Vegetation of Michigan *circa* 1800

An Interpretion of the
General Land Office Surveys 1816-1856

MNFI Report 1995-006

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INTRODUCTION

The growing awareness of the decline of biodiversity has been one of the driving forces behind changing views on land-use planning and land management. As pressure on land resources increases, planners and managers must find new ways to guide economic development while restoring and maintaining the integrity of the natural systems within their jurisdiction. Tools that enhance our understanding of natural patterns and processes across large landscapes often provide insights for land-use planning and land management.

Knowledge of the type, location, and ecological context of Michigan's native vegetation, as it appeared prior to widespread European settlement in the 1800s, provides an important building block for ecologically meaningful management strategies. By comparing historical data with more recent data, spatial changes of vegetation 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 disturbances such as wildfire, windthrows, and beaver floodings played an important role in the development of vegetative pattern across Michigan's landscape. Clarifying the type, location, and ecological context of natural disturbances provides useful insights for developing ecological models. These models can lead to management strategies that more efficiently mimic natural processes.

Native Americans also used fire as a land management tool and played a role in the development and maintenance of Michigan's native vegetation (Jones & Kapp 1970, Whitney 1994). It is helpful to know where their activities were most concentrated so that vegetative patterns can be viewed in the most accurate context.

Of course natural ecosystems are quite dynamic, and the pattern of Michigan's native vegetation, natural disturbances, and Native American activities changed continually over the past 16,000 years since the last glaciation (Delcourt & Delcourt 1981). However, a clear picture of the patterns and processes 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.

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 presettlement vegetation (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, prior to widespread European settlement (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 natural landscape since the last glaciation.

Survey 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

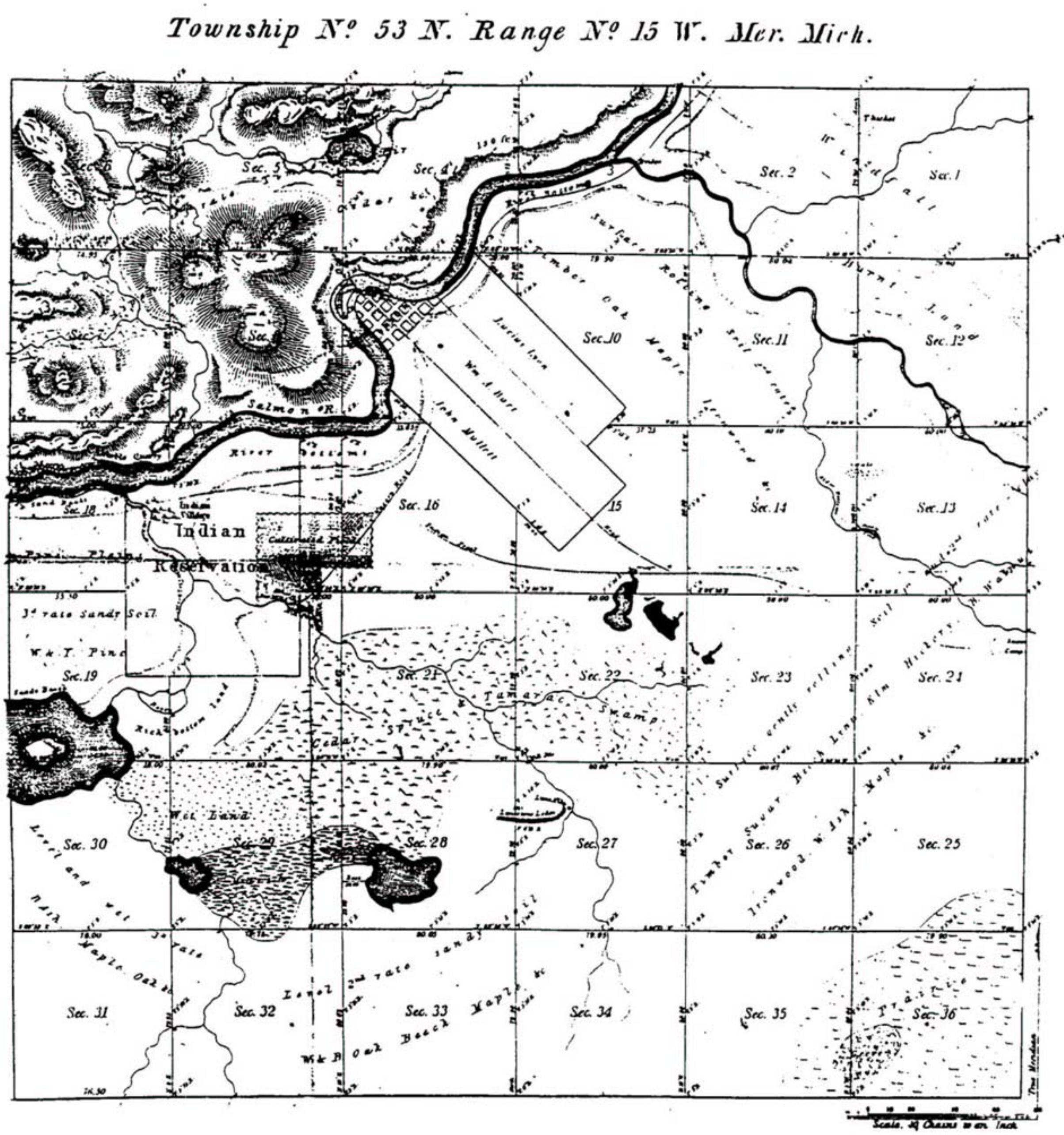


Figure 1: Hypothetical Township Plat Map used to train surveyors in Michigan.

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 purchase, 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 a compass and "chain" to make accurate measurements. Chains were made up of 100 "links" that totaled 66 feet in length (80 chains per mile). 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.

This square mile grid of the state, surveyed during the establishment of counties and 36 square mile townships, formed the framework for surveyor's maps and field notes, which provided the core of historical data for this project.

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, 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 abrupt topographic features, 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 noted their species and diameter at breast height. Tree species and diameter was 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.

These detailed records formed the basis for the development of our presettlement vegetation map. Our maps were compiled by plant ecologists familiar with Michigan's tree species, surface geology, and soils. This document will discuss the methods used in map production and provide some general considerations for using the maps. It is intended as a guide to be used along with Michigan's presettlement vegetation map.

Previous efforts

Previous state-wide attempts at mapping Michigan's presettlement vegetation were completed by Marschner (1940) and Veatch (1959). Marschner utilized maps and field notes from the original land surveys to complete a map of Michigan, Wisconsin, and Minnesota.

The Marschner map (scale 1:2,500,000), as re-drawn by Perejda (1946), depicted the location of eight different categories of vegetation including swamp, hardwood forest, hardwood-conifer forest, pine flats (hemlock, white pine, cedar, fir, and spruce), pine plains (jack pine, "Norway" pine, and white pine), wet and dry mixed forest, marsh and wet prairie, and prairie (Figure 2).

Veatch (1959) relied to a large extent on soil association maps, but also utilized surveyor's data and local histories. He produced one map for each Michigan peninsula (scale 1:500,000).

Trygg (1964) produced composite maps for the Upper Midwest using the surveyor's township plat maps. His intent was to display cultural features. The Trygg maps differentiate between prairie, marsh, bottom lands, and swamp. They do not indicate the dominant tree species of the swamps. Information on upland forest was limited to the locations of historical pineries. Trygg completed no maps for southern Lower Michigan, due to the above mentioned lack of information on the township plat maps.

Although not a statewide treatment, Brewer et al. (1984) produced a detailed presettlement vegetation map for southwest Lower Michigan using GLO survey data combined with information on historic prairies. Their interpretations differ from ours primarily in the methodology used for delineating savannas.

Our presettlement vegetation map of Michigan is the first attempt to create a detailed view of the entire state's presettlement vegetative pattern and natural disturbances within a digital environment. The utility of this spatial database is greatly enhanced by the ability to conduct spatial analyses within the electronic environment of a computerized Geographic Information System (GIS).

METHODS

Map Production

We used the transcribed General Land Office survey notes (1890), which were made available to our mapping team by the State Archives of Michigan. Township plat maps produced by surveyors were copied from microfilm available from the Real Estate Division of the Michigan Department of Natural Resources and State Archives of Michigan. We attached matte mylar to the most recent 7.5 minute, U.S. Geological Survey topographic maps, which for Michigan, are available in 1:24,000 and 1:25,000 scales and include topographic contour intervals of five, 10, and 20 feet depending both on the date of map publication and local topographic relief. A scale indicating chains (at 1:24,000 and 1:25,000 scales) was used for precise measurements along each section line.

We plotted all information extracted from the GLO survey notes and maps onto the mylar overlays and map margins. Information in the transcribed surveyor's notes is organized in a systematic pattern, reflecting the measurement of each section line in the township (Figure 3). We abbreviated common names of tree species in 3-5 letter combinations to speed the plotting of data (Table 1). Surveyors noted some tree species more generically than others. For example "elm", "ash", and "maple" were commonly used without distinguishing among the several native species that could have been encountered. We consulted published floras and other sources (Hutchinson 1988) to determine which old common names referred to which tree species; (e.g. "spruce pine" = jack pine, "yellow pine" = red pine). Tree abbreviations reflect the common name used by the surveyors. We plotted tree species and diameter along each section line at the approximate distance (in chains) where they were mentioned in the notes. At each section corner, we plotted tree species, diameter, bearing, and distance information. Although distance information exists for witness trees at all half-mile posts, we recorded that information only in open savannas.

Surveyors often included a list of tree species (generally ranked by relative abundance, but sometimes biased by surveyor's view of their

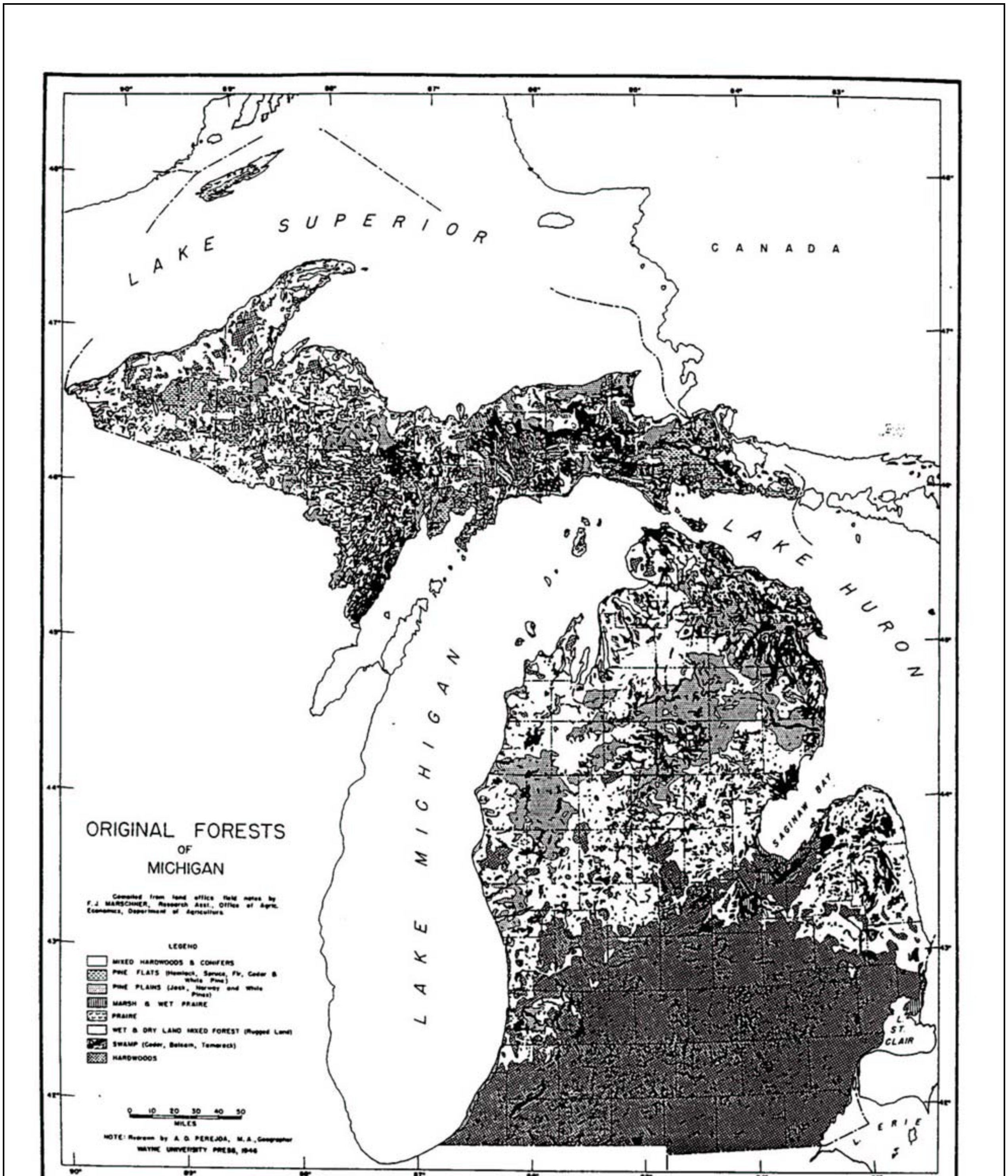
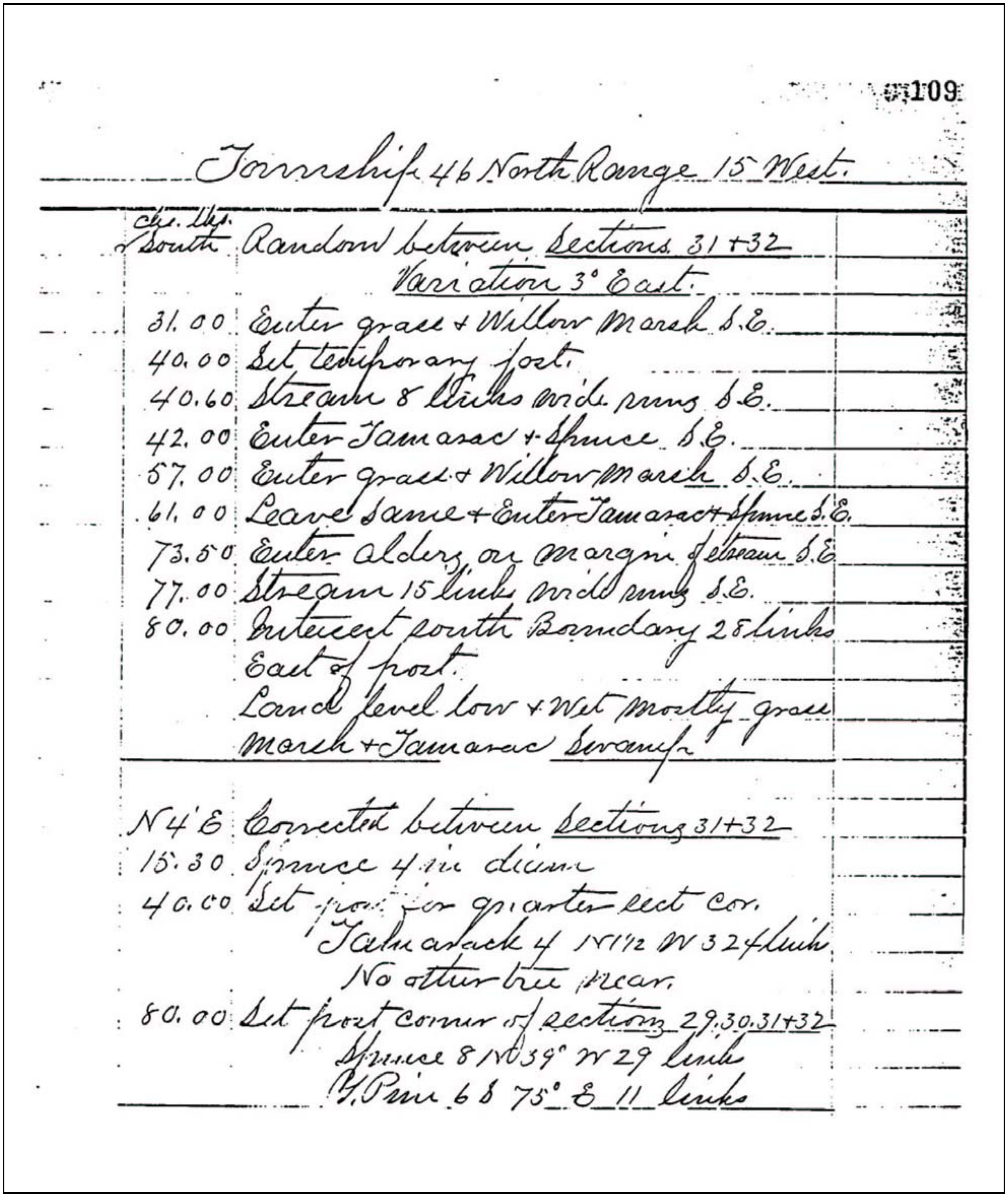


Figure 2: Marschner's Original Forests of Michigan redrawn in 1946 by Perejda. (Wayne State University Press)


109

Township 46 North Range 15 West.

chs. lks.

South Random between Sections 31 + 32

Variation 3° East.

31.00 Enter grass + Willow Marsh S.E.

40.00 Set temporary post.

40.60 Stream 8 links wide runs S.E.

42.00 Enter Tamarac + Spruce S.E.

57.00 Enter grass + Willow Marsh S.E.

61.00 Leave same + Enter Tamarac + Spruce S.E.

73.50 Enter alders on margin of stream S.E.

77.00 Stream 15 links wide runs S.E.

80.00 Intersect south Boundary 28 links East of post.

Land level low + Wet mostly grass marsh + Tamarac Swamp

N 4' E Corrected between Sections 31+32

15.30 Spruce 4 in diam

40.00 Set post for quarter sect cor.

Tamarack 4 N 1½ W 324 links

No other tree near.

80.00 Set post corner of sections 29.30.31+32

Spruce 8 N 39° W 29 links

Y. Pine 6 S 75° E 11 links

Figure 3: Sample page of transcribed GLO field notes from Schoolcraft County, Michigan.

Table 1: Presettlement Vegetation Maps: species abbreviation, alias, comments, and scientific name.

ABBREV	SPECIES	ALIAS	COMMENTS	SCIENTIFIC NAME
ALD	SPECKLED ALDER	tag alder		*Alnus rugosa*
APPLE	APPLE			*Malus spp*
ASH	ASH		white, black, or red	*Fraxinus spp*
ASP	ASPEN		quaking or bigtooth	*Populus spp*
BASH	BLACK ASH			*Fraxinus nigra*
BCH	BEECH			*Fagus grandifolia*
BLASH	BLUE ASH			*Fraxinus quadrangulata*
BLBCH	BLUE BEECH	muscle wood, water beech		*Carpinus caroliniana*
BO	BLACK OAK	yellow oak	pin oak and N. pin oak	*Quercus velutina*
BPOP	BALSAM POPLAR	balm of Gilead		*Populus balsamifera*
BRC	BIRCH			*Betula spp.*
BUCK	OHIO BUCKEYE			*Aesculus glabra*
BUR	BUR OAK			*Quercus macrocarpa*
BWALN	BLACK WALNUT			*Juglans nigra*
BXWD	BOX ELDER	boxwood		*Acer negundo*
CED	NORTHERN WHITE CEDAR			*Thuja occidentalis*
CHER	BLACK CHERRY	cherry		*Prunus serotina*
CHEST	CHESTNUT			*Castanea dentata*
COTN	COTTONWOOD			*Populus deltoides*
DOG	DOGWOOD			*Cornus spp*
ELM	ELM		American or slippery	*Ulmus spp*
FIR	BALSAM FIR	balsam		*Abies balsamea*
GHEM	CANADA YEW	ground hemlock		*Taxus canadensis*
GRAPE	GRAPEVINE			*Vitis spp.*
GUM	BLACK GUM	pepperidge		*Nyssa sylvatica*
HACK	HACKBERRY			*Celtis occidentalis*
HAZL	WITCH HAZEL			*Hamamelis virginiana*
HCK	HICKORY		species uncertain	*Carya spp*
HEM	EASTERN HEMLOCK			*Tsuga canadensis*
IRON	IRONWOOD	hornbeam		*Ostrya virginiana*
KYCOF	KENTUCKY COFFEE TREE	coffee nut		*Gymnocladus dioicus*
LOC	LOCUST			*Gleditsia triacanthos*
LYN	BASSWOOD	lyn		*Tilia americana*
PAW	PAW PAW			*Asimina triloba*
PIN	PIN OAK	jack oak	use uncertain	*Quercus palustris*
PLUM	PLUM		species uncertain	*Prunus spp*
POPL	BIGTOOTH ASPEN	poplar		*Populus grandidentata*
PRASH	PRICKLY ASH			*Zanthoxylum americanum*
QASP	QUAKING ASPEN			*Populus tremuloides*
RBUD	RED BUD			*Cercis canadensis*
RCED	RED CEDAR	juniper		*Juniperus virginiana*
RO	RED OAK		pin oak also	*Quercus rubra*
SAS	SASSAFRAS			*Sassafras albidum*
SM	SUGAR MAPLE	sugar tree, hard maple		*Acer saccharum*
SMAPL	SOFT MAPLE		red or silver	*Acer spp*
SP	JACK PINE	spruce pine, pine		*Pinus banksiana*
SPICE	SPICEBUSH			*Lindera benzoin*
SPR	SPRUCE		species uncertain	*Picea spp.*
SWO	SWAMP WHITE OAK	swamp oak		*Quercus bicolor*
SYC	SYCAMORE	buttonwood		*Platanus occidentalis*
TAM	TAMARACK	tamarach		*Larix laricina*
THORN	HAWTHORN	thorn, thornapple	species uncertain	*Crataegus spp.*
WBRC	WHITE BIRCH			*Betula papyrifera*
WIL	WILLOW		species uncertain	*Salix spp*
WMAPL	SILVER MAPLE	white maple	not consistent	*Acer saccharinum*
WO	WHITE OAK			*Quercus alba*
WP	WHITE PINE	pine		*Pinus strobus*
WSPR	WHITE SPRUCE			*Picea glauca*
WTWD	TULIP TREE	whitewood		*Liriodendron tulipifera*
WWALN	BUTTERNUT	white walnut		*Juglans cinerea*
YBRC	YELLOW BIRCH			*Betula alleghaniensis*
YO	CHINKAPIN OAK	yellow oak	possibly black	*Quercus muehlenbergii*
YP	RED PINE	yellow or Norway pine		*Pinus resinosa*

relative importance), impressions of soil character, and drainage characteristics along each surveyed mile. These comments, where they added significant ecological information, were copied to the mylar overlays in quotes along the section line. We located wetland boundaries along each section line at the chain distances mentioned in the field notes. Surveyor's comments on the character of rivers and streams were also copied to the mylar overlays. We found that the township plat maps accurately represent the chain distances described in the notes. The same was true for the locations of natural disturbances such as windthrows and recent fires. In Northern Michigan, surveyors often provided several paragraphs of description for each township. We copied this information on the margins of each topographic map to aid in later interpretation

With this information plotted over topography, we interpreted cover type boundaries primarily using the locations of dominant tree species and associated landforms. Wetland boundaries were interpolated between section lines by using associated elevation lines as they were depicted on the topographic maps. There were a few cases where surveyors did not note their entrance and exit points for wetlands along the section line, but instead used comments such as "...last mile, wet and swampy." These situations were most common on flat topography where the land was a complex mosaic of uplands and wetlands. When this occurred, the wetland boundary was determined using the comments and tree species that were encountered along the section line. We depicted wetlands falling entirely within interior sections as they were indicated on the topographic map. Typically, the smallest wetlands we included were 15-20 acres in size.

We consulted surface geology maps, soils maps, and earlier vegetation maps throughout the process of interpretation. Michigan Natural Features Inventory (MNFI) maps from field surveys of Great Lakes marshes (MNFI 1987-1989) and wooded dune and swale complexes (Comer & Albert 1993) were used to clarify wetland boundaries in areas that had been sampled on the ground along the Great Lakes shoreline. Great Lakes shoreline boundaries were interpreted from points of intersection with section lines and the prevailing orientation of current shorelines (where not obviously manipulated artificially). Surveyor's notes on meanders along the shoreline were not used, since normal water level fluctuations resulted in inconsistencies along the shoreline, depending on the year of the survey.

We interpolated boundaries for natural disturbances such as wildfires and large windthrows between section lines taking the directions noted by surveyors (e.g."entered land burnt from southwest to northeast..."), topography, and likely fire breaks into account. Cultural features, both Native American and early European, were placed on the mylar overlays as they were mentioned in the notes.

We developed cover type codes to identify all vegetation types, natural disturbances, and cultural features. The code system was designed to capture the complexity of plant communities that were distinguishable in the survey notes (Table 2). The code system for vegetation is based on the natural community classification currently in use by MNFI (1990). The classification reflects existing scientific literature and experience of MNFI staff. Additional codes were created throughout the course of this project to reflect previously unrecognized associations of dominant tree species that were repeatedly encountered and described by surveyors. The code system is structured to distinguish uplands from wetlands, and describes forested, unforested, sparsely vegetated, and aquatic systems. It is important to note that, while the four-digit code system mirrors the land cover code system used by the Michigan Resource Information System (MIRIS), the codes themselves represent differing assemblages of vegetation. As with all different vegetation classifications, they need to be carefully cross-walked before map comparisons are made.

Upland forest codes reflect the two to three most abundant species, as determined by the map interpreter. While a quantitative analysis and characterization of species composition within each cover type was not completed for this project, typically, the dominant tree species were encountered among at least 60% of the

Table 2: Vegetation and wetland grade codes for presettlement vegetation maps.

WETLAND

NON-FORESTED WETLAND

Emergent Marsh / Meadow / Prairie

- **6221** EMERGENT MARSH
- **6222** GREAT LAKES MARSH
- **6223** INTERDUNAL WETLAND
- **6224** WET MEADOW
- **6225** INLAND SALT MARSH
- **6226** LAKE PLAIN PRAIRIE
- **6227** INLAND WET PRAIRIE
- **6228** INTERMITTENT WETLAND

Mud Flats

- **6231** MARL FLATS

Shrub-Dominated Wetland

- **6121** BOG
- **6122** ALDER, WILLOW, BOG BIRCH THICKET
- **6123** BUTTONBUSH, WILLOW SWAMP
- **6124** PATTERNED PEATLAND
- **6125** MUSKEG

Upland/Wetland Complex

- **911** WOODED DUNE / SWALE COMPLEX

FORESTED WETLAND

41 Hardwood / Conifer - hardwood dominant

- **414** LOWLAND HARDWOOD
  - **4141** BLACK ASH
  - **4142** ELMS
  - **4143** SILVER MAPLE, RED MAPLE
  - **4144** COTTONWOOD
  - **4145** BALSAM POPLAR
  - **4146** ASPENS
  - **4147** WHITE BIRCH
  - **4148** BLACK WILLOW

42 Conifer / Hardwood - conifer dominant

- **423** LOWLAND CONIFER
  - **4231** CEDAR
  - **4232** BLACK SPRUCE
  - **4233** TAMARACK
  - **4234** BALSAM FIR, WHITE SPRUCE
  - **4235** BALSAM FIR
  - **4236** JACK PINE
  - **4237** HEMLOCK
  - **4238** WHITE PINE

LAKES AND RIVERS

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

WETLAND GRADE

- **I = INTACT**; well buffered, no altered hydrology
- **D = DEGRADED**; lacking complete upland buffer
- **M = MANIPULATED**; any activity altering hydrology
- **E = ELIMINATED**; all or most of area gone

UPLAND

NON-FORESTED

Grassland

- **31** HERBACEOUS - UPLAND GRASSLAND

Savanna

- **331** LAKE PLAIN OAK OPENING
- **332** OAK BARRENS
- **333** PINE BARRENS
- **334** OAK-PINE BARRENS
- **335** BUR OAK SAVANNA
- **336** OAK OPENING

FORESTED

Northern Hardwoods

- **4111** BEECH, SUGAR MAPLE, YELLOW BIRCH
- **4115** SUGAR MAPLE, YELLOW BIRCH, FIR
- **4117** SUGAR MAPLE, BASSWOOD
- **4119** BEECH, HEMLOCK
- **413** ASPENS, PAPER BIRCH

Central Hardwoods

- **4121** BEECH, SUGAR MAPLE, BASSWOOD
- **4122** WHITE OAK, BLACK OAK, HICKORY
- **4123** BLACK OAK, WHITE OAK
- **4124** PIN OAK, BLACK OAK

Pine

- **4211** WHITE PINE
- **4212** RED PINE
- **4213** JACK PINE
- **4215** RED PINE, JACK PINE
- **4216** RED PINE, WHITE PINE
- **4217** WHITE PINE, WHITE OAK
- **4218** RED PINE, OAK
- **4219** WHITE PINE, BEECH, RED MAPLE

Other Upland Conifer

- **4221** WHITE SPRUCE
- **4222** HEMLOCK, CEDAR
- **4223** FIR, SPRUCE, CEDAR
- **4226** HEMLOCK
- **4227** HEMLOCK, WHITE PINE
- **4228** HEMLOCK, SUGAR MAPLE
- **4229** HEMLOCK, YELLOW BIRCH

SPARSELY VEGETATED

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

NATURAL DISTURBANCES / CULTURAL FEATURES

- **92** WILDFIRE
- **93** WINDTHROW
- **94** BEAVER FLOODING
- **95** GREAT LAKES LEVEL CHANGE
- **96** CULTURAL FEATURE
- **97** JACK PINE THICKET (response to recent fire)

witness trees within the mapped area. Individual species named with each code (e.g. beech and hemlock) were each found among at least 30% of the corner and section line trees. The determination of the relative percentages of individual species was a subjective determination of the map interpreter.

We made the distinction between forest and savanna primarily by using the distance information from individual witness trees. Because surveyors needed to use trees close to the section corner post, the distance from those trees to the post can be used to indicate the typical distance between trees (Anderson and Anderson 1975). Typically, when distance measures increased beyond 75 links (about 50 ft.) for both trees from opposing quadrants, there was an open forest canopy. When two or more adjacent section corners or half mile points included distances greater than 75 links, the area was coded as savanna and boundaries were established. Surveyors used a variety of names for savannas, some of which were misleading and used inconsistently. Terms included "opening," "barrens," and "plains." Because the distance information from section corners provided the most objective information, it was used to over-rule more subjective surveyor's descriptions, when the two were in contradiction.

We coded wetlands according to the same method as uplands where they were large enough to include several section corners. Smaller wetlands were often called "cedar swamp," "tamarack swamp," or "wet prairie," by surveyors, and we coded them as such. Small wetlands falling entirely within sections were coded based on an interpretation of surrounding wetlands and the basins where they occurred.

Mapped wetlands were also graded according to the type of changes that were apparent from the topographic maps (Table 2). A grade code was assigned to each wetland. The wetland grade codes include:

- **I for intact**; signifying a well buffered (>300 feet of relatively intact vegetation on all sides), undisturbed wetland;
- **D for degraded**; signifying an incomplete upland buffer;
- **M for manipulated**; signifying some man-made alteration that could affect the hydrology of the wetland, e.g. roads, drains, upstream impoundment;
- **E for eliminated**; signifying the apparent complete (or nearly complete) destruction of the wetland, also applied to drained marshes that are now apparently upland.

The only exception to this practice was where surveyors noted in more general terms where the wetland occurred ("last mile, wet and swampy..."), typically limited to areas of flat glacial lake plain. We felt that it was important to distinguish wetlands where our interpretation of wetland boundaries was based on this much more general information. These areas are coded as wetlands (414 or 423 typically) and can be distinguished on the map by their lack of a wetland grade.

Digital Map Production

Once cover type boundaries were interpreted and assigned codes, the maps were proofed and then digitized using Intergraph MicroStation™ software. Both cover type boundaries and associated codes were digitized. To avoid cluttering the final digitized maps, surveyors comments were included (in quotes) only where they added significant information. For many upland cover types, a tree species list, ranked in order of relative abundance, was included in one or two locations within each township to reflect the relative composition of tree species. A similar approach was utilized for large wetlands. An example in this case would be a large swamp dominated by three conifer species. This area would be given a three digit code 423 (indicating mixed lowland conifer), and a ranked list of those species would appear as text.

During the digitizing process, current cover type maps from the Michigan Resource Information System (MIRIS) were occasionally utilized for direct comparisons with the historical interpretations. We did this primarily in coastal wetlands of the Lower Peninsula where small wetlands fell mostly within section lines. If there was a difference between historical interpretation and current cover type for those wetlands that were traversed by surveyors (those intersecting section lines), the historical interpretation was maintained. For apparently intact wetlands occurring entirely within the interior portions of a section, the MIRIS interpretation was sometimes used to code the map. In these cases, adjacent to the wetland code, the (MIRIS) notation was added to indicate the source of that information. The same procedure was used to indicate where other information sources, such as the National Wetlands Inventory (NWI) maps, were utilized. Several other historical maps were utilized in southeast Michigan. The authors and dates of those maps are indicated in those cases.

Digitized maps were stored as multiple layers of information, organized by county (Table 3). Any combination of these layers may be turned "on" or "off" depending on the type of information desired by the user. For example, if levels 1,3, and 5 were turned on, vegetation boundaries, vegetation codes, and surveyors comments would appear on the map. GIS processing was completed for vegetation cover boundaries with Modular GIS Environment MGE PC-1™ and MGE/SX™. Labels were rechecked using C-Map™ software. Maps created in an Intergraph Microstation™ vector format can be translated to DXF (Data Exchange Format).

Table 3: Description of presettlement cover layers in design file.

LEVEL	DESCRIPTION
* 1	vegetation borders
3	text (selected surveyors comments & species list)
5	label (code; grade: D (degraded), E (eliminated), I (intact), M (manipulated), and source: (if MIRIS, NWI, or other historical source)
7	wildfire border (92)
8	windthrow border (93)
9	beaver flooding border (94)
10	impact of Great Lakes level fluctuation border (95)
11	Native American settlement border (96)
12	trails
13	upland/wetland complex border (911)
14	county boundary
15	label for 92
16	label for 93
17	label for 94
18	label for 95
19	label for 96
20	label for 911
22	jack pine thicket (97)
23	label for 97
38	U.S.G.S. quad tics
39	U.S.G.S quad lines
40	U.S.G.S quad names
41	section numbers
42 or 63	section lines

* Level 1 is the only level that has been GIS processed: "lineweeder" (tolerance of 10 feet) and "linecleaner" were run using MGE-PC 1™ and MGE/SX™ and labels (level 5) were checked using C-Map™.

DISCUSSION

Surveys as a Data Source:

There are limitations associated with the use of the General Land Office surveys that should be clear to all users of presettlement vegetation maps. 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. There have been a number of discussions of surveyor's bias in their selection of witness trees (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 American beech, northern-white cedar, and white oak were used more often than their actual frequency on the landscape. Shorter-lived species, such as aspens and paper birch, or typically small diameter species, such as speckled alder, sassafras, and hop hornbeam, were used less often than their actual frequency.

We used records from the original surveys where they had been found to be adequate by the Surveyor General. There was a number of townships re-surveyed because the original surveys were found to be either very inaccurate or completely fraudulent. In these cases, we used the records from the re-surveys completed during the 1840s and 1850s. These survey records were found to be quite reliable, since their stated measurements corresponded quite well with features on current topographic maps.

Historical Context

Given that the presettlement vegetation map depicts a "snapshot in time" taken at the time of the surveys, it is important to place the map within the context of the times when the surveys were conducted. Aspects of long-term climatic cycles, Native American activities, and the European fur trade, all had the potential to influence natural patterns on the landscape traversed by surveyors in the nineteenth century.

Climate: There are numerous studies of the changes in climate and its influence on vegetation that have occurred in the Great Lakes region since the last glaciation (Webb et al. 1993). The mosaic of vegetation described by surveyors was one that had been influenced by multiple climatic cycles, ranging from tens to thousands of years. While long-term climate changes were obviously important to the migration of species, shorter-term cycles in temperature, humidity, and precipitation probably had significant effects at the local level by varying the frequency of natural disturbance processes such as wildfire and flooding. These factors also influenced the rate of vegetative succession following natural disturbances.

Generally, temperatures increased steadily during the first 9,000 years following the last glacial maximum. Maximum warmth and dryness was reached 6,000 years ago in the Midwest, with July temperatures 1-2° F greater than today (Webb et al. 1993). It is likely that many plant communities most associated with wildfires, such as dry prairies, pine barrens, and oak savannas, reached their maximum extent in Michigan at that time. Since then, there has been a slight decrease in average temperature and increase in humidity (Webb et al. 1993). The "Little Ice Age," from roughly 800-600 years before present, was a shorter-term interval of cool and arid climate. It was characterized as having reduced summer precipitation and enhanced westerly winds in winter. It is possible that it affected fire regimes, by increasing the probability of "dry lightning" during the cool, dry summers. While, as a general rule, the distribution of vegetation lags behind climatic trends, the pattern of vegetation described by surveyors in the nineteenth century reflected, in large part, the climatic regime of the previous 2-4,000 years (Webb et al. 1993).

Native American Activities: Native Americans certainly played a role in shaping the mosaic of vegetation that surrounded their principle centers of activity. However, it is important to consider both the various ways their activities influenced vegetation, and how that influence varied in location and intensity over time. An excellent overview of existing knowledge on Native Americans in the Great Lakes region is found in Tanner (1987). Much of the following discussion is derived from that source.

Archeological evidence indicates that early human inhabitants of Michigan fall into the Woodland Culture, which apparently entered the state as glaciers receded. Their numbers and character changed over time with the influx of immigrants from the Atlantic coast and with alliances with cultures further west and south. Subsistence activities among Native Americans in the Michigan fell into four general categories: tending domesticated plants, fishing, hunting, and collecting wild rice. Fishing and collecting wild rice was most common in the marshes and waters off of the Upper Peninsula, and probably had minimal influence on vegetation. Clearing fields for domesticated crops was most concentrated in the southern half of the Lower Peninsula, but took place wherever the growing season reached about 120 days. Hunting took place throughout the state, sometimes involving fires set to herd animals toward a harvesting zone (Whitney 1994). Fire was apparently also used to maintain trails and forest openings to ease travel, encourage wild food plants, fertilize cropped land, and remove cover for potential enemies (Driver and Massey 1957, Chapman 1984, Albert and Minc 1987). The relative influence these practices had on Michigan's landscape was most likely in proportion to the concentration of native populations that used them. Tanner (1987) estimated approximately 14,000 Native Americans resided in Lower Michigan in 1830. They were found in 131 villages mostly concentrated along the St. Joseph, Kalamazoo, Grand, Shiawassee, Saginaw, and St. Clair rivers. Ottawa tribes were most common on the west side of the peninsula, from the Kalamazoo River north to the straits area. Ojibwa tribes were dominant near Lake St. Clair, Saginaw Bay, and along Lake Huron extending into the Upper Peninsula. Potawatomi were mostly found in southwest Lower Michigan, extending into the Chicago region.

We can assume that Native American's influence on vegetation varied as populations and land management practices varied over time. Disruptions in Native American populations within a century prior to the surveys could have affected what surveyors saw and described. Tribal disruption during the Iroquois Wars of the seventeenth century was stimulated in part by friction over the fur trade, and is said to have reduced much of the Great Lakes region to a "No Man's Land" (Mason 1981), but this is difficult to verify. Although most of the fighting took place outside of Michigan, tribal dislocations did occur around Detroit, Niles, Michilimackinac, and Sault Ste. Marie (Tanner 1987). Epidemics brought by Europeans also had a disastrous impact on native populations. Smallpox, whooping cough, and typhoid were among some of the diseases that wiped out villages around Detroit, Lake St. Clair, Saginaw Bay, and Michilimackinac during the seventeenth and eighteenth centuries. The decade of the 1830s was particularly notable for the sudden rise in European population and a rapid series of treaties involving land cessation and movement of Native American populations (Tanner 1987).

Because Native American population density, farming, and hunting were most concentrated in the southern Lower Peninsula, it can be assumed that Native American influences were greatest in that area. It is at least possible that some of the burned areas that surveyors recorded in northern portions of the state had their origin in Native American hunting activities.

Fur Trade: Fur-bearing animals play a variety of roles in Michigan's ecosystems, so we should assume that the impact on fur-bearer populations brought about by the early European fur trade may have had some effect on the landscape being described by surveyors in the nineteenth century. Unfortunately, any realistic estimate of the actual impact of the fur trade is all but impossible to establish. But, it is helpful to keep the relative impact of the fur trade in mind while using presettlement vegetation maps.

It could be said that the European fur trade began in Michigan in 1635 with the first visit to the Straits of Mackinac by Nicolet. In 1660, Radisson and Groseiliers returned to Montreal from Michigan with 60 canoes full of fur (Bradt 1947). Over the years, intense competition developed involving the French "coureurs de bois," English, American, and Native American tribes, often causing violent conflicts, and resulting in a severe depletion in fur-bearer populations. The fur trade involved a variety species. A 1796 ledger from Michilimackinac gives some idea of the variety of furs being traded at the time: "...sold 99 packs composed of 5 bears, 5 pound beaver, 10 fishers, 58 cats, 74 doe, 78 foxes, 108 wolves, 117 otters, 183 minks, 557 bucks, 1,231 deer, 1,340 muskrats, and 5,587 racoons" (Johnson 1971).

From the standpoint of impact on the landscape, the beaver population should have been by far the most significant, so this would be the species for which the depletion in populations most likely altered the landscapes later described by surveyors. We will never know just how many beaver lived within Michigan prior to the fur trade, but estimates of fur traders catch gives us some notion. In 1767, for example, 50,938 beaver skins were shipped through Michilimackinac (Lart 1922). The trade in beaver pelts was still on the rise at that time, so considerably more were likely taken in later years. Principle fur trading posts in Michigan were at Michilimackinac, Sault Ste. Marie, Detroit, Grand Rapids, and Niles. Since Michilimackinac was the principle trading post for the entire Upper Great Lakes region, we must assume that many pelts passing through there were actually taken from Wisconsin and beyond. The range-wide decline in beaver populations occurred throughout the nineteenth century, causing the prices of pelts to increase. In 1920, Michigan's beaver trapping season had to be closed to allow populations to recover (Bradt 1947).

As for the actual influence beavers had on Michigan's native vegetation, we can only speculate. Bela Hubbard considered beaver to be the principle cause for the development of wet prairies in the Detroit area (Hubbard 1887). We now know this to be an overstatement, given the importance of the hydrology on the sand lake plain, and the fragments of prairie on the lake plain today (Comer et al. 1995b). However, they may have played some role in creating what surveyors described as "wet prairie" and "marsh" throughout the southern Lower Peninsula. Further north, it is possible that the decline of beaver populations impacted the relative abundance of aspen-dominated wetlands in the years leading up to the surveys.

Technical Aspects of Digital Maps

Cover type boundaries should be assumed to be most reliable where they intersect section lines. The interpolated boundary line between each section line 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. Given the scale of survey data, we were unable to represent much of the small-scale variation one normally encounters in natural environments. 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 smaller vegetation units, such as alder-willow swamp, emergent marsh, and beaver floodings are most likely underestimated. Because aspen-birch forest often resulted from windthrows smaller than 50 acres, they too are probably slightly under-represented in the map. The cover type codes, when taken to the fourth digit, should be interpreted by the user to indicate the most abundant tree species of the area, not the only tree species present. Users should consult with published materials and local experts for expanded plant and animal species lists which would likely be associated with the specific vegetation type.

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