Historic notebooks play a critical role in the future of sustainable ecosystems.

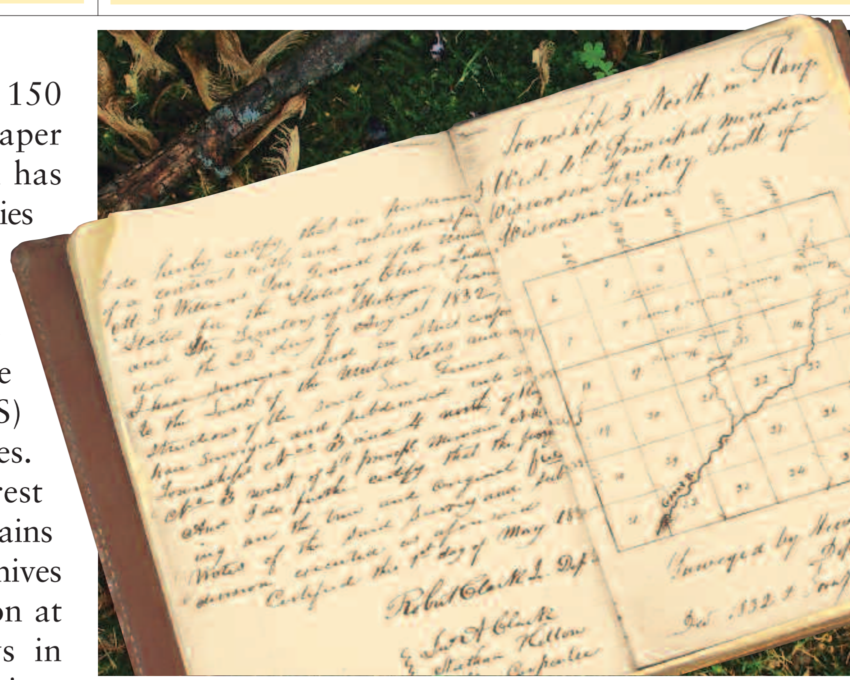
SEE WISCONSIN THROUGH THE EYES OF 19th CENTURY SURVEYORS


IOWA HISTORICAL COLLECTIONS

U.S. Deputy Surveyor Ira Cook

Natasha Kassulke

The notebooks are about 150 years old. Some of the paper has deteriorated and ink has faded. The handwriting varies from fine script to an almost unreadable scrawl. And the records are written in shorthand. ■ Yet, those able to decipher these U.S. Public Land Survey System (PLSS) notebooks are treated to some useful tales. University of Wisconsin-Madison forest ecology professor David Mladenoff explains that these notes (collectively known as Archives Series 701) provide a view of vegetation at the time of the original land surveys in the 19th century, before intensive logging, farming, industrial development and Euro-American settlement. They are used to recreate historic vegetation maps with general descriptions of the dominant vegetation, such as forest types, wetlands, prairies and savannas. →


WISCONSIN BOARD OF COMMISSIONERS OF PUBLIC LANDS

Deputy surveyors, who led the field crews, generally were private contractors and they recorded observations of land cover and use in Wisconsin in the 1800s.

Microfilm copies of surveyors' notes are housed with the Wisconsin Historical Society. Original notes and survey plats plus additional local land office records are held by the Wisconsin Board of Commissioners of Public Lands in Madison. Images of surveyors' notes and the survey plats can be found at digicoll.library.wisc.edu/SurveyNotes

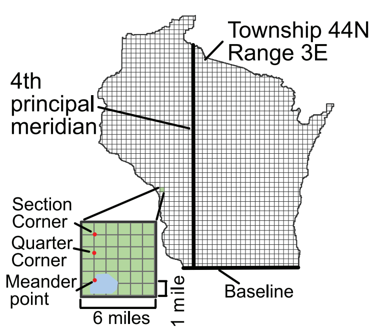
HOW IT ALL BEGAN

Between 1832 and 1866, United States government contractors surveyed lands that would become the State of Wisconsin for the purpose of subdividing and selling land to timber companies, speculators and settlers. The survey also was needed to make land grants to railroad and canal companies to finance construction.

The Public Land Survey work in Wisconsin was directed by a Surveyor General. For the rectangular land survey to proceed, two major directional lines were established: an east-west line and a north-south line. The east-west line (the baseline) ran from Lake Michigan to the Mississippi forming the boundary between Illinois and Wisconsin. The federal government designated the second major line (north-south) called the Fourth Principal Meridian, beginning at the mouth of the Illinois River and running northward intersecting the Wisconsin/Illinois baseline at the Grant County and Lafayette County border. The point where the Fourth Principal Meridian intersects with the east-west baseline is known as the "Point of Beginnings." All survey lines in Wisconsin were measured from this point.

After establishing the Point of Beginnings, surveyors began to lay lines for individual townships. Over 100 surveyors worked in Wisconsin over the survey period. The survey was systematically carried out, with survey posts (wooden posts or stones) set every half mile along a grid of one mile square blocks of land called sections. Surveyors were joined by chainmen who stretched out the measuring chain, and sometimes by axmen, flagmen or markers and general laborers. Surveying crews carried tools, camping supplies and sometimes even canoes.

The Wisconsin survey series begins with a field notebook completed by deputy surveyor Lucius Lyon in 1830. He and his surveying team walked and marked a portion of what would become the Wisconsin/Illinois border.



Wisconsin was subdivided into townships, along with the two original baselines used to begin the survey in the state. The inset of a single township shows its further subdivision into square-mile sections, and where the main survey markers were placed.

Although this was a land survey rather than a botanical survey or inventory, at each half-mile and section (mile) endpoint surveyors noted the location, species and size of two to four "witness trees" (or bearing trees). These trees were scribed with the corner post identification. It is largely these tree data that are the basis for the vegetation mapping presented here. In areas without trees such as prairies and marshes, mounds of earth or stone were constructed to mark the corner locations. With each section corner, a brief description of the vegetation, soils and other note-worthy observations were summarized for the last mile of survey run.


Field Notes of the survey and establishment of the Base Line for the surveys in the North west Territory, for that part of Michigan Terr. lying west of the Lake, by Lucius Lyon D.S. 1833. (January)

4th Principal Meridian

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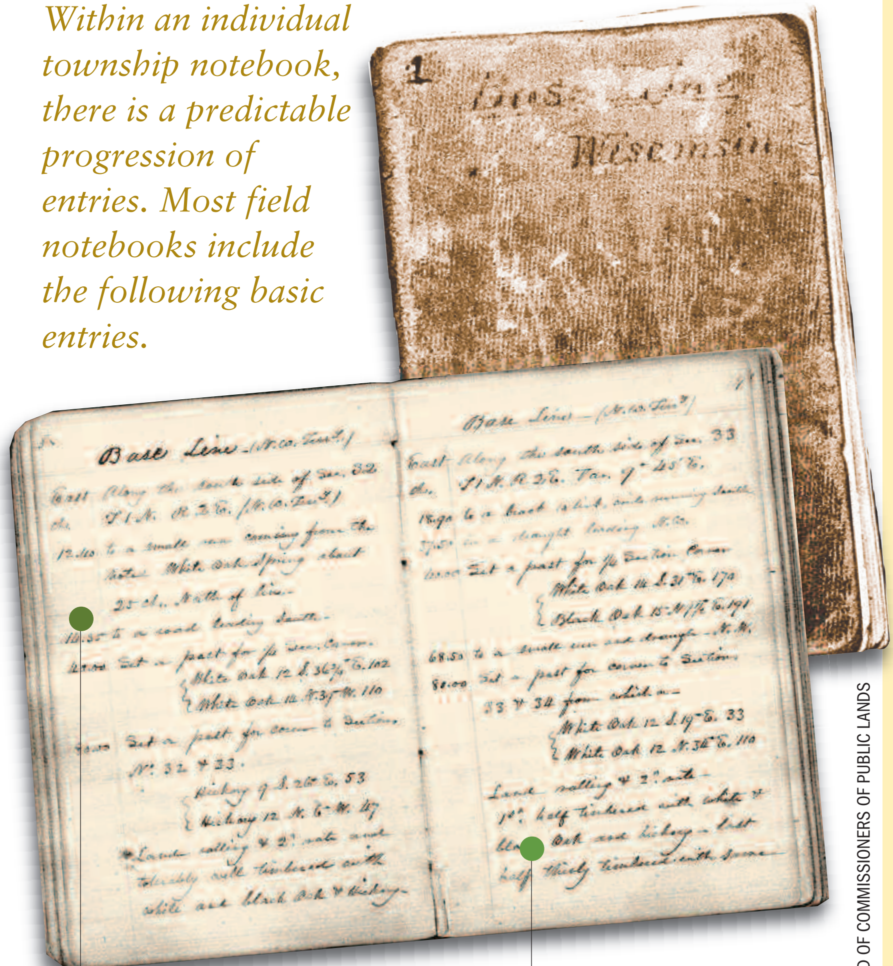
Excerpt from a letter by surveyor H.A. Wiltse in 1847

During four consecutive weeks there was not a dry garment in the party, day or night… we were constantly surrounded and as constantly excoriated by swarms or rather clouds of mosquitoes, and still more troublesome insects; and consider further that we were all the while confined to a line; and consequently had no choice of ground . . . and you can form some idea of our suffering conditioning. I contracted to execute this work at ten dollars per mile . . . but would not again, after a lifetime of experience in the field, and a great fondness for camp life, enter upon the same, or similar survey, at any price whatsoever.

UNDER THE COVER

The public land survey work was recorded in small notebooks that became the official survey record. Collectively these are known as the field notes. Within an individual township notebook, there is a predictable progression of entries. Most field notebooks include the following basic entries.



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SECTION LINE NOTES

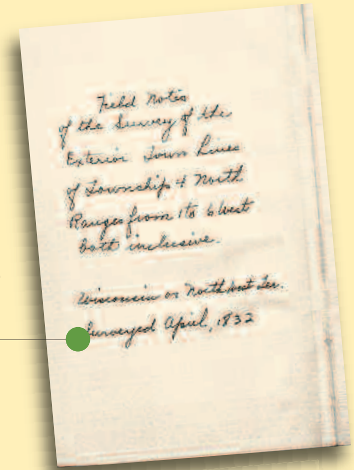
The measurement system used was the statute mile subdivided into chains and links, not feet and inches. A measuring chain is 66 feet long and there are 80 chains in a mile. Each chain is composed of 100 links each of which are 7.92 inches in length. To convert measurements from chains to feet, multiply the number of chains by 66, i.e. 80 chains x 66 (feet per chain) = 5,280 feet. Entries also list the species and diameter of bearing trees as well as direction and distance to those trees from survey posts. Other entries include locations on the section lines where they entered and left fields, swamps, prairie, wetlands, timber or other landscape or other vegetation types, crossing streams, or intersecting trees directly on the survey line. At the end of each section line, the surveyor wrote a brief description of the mile just traveled.

GENERAL DESCRIPTION

At the end of the township's survey, the surveyors wrote a general description of what they had seen (such as level, rolling, broken) and soil (first, second or third rate) as well as the dominant timber and understory species seen along that mile. Some field notebooks list Indian trails and villages, wagon roads, sugar camps, trading posts and single cabins. Some surveyors found lead mines, mill sites, scatterings of farms and cultivated fields.

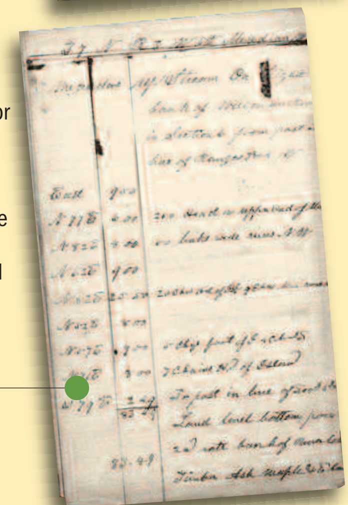
TITLE PAGE

This page includes the legal description of the surveyed township, Deputy Surveyor name and the dates that the work was done. Sometimes the survey crew is also listed here, and occasionally on the next page.



MEANDER NOTES

Whenever the surveyors encountered a sizeable lake or river along the line, they set a post at the shoreline. For larger lakes, once these meander posts were set at the section lines that intersected the lake, the shoreline around the lake was surveyed by connecting the meander corners by tangential lines.



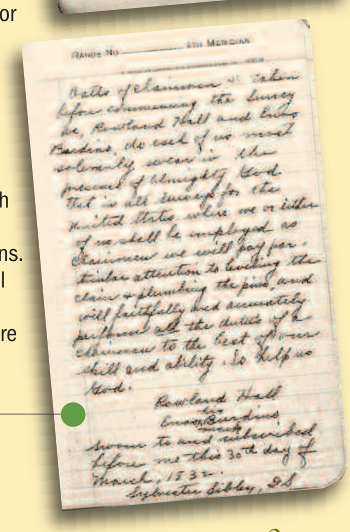
SKETCH MAP

This map was drawn in the field. Later, these maps, the township summary and field notes were used by U.S. General Land Office draftsmen to draft larger maps of each township.

AFFIDAVIT

The last portion is an affidavit or certificate by which the surveyor swears to have done his work properly and in compliance with the terms of his contract.

There is variability in the field notes. It's likely that each surveyor had his own approach to surveying and his own interpretation of the instructions. Researchers have been careful to remember, when using vegetation data, that these were collected by surveyors rather than botanists or ecologists.



FROM NOTES TO MAPS

From microfilms of these notebooks, University of Wisconsin researchers have extracted ecological information and compiled a computerized, statewide tabular database of Wisconsin's 19th century vegetation. David Mladenoff began the project in 1994 with a graduate student, GIS scientist Ted Sickley, and hired students.

The Wisconsin DNR produced a geographic information system (GIS) database of statewide PLSS corners, allowing for information mapping and spatial analysis. This has been a more than 12-year ongoing project with several partners including DNR Science Services and Forestry programs staff.

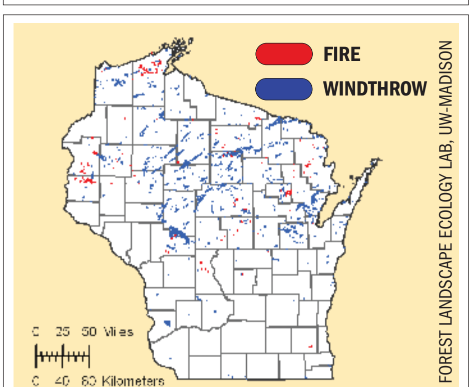
Mladenoff explains that this map and database have advantages over past efforts. The Finley map, published in 1976 by the U.S. Forest Service, had been compiled and qualitatively mapped by hand by Robert Finley — Professor of Geography Emeritus, University of Wisconsin Center System. This was a huge effort and a valuable tool used for many years. John Curtis and others in the UW Botany department had created a more general, subjectively drawn map in the 1950s. A large format, more general map also was compiled and published as part of Chamberlin's *Geology of Wisconsin* (1873 to 1879).

The big advantage of the current GIS database is that it can be analyzed with many other mapped data sets, or classified at different levels of detail. Large or small areas can be selectively mapped and analyzed for many uses, such as understanding the relationship of vegetation to soil type and understanding how landscape patterns, forests and wildlife habitats have changed over time, as well as identifying priorities and locations for restoring ecosystems. For example, looking at this map, it is clear that vegetation is not randomly distributed statewide. The vegetation pattern is a product of interaction among climate, soils and Native American use. Disturbances such as natural fires, and especially windstorms, also occurred and were important in shaping the forests.

Native populations in the south burned the landscape more frequently, favorable to prairie, oak savanna and open woodlands. Sandy soils left here by glacial outwash in the north and an old glacial lake bed in the central part of the state were drier landscapes and burned more often, favoring pine species. Northern hardwoods, such as sugar maple, yellow birch and basswood, along with eastern hemlock, predominated on sites that rarely burned and were less sandy with greater moisture-holding ability.

Surveyors also recorded fire and windthrow locations and Mladenoff's group has used these data to show where natural disturbances were important in the northern forests.

HISTORIC VEGETATION
MAJOR NATURAL DISTURBANCES



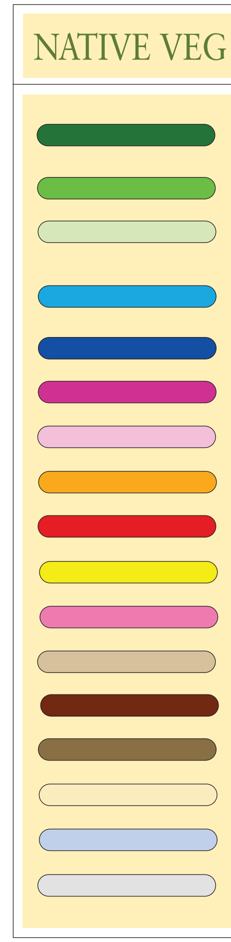
In northern Wisconsin surveyors noted where fire and windthrow disturbances had occurred. Fewer locations were mapped in southern Wisconsin because the open prairie and savanna showed less evidence of such events.

Before the data are used, it is important to understand the limitations of how the data can be applied. Because the data were not collected for ecological purposes, they approximate, but do not duplicate, quantitative methods used for forest inventory or ecological surveys today. Therefore the variability and potential biases of the data need to be known and considered. Several studies have been done to understand biases in the data. One such study used the same survey methods as the original surveyors in today's current vegetation to see how accurately the survey data matched current vegetation. Technical scientific publications on these issues and other research using the data can be found at Mladenoff's Forest Landscape Ecology website: landscape.forest.wisc.edu/

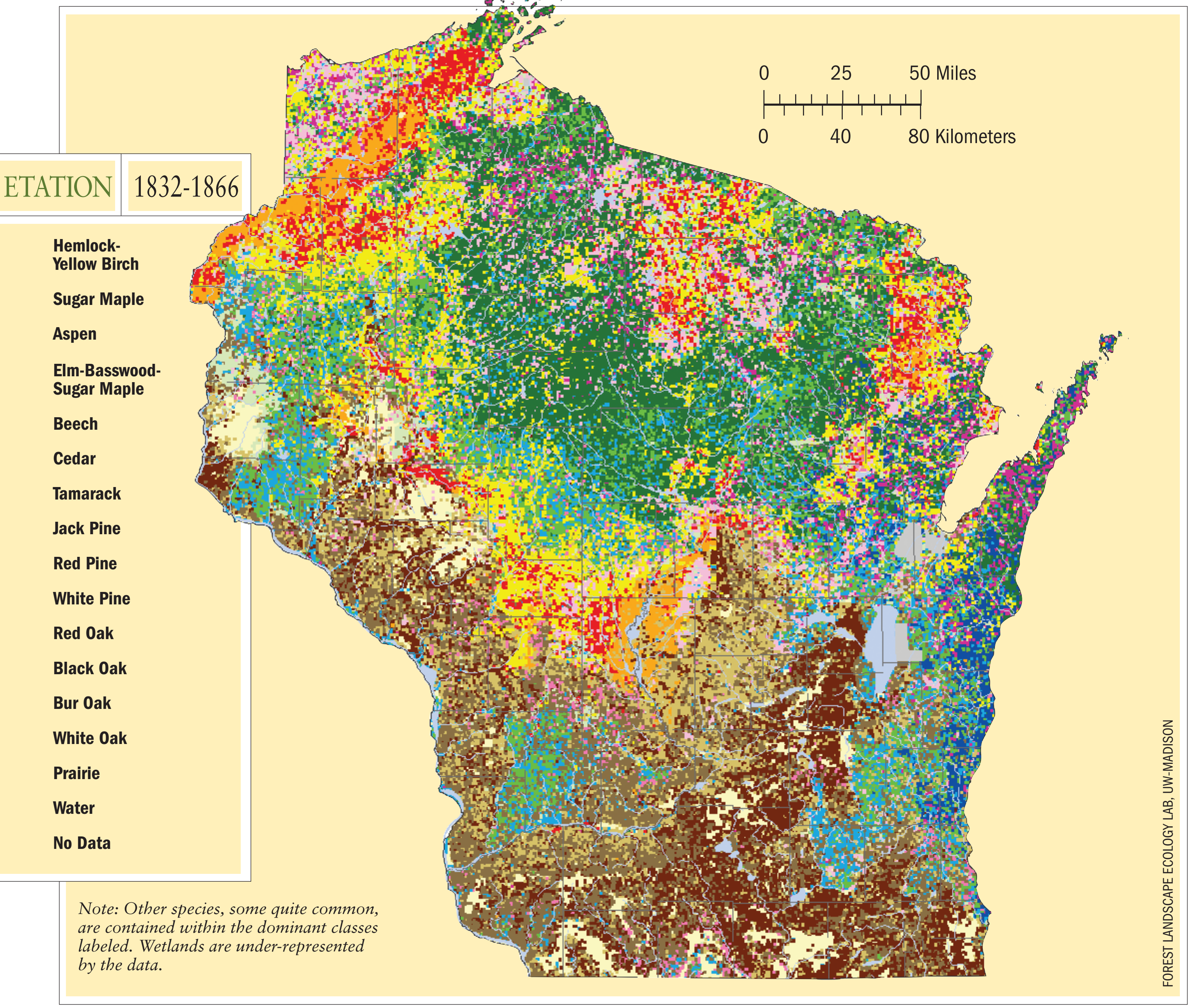
Changes during the last 150 years due to logging, farming, reforesting and development have made it difficult to assess what the presettlement ecosystems looked like in Wisconsin. Wild prairie fires declined in southern Wisconsin as early as the 1830s, allowing open landscapes to quickly revert to brush and forest. Logging started around 1850 and loggers were followed by settlers changing the landscape.

This database development project was primarily funded by the Wisconsin Department of Natural Resources and the U.S. Fish and Wildlife Service to understand relationships between locations of historical vegetation and potential wildlife habitat management. However, the data have much broader implications and contributions were also received from the U.S. Forest Service, U.S. Geological Survey and the UW-Madison. The goal of the project was never to suggest restoration of the state to historic conditions. That is not desirable or possible. The goal was to understand where in the state are the best places to manage different habitat types based on where they occurred naturally in the past.

The main user of the data has been the DNR for improving the land management planning process. Dozens of agency projects, consultants, conservation organizations,



PRE-EUROPEAN SETTLEMENT LAND COVER



private individuals and researchers have used the data and been assisted by Mladenoff's lab. Agency data use has provided information about what the land formerly held and what vegetation types different parts of the state were capable of supporting.

This is very useful information for understanding sustainable management and managing within the ecological boundaries of an area. It contrasts past practices in which individual agencies or programs developed plans for the few species or resources for which they were responsible.

From the perspective of the cost of achieving the desired goals, management plans will be most effective when they respect the natural variability of the area and work within its boundaries and constraints. For example, reintroducing a species to an area where it once existed is more likely to be successful and less likely to have unexpected, unwanted effects than introducing a species never found there.

More uses for the data are continually being found. For example, Mladenoff's lab has used the understanding of past vegetation, soils and climate to simulate modeling of future forests in the state with climate change.

"Ironically, paleoecologists are helping us to better understand the past climate that created the vegetation we see in the public land survey data," he says. "The more we understand these past relationships, the better we understand in general how tree species respond to climate, even as it continues to change. The usefulness of these data will only continue to grow and help us manage land use today and in the future."

Natasha Kassulke is creative products manager for Wisconsin Natural Resources *magazine.*

INTERPRETING THE MAPS

David J. Mladenoff

Vegetation changes constantly; slowly with gradual climate change, or faster with fire or human use. Wisconsin's vegetation has changed constantly since de-glaciation approximately 10,000 years ago, as climate warmed, cooled and warmed again, and plant species migrated north at different rates.

Wisconsin vegetation of the 1800s was the product of climate interaction, soil types, topography and Native American activity. Euro-American activity existed for 200 years before this, but was highly localized at a few Great Lakes and major river sites.

While any vegetation map from one period is static, there is some constancy to the picture of the 1800s in Wisconsin. All tree species had migrated into the state by about 3,000 years ago. Change occurred during warmer and cooler periods, and with the different amounts of fire. For example, we know that the extent of prairie varied with warm and cool periods, as did the relative amounts of pine and oak on the northwest sand plain. But studies of fossil pollen show that the basic pattern we see at the scale of this map had been relatively constant, with some shifting abundance, for several thousand years.

Climate is the broadest gradient: warmer to the south and southwest, and colder to the north. Lakes Michigan and Superior modify extremes. In the south, warmer climate and more frequent dry conditions contributed to conditions suitable for burning, likely largely due to greater Native American populations.

Resulting vegetation was largely a gradient of open prairie to savanna, to open woodland in the southern part of the state. A noteworthy mesic forest island, predominately sugar maple, basswood, oak and other species, occurred in the southwest along the Kickapoo River, which served as a firebreak from fires being driven by prevailing southwesterly winds. Black oak was most abundant in the central areas on sandy soils. White oak and bur oak were more abundant to the west and east, respectively, but common throughout.

More closed canopy mesic forest, with beech a major component, occurred along Lake Michigan, with sugar maple and other species, and more northern white cedar and hemlock on the Door County peninsula in Lake Michigan. Beech abruptly reaches its western range limit just a few counties in from Lake Michigan.

Especially away from Lake Michigan, this mosaic in the south was the result of dominant use of fire, interacting with climate, soils and topography.

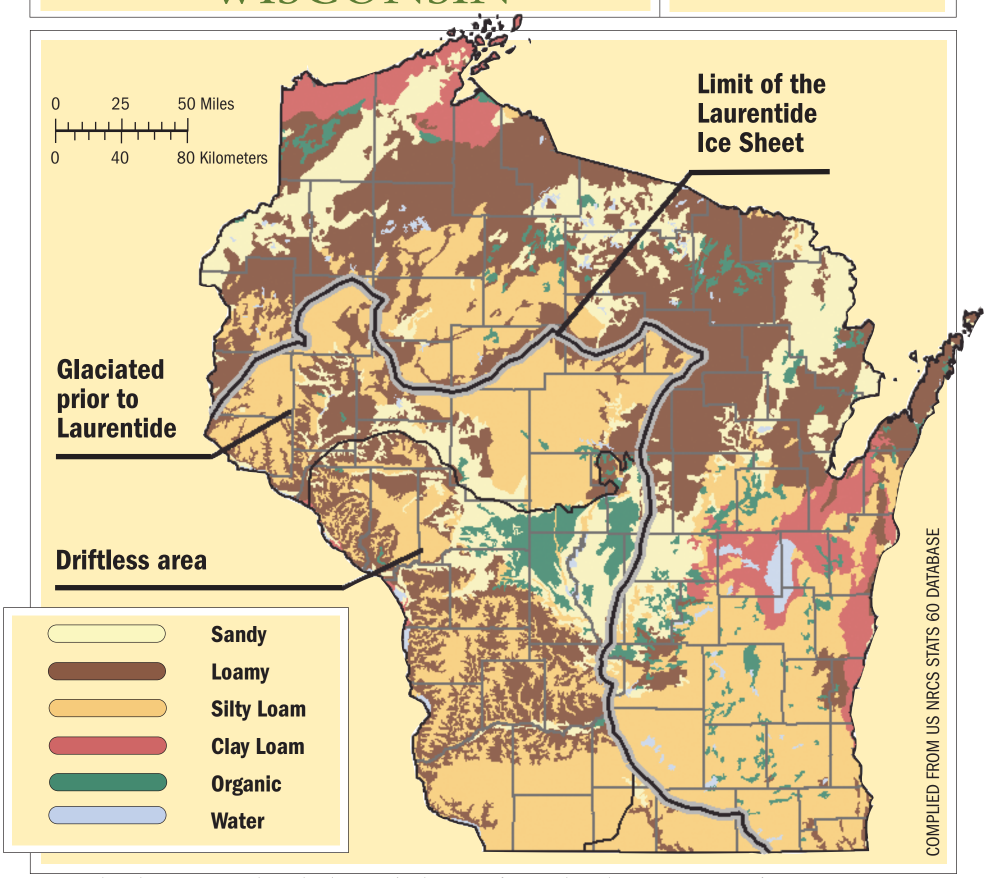
Wetlands do not map well in the south based on the Public Land Survey System data because of the density of the PLSS survey points on the landscape, and because wetlands are often small and patchy, or long and narrow and were missed by survey points.

While we usually think of the prairies as being more southerly, there were several noteworthy large open prairie areas in west central Wisconsin. Survey notes suggest that these likely differed somewhat in vegetation from those further south, having more brush and aspen.

In the north, cooler climate with less frequent drought favored more conifer species, and less fire than in the south. Lightning fire, and likely more commonly fire caused by Native Americans, was most frequent in the sandy outwash plains in the north. These can be located by noting the concentration of pines in these plains in the northwest, north central and northeast, as well as the sandy former glacial Lake Wisconsin lakebed in the central part of the state. Red oak was common with pine.

Pine concentrations also can be seen along the border of the southern oak savannas and northern forests, where fires were also more common than generally in the north, and along the major river valleys, which often have glacial outwash channels with sandier soils. The three species of

WISCONSIN SOIL TYPES



General soil regions are largely due to the legacy of past glacial activity, or its absence. Comparing this map with the 1800s vegetation map shows the importance of soil types, especially dry, sandy soils, in driving vegetation. The Laurentide Ice Sheet covered northern and eastern Wisconsin during the last glacial period.

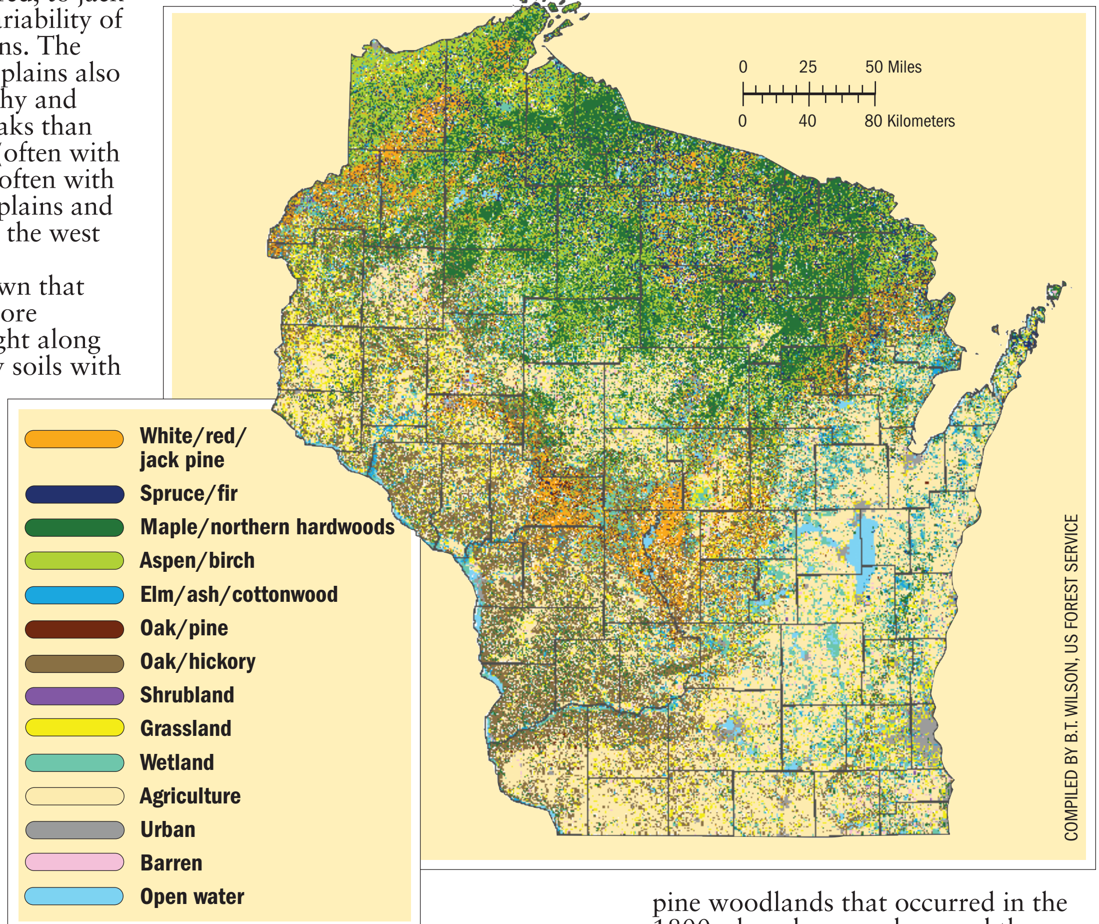
pines generally indicate a gradient of greater fire frequency and poorer, sandier soil, from white, to red, to jack pine. This is visible in the variability of the three northern sand plains. The north central and northeast plains also had more variable topography and more lakes to act as fire breaks than the northwest plain. Aspen (often with paper birch) occurred most often with pine on the fire-prone sand plains and along the savanna border in the west central area.

The PLSS data have shown that white pine especially was more common than we had thought along Lake Superior, often on clay soils with a mix of boreal conifers and white birch. Similarly, yellow birch was even more common than believed, and often dominant in the mesic forest region with sugar maple and hemlock. Hemlock and yellow birch reach the edge of their range east of the northwest sand plain, except for a few scattered infrequent occurrences further west and on the western edge of Minnesota.

Many areas of lowland forested wetlands were often dominated by tamarack and white cedar, with spruce, fir and black ash also visible. Many more smaller areas also occurred in the north, but are too small to be mapped well by the density of the survey points on the landscape.

In a wide arc around and in between the pine plains, the northern mesic forest of sugar maple, hemlock and yellow birch constituted the largest and most abundant forest type, on better soils and with very infrequent fire. Again, contrary to common assumptions, this was the most abundant forest type in northern Wisconsin, followed by pine. In fact, sugar maple, yellow birch and hemlock trees were all more abundant than white pine, though white pine was a close fourth.

CURRENT WISCONSIN LAND COVER



Vegetation change

While vegetation change is indeed constant, the change from the 1800s to the present has been unprecedented. Besides elimination of most prairie, savanna and pine ecosystems, fossil pollen studies show us that relative abundances of species changed about five times as much since the 1800s as changed in the preceding 3,000 years.

The most striking change in the 19th century map and the present vegetation map is due to agriculture. Nearly all prairies, savanna and the eastern mesic forest with beech have been replaced by agriculture. Those remnant areas of oak savanna not converted to agriculture grew into dense canopy following fire suppression. The majority of wetlands in the south, poorly mapped with this data source, have been eliminated by agricultural drainage and development.

In the north, the big change has been large declines in the evergreen conifers in the uplands, the pines and hemlock. White pine is only five percent of its volume level in the 1800s, and hemlock less than 0.5 percent. In the north, the major cause of these declines is logging that occurred from the mid-1800s to the early 1900s, followed by extreme, repeated slash fires. Significant agriculture followed logging and still persists in the south central area of northern Wisconsin.

On the other hand, the cessation of more varied, natural and Native American-caused fires has eliminated the open pine savannas and open pine woodlands that occurred in the 1800s, largely on and around the three outwash plains. These are probably among the ecosystems with the greatest loss, even more than the closed pine forests.

Research shows that contrary to common belief, less agriculture was attempted than often assumed in the north. Following the fires, aspen was favored in the north and became the dominant forest type for the first half of the 20th century, and the most important commercial species. Those areas in the north that did not burn, largely on the better soils, became dominated by a simplified mesic forest of predominantly sugar maple. This also increased slowly since the 1950s, replacing some aspen, but has stopped increasing. Yellow birch was largely lost from these forests as a dominant species, as was hemlock.

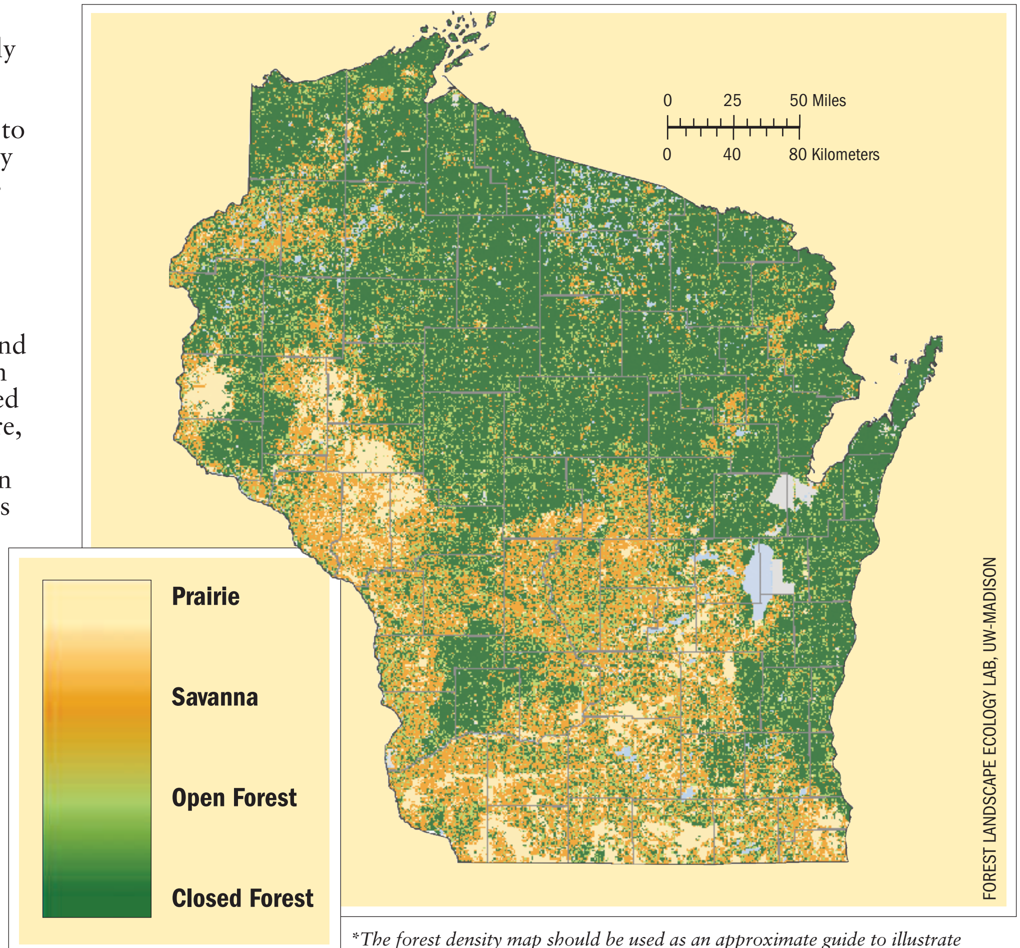
Ironically, the satellite map of today's vegetation cannot show the detailed species and genus level forest changes that we can derive from the survey data. Commonly available Landsat satellite data, while detailed, cannot distinguish tree types well, beyond evergreen and broadleaved deciduous.

Wetlands have not been lost in the north to the degree they have in the south, especially forested wetlands. However, northern wetlands dependent on frequent fire have likely declined significantly.

Less visible, with maps of this coarse scale, are continuing changes to the vegetation of the state due to very high deer abundance. This continues to affect both understory plants, herbaceous plants and shrubs such as Canada yew, as well as browse sensitive tree species, inhibiting their recovery. These include hemlock, northern white cedar, yellow birch and white pine, especially in the north. In the south, oak regeneration is affected by browsing as well as the lack of fire, which favors maple invasion.

Overall, changes have been driven by human use that directly eliminates ecosystems, such as agriculture and development, especially in the south, and logging followed by extreme fire in the north. Currently, commercial forestry is more important in the north, but also can either maintain types, such as aspen, or prevent forest succession to other types. Recent forest inventory data suggest that white pine is notably increasing in the north. The end of varied, natural fires has affected ecosystems in both the north and south.

PRE-EUROPEAN SETTLEMENT FOREST DENSITY



**The forest density map should be used as an approximate guide to illustrate relative gradients of openness. Actual tree density calculations from the survey data cannot precisely be made.*

Future change

Future changes are perhaps less likely to be characterized by recovery than we have assumed. Loss of seed sources for trees such as pine, hemlock, yellow birch and cedar, along with deer browsing, will be the reason for some of this. Climate warming directly, and broader global change-caused effects, such as new insect and disease pests arriving due to global commerce, will undoubtedly have an effect and already have. Our recent research using computer modeling also suggests that northern forest species may decline with warming and some at the southern edge of their range may be lost over the next century. Our biggest challenge now is uncertainty associated with what future changes will be from climate to land use change.

Interestingly, even with great change in the recent past and likely change in the future, the data on the vegetation of the 1800s continue to be of great value. First, because of high future uncertainty and concern for biodiversity loss, a conservative approach to maintain what we have had is prudent. Second, as paleoecological research continues to increase our knowledge about past climates that produced the vegetation of the 1800s, it helps us to better understand species-climate relationships in general.

THE UNIVERSITY of WISCONSIN MADISON

WISCONSIN DEPT. OF NATURAL RESOURCES

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