments and wave action of proglacial lakes. Sand from inland outwash channels was deposited over the clay-rich lake sediments, then re-worked by wave action as the proglacial lake receded. This formed a mosaic of clay plain as well as sand plain, where several feet of sand overlay clay, and low sandy beach ridges with excessively drained sands. The majority of the lake plain in Wayne County contains poorly drained soils classified as several different soil associations. End moraine ridges with fine-textured soils are found in the northeast and northwest extremes of the county. Soils of these gently rolling features are somewhat poorly drained, mostly classified as the Morley-Blount association. Poorly drained outwash occurs between end moraine ridges near Northville. These soils are classified as the Wasepi-Gilford-Boyer association.

In the early 1800s, uplands on the moraines and clay lake plain supported beech-sugar maple-basswood forest. On sand lake plain, oak-hickory forest, mixed oak forest, and oak savanna were more common. Historically, wetlands accounted for about 151,000 acres, or 35% of the county surface. Mixed hardwood swamp and lake plain prairie were the most abundant wetland types, concentrated on clay and sand lake plain, respectively. An extensive lake plain prairie encompassed roughly 16,000 acres in what is now Brownstown and Huron Townships. Large portions of Sumpter Township were also lake plain prairie and mixed hardwood swamp. A similar mosaic of lake plain prairie, oak savanna, and mixed hardwood swamp was characteristic of the Highland Park area of metropolitan Detroit. Extensive Great Lakes marsh occurred along Lake St. Clair and the Detroit River in the Grosse Point area, and near the mouth of the River Rouge. Black ash swamp and tamarack swamp were found on poorly drained sand lake plain and outwash deposits.

Comparison of historical data with MIRIS estimates indicates a net wetland loss of 84% for Wayne County. That represents the drainage of about 127,000 wetland acres. All wetland categories indicate significant declines. About 98% of emergent wetlands, or roughly 46,000 acres have been lost. Of the estimated 39,000 acres of lake plain prairie that historically occurred in the county, about 450 acres remain (Comer et. al. 1995c). About 78%, or 78,000 acres of lowland hardwoods were drained. Both shrub swamps and tamarack swamps, while not among the most abundant wetland types historically, also have declined significantly in acreage.