

THE PRE-EURO-AMERICAN VEGETATION COVER SURROUNDING WISCONSIN'S DEEPEST INLAND NATURAL LAKE

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ABSTRACT

The interior section lines from the early land survey records c. 1830 were examined to identify and quantify the pre-Euro-American settlement vegetation cover in the four survey townships surrounding Green Lake, Wisconsin. A main emphasis of this paper is on the presence of oak savanna communities prior to early settlement. In addition to the field notes data, historical narratives that include eyewitness accounts characterize the vegetation cover as oak savanna, with open woodlands and oak openings as prevalent communities surrounding Green Lake.

KEYWORDS: Green Lake, Euro-American, presettlement, oak savanna, survey field notes

INTRODUCTION

Green Lake, Wisconsin's deepest inland natural lake, is located in Green Lake County approximately 70 miles northeast of Madison. The mostly rural landscape surrounding Green Lake includes roads, farm fields, pastures, various businesses (manufacturing, convenience stores, restaurants, motels), private residences, golf courses, stone/gravel quarries, oak woodlands, wetlands and lake tributaries, city and county parks, and conservancy properties.

The City of Green Lake (43.845207, -88.960131), the county seat of Green Lake County, is a popular tourist and recreational destination located in east central Wisconsin. The city of 1,101 people is located along the northeast shore where the lake's outlet, the Puchyan River, begins, which then flows eventually into the Fox River.

Green Lake formed in an ancient preglacial river valley approximately 12,000 years BP after the west end was dammed by deposition of outwash and glacial terminal moraines (Martin 1965; Hooyer et al. 2021). Classified as a drainage lake, Green Lake is 236 feet deep and covering an area of 7,920 acres (Wisconsin DNR 2023a). The lake is 7.3 miles long and two miles at its greatest width. The 27.3 miles of diverse shoreline, parts of which remain undeveloped, varies from prominent exposed sandstone and dolomitic bluffs and steep slopes to terraces, ravines, and rolling hills.

In a late nineteenth century lithograph entitled "Birds Eye View of Green Lake Wis. 1875" by George L. Richards, a draftsman and publisher of panoramic views during the 1870s, most of the Green Lake shoreland is depicted as closed canopy deciduous forest (Figure 1). The bucolic scene reveals a panoramic aer-

ial view from the south side of the lake looking north, complete with fishing boats, sailboats, and steamers plying the water.

This “birds eye view” of Green Lake, surrounded by forested shoreland, is not what the Ho-Chunk tribe experienced as long-time inhabitants of the region, nor later by the early pioneers and settlers on their arrival at Green Lake in the early to mid-nineteenth century. The evidence supports the view of a vegetation cover prior to settlement that was dominated by oak savanna with communities of open oak woodlands, oak openings, and small tracts of upland oak forest surrounding Green Lake (Wisconsin DNR 2017a). An oak savanna landscape was frequently referred to by early settlers whose land claims were established within the four survey townships surrounding Green Lake (Dart 1910; Gillespy 1860).

Green Lake County is located slightly below Wisconsin’s tension zone, a transition zone between two floristic provinces, the northern hardwood province and the prairie-forest province (Curtis 1959). At the time of early Euro-American settlement the prairie-forest province was dominated by oak savannas and open oak woodlands (Cochrane & Iltis 2000). According to Leach and Givnish (1999), oak savannas in aggregate were the most widespread communities in southern Wisconsin, occupying approximately 42% of the land area below the tension zone.

Two geographical provinces are represented in Green Lake County based upon the underlying bedrock, Cambrian sandstone and Ordovician dolomite (Martin 1965). The Central Plain occupies the western and northwestern portions of the county, while the Eastern Ridges and Lowlands represent a slightly larger area to the east. Green Lake and part of its surrounding watershed reside in both of these geographical provinces.

Four soil associations are present in the survey townships surrounding Green Lake (USDA 1977). Of these, two soil associations comprise most of the study area. The Plano-Mendota–St. Charles association consists of soils that are found on the uplands south of Green Lake where prairie and oak openings were present. The soils are well drained, nearly level to sloping soils that have a subsoil mainly of silt loam and silty clay. The Kidder–Rotamer–Grellton association is found on steeper slopes mainly north of Green Lake where open oak woodlands and oak openings were established. Bur oak was especially prevalent on the loamy outwash sands of the Boyer–Oshtemo–Gotham association at the west end of the lake. Wetlands that include marsh and sedge meadows consist of level and poorly drained organic soils of the Adrian–Houghton association.

The Wisconsin Department of Natural Resources recognizes 16 ecoregions in Wisconsin, areas defined by environmental conditions, e.g., climate, landforms, and soil characteristics (Wisconsin DNR 2023b). Of these, most of Green Lake County (73%) belongs in the Central Sand Hills region where landform features include glacial moraines that are covered by glacial outwash. Historically, over 75% of the vegetative cover of the Central Sand Hills was comprised of forest, woodland, and savanna communities (Finley 1976).

Smaller areas in the northern and eastern portions of the county (27%) are part of the Southeast Glacial Plains where a thick layer of glacial deposits is mainly underlain by limestone, dolomite, and sandstone. The vegetation cover in the mid-1800s included forest, savanna, and prairie, combined with various wet-



FIGURE 1. Panoramic view of Green Lake, Wisconsin from a late 19th century lithograph entitled "BIRDSEYE VIEW OF GREEN LAKE OF GREEN LAKE WIS. 1875." Author's lithograph copy.

lands (Finley 1976). Green Lake and the surrounding watershed occupy both of these ecoregions.

A primary objective of this study was to examine the original land survey field notes c.1830 for the four survey townships surrounding Green Lake (Figure 2). Tree species data that was recorded along interior section lines were tabulated to quantify and interpret the vegetation cover prior to early Euro-American settlement. The study results also offer a contrast between the original vegetation cover within the four survey townships with that of present-day vegetation patterns brought about by the accompanying land use changes.

In addition to the field notes, a further understanding of the vegetation cover prior to settlement reported by other sources provides a more comprehensive interpretation of the vegetation cover (Dart 1910; Finley 1976; Gillespy 1860; Leach and Givnish 1999; Tans 1976). Practical application of this information is used toward native habitat restoration efforts for several locally protected conservancy lands that previously had been developed or degraded natural areas, e.g., Tichora Conservancy, Green Lake Township, NE $\frac{1}{4}$ Section 12, T15N, R12E (43.790646, -89.012230), Tuleta Hill Prairie Conservancy, Green Lake Township, NW $\frac{1}{4}$ Section 5, T16N, R13E (43.808425, -88.983004), Norwegian Bay Conservancy, Brooklyn Township, Section 35, T16N, R12E (43.812111, -89.043472), Sunnyside Conservancy, Brooklyn Township, SW $\frac{1}{4}$, Section 23, T16N, R13E (43.838985, -88.924597) and Winnebago Trail Conservancy, Brooklyn Township, Section 36, T16N, R12E (43.814991, -89.025834).

MATERIALS AND METHODS

Early Land Survey Field Notes

The original survey field notes recorded by the early land surveyors may provide the most comprehensive record of the pre-Euro-American vegetation cover. The original surveyors' field notes are made available online by the Wisconsin Board of Commissioners of Public Lands (2023). The descriptions of the surveys and the techniques used that are recounted below are taken from the same source. The Public Land Survey System was created under the Land Ordinance of 1785, which was enacted into law by the United States Congress under the Articles of Confederation. The survey was conducted by the federal General Land Office, which was created by Congress in 1812, and is founded on the township, range and section grid upon which legal land ownership and land use is based on.

Surveys in what is now Wisconsin took place between 1832 and 1865, although surveys in a few townships with Indian reservations were not completed until later in the century (Sickley et al. 2000). Schulte and Mladenoff (2001) explained that the Public Land Survey records "generally provide their best description of presettlement vegetation when used in a relative way, analyzed over broad spatial extents and at coarse spatial resolutions, and used in conjunction with other historical data sources."

The early land surveyors were instructed to record the location of the quarter and corner sections, the name and diameter of each bearing tree, as well as its compass bearing and the distance from the quarter and corner sections. Wherever possible, line trees that intersected section lines were recorded. Treeless habitats such as prairie and marshes required earthen mounds of soil or stone to mark the location of the corners. Wooden posts, approximately four inches square and two feet tall, were positioned at section and quarter-section corners that were near to at least two bearing trees. Survey posts were marked with the township, range, and section numbers.

Measurements were obtained by using chains and links, in which one 66-foot chain consisted of 100 links and each link equaled 7.92 inches. Eighty chains are one mile. For example, the entry for T16N R13E, "South Between sections 27 & 28 3.28 [3 chains and 28 links] White oak 8," is understood to mean that a white oak eight inches in diameter occurs 216.48 feet south of where sections 21, 22, 27 and 28 intersect.

The study area included the four survey townships surrounding Green Lake where the interior section lines from the field notes were examined to quantify tree data (Figure 2). According to the Public Land Survey System which is accessible online, the government land surveys for Green Lake County were conducted from 1834 to 1835 and in 1851. The survey townships (abbreviated names used here referring to the township direction relative to Green Lake in parentheses) of T15N R13E (SE Lake) and T16N R13E (NE Lake) were surveyed in 1834 and 1835, while those of T15N R12E (SW Lake) and T16N R12E (NW Lake) were completed in 1851.

The four present-day civil townships bordering Green Lake roughly correspond to the four survey townships. Unlike a 36 square miles survey township, a civil township delineates the units of local government surrounding Green Lake and include the townships of Green Lake, Brooklyn, Marquette, and Princeton (Figure 3).

The field notes data that were compiled and summarized include the identification of line and bearing trees, the mean distance in links from the quarter and corner section posts to bearing trees, tree diameters and class size distribution of trees intersecting section lines, and a calculation of the number of trees per acre and canopy cover for each survey township.

The method of calculating the density of trees per acre is equal to $[43,560 \text{ square feet per acre}] / d^2$ where d is the average distance between the sample point and all the bearing trees associated with the sample point (Cottam and Curtis 1956). The canopy cover was determined by using a 50% canopy cover in oak savannas equivalent to 19 trees per acre (Anderson and Anderson 1975).

Literature Survey

Published floras based on field observations and collected specimen vouchers housed in the Neil A. Harriman Herbarium (OSH) at University of Wisconsin-Oshkosh were examined to provide a more comprehensive knowledge of the early vegetation cover for the area (see, e.g., Eddy 1996, 1999, 2001, 2005).

Nomenclature follows the Online Virtual Flora of Wisconsin (2023), which in turn is based on a

number of sources, including Voss and Reznicek (2012), the latest Flora of North America volumes, and recent monographs (Dr. Mary Ann Feist, personal communication).

Township, range and section are used to identify the place locations that are referred to on and nearby Green Lake (Rockford Map Publishers 2019). The same sites are also georeferenced in decimal degrees by means of Google Maps (2023) and the android/mac app onX Maps (2023).

Online literature searches via Google Scholar were conducted to identify sources that provided a broader overview of the original pre-Euro-American presettlement vegetation cover c.1830 throughout the southern half of Wisconsin and to the extent possible, most proximate to Green Lake County.

A map of the original vegetation cover for Green Lake County (Figure 4) was prepared by the Green Lake County Land Use Planning and Zoning Department (2023) using the Wisconsin DNR's original vegetation polygon layer derived from a 1:500,000-scale map prepared by Robert W. Finley (Wisconsin DNR 2017a). Seven different polygons represent the county's different plant community types along with a hydrographic area polygon.

Historical Accounts

Historical narratives and eyewitness accounts include (i) a letter dated August 28, 1854 by Julia Peck Sherwood, wife of pioneer William Case Sherwood, written to her sister Harriet Sage and family (original letter loaned by Clarence F. Busse); (ii) letters written by S. D. Mitchell and catalogued by the State Historical Society of Wisconsin's archaeological collection from Green Lake and Marquette counties Wisconsin (Archives Division, Register of the Charles E. Brown Papers, 1889–1946, Box 26 Folder 1); (iii) anecdotes “as related by old pioneers” reported by Gillespy (1860) in his publication “The History of Green Lake County”; and (iv) a historical narrative, titled “Settlement of Green Lake County” (Dart 1910), prepared by Richard Dart, who was 12 years old in 1840 when Dart, his father, Anson Dart, and two brothers, Charles and Putnam, arrived and settled near Green Lake.

RESULTS AND DISCUSSION

Curtis (1959) distinguished three main types of oak savanna based on canopy composition and substrate: oak openings, oak barrens, and lowland oak savanna (Figure 5). Oak savanna was the most widespread vegetation cover throughout Green Lake County, occupying loamy soils on uplands, slopes, and sandy terraces (USDA 1977; Wisconsin DNR 2017a). Plant communities would have included tracts of oak forest, open oak woodlands, oak openings, prairie, and various wetlands (Finley 1976).

In addition to oak savanna there was a disjunct area of sugar maple–basswood forest near the southeast end of Green Lake, as well as an isolated stand of red and white pine forest north of Lake Puckaway.

An extensive oak savanna complex was present on the two low-relief dolomitic escarpments formed by the Prairie du Chien Group located on the north and south sides of Green Lake and the Sinipee Group located on the south side (Martin 1965; Hooyer et al. 2021). The area surrounding Green Lake was thinly timbered with oak woodlands, oak openings, and, to a lesser extent, occasional small tracts of oak forest. On the uplands south of the lake, dry to mesic prairies merged with oak savanna, while wetlands and lake tributaries occupied the lowlands surrounding Green Lake. Lake Puckaway and the Fox River are located west of Green Lake, while Big Twin and Little Twin Lakes, Spring Lake, and Little Green Lake lie to the south.

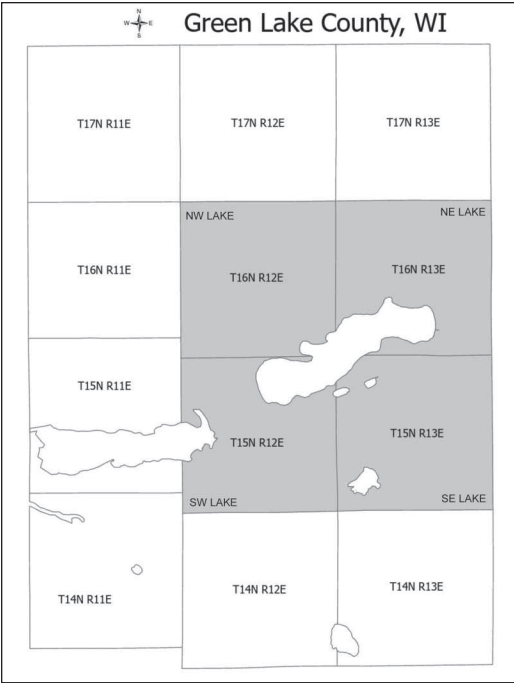


FIGURE 2. A map of the study area, the four survey townships (shaded) surrounding Green Lake. The interior section lines from the field notes were examined to quantify tree data for the four survey townships (Green Lake County Land Use Planning and Zoning Department 2023).

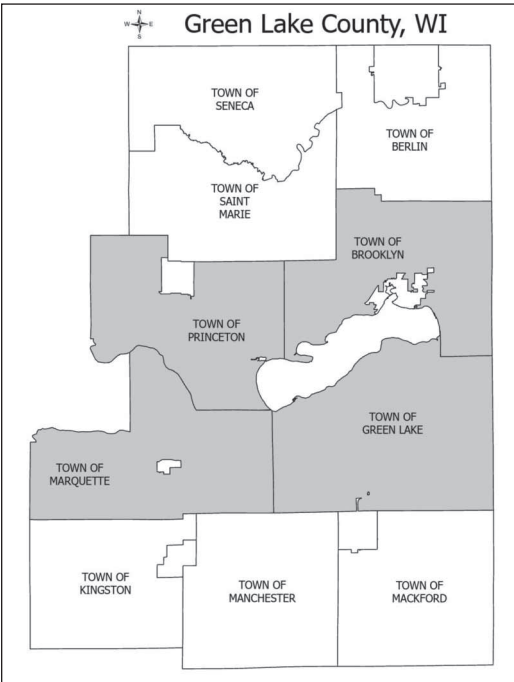


FIGURE 3. A map of the four present-day civil townships (shaded) that delineate the units of local government surrounding Green Lake and include the townships of Green Lake, Brooklyn, Marquette, and Princeton. The civil townships roughly correspond to the survey townships (Green Lake County Land Use Planning and Zoning Department 2023).

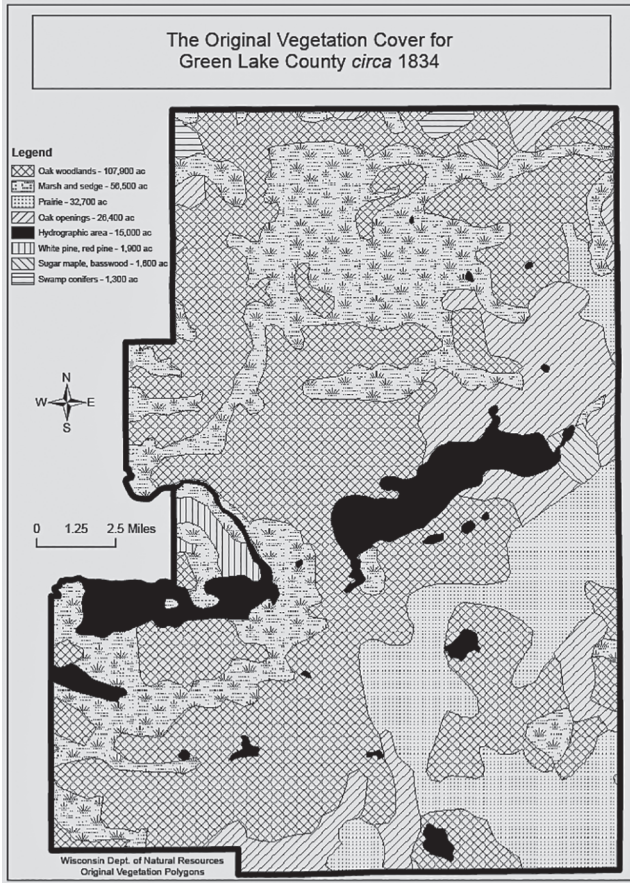


FIGURE 4. A map of the original vegetation cover for Green Lake County prepared by the Green Lake County Land Use Planning and Zoning Department and based on the Wisconsin DNR’s original vegetation polygons (Green Lake County Land Use Planning and Zoning Department 2023; Wisconsin DNR 2023).

Survey Records

The prevalence of oak savanna extends beyond the four survey townships surrounding Green Lake. Oak woodlands and oak openings accounted for a combined 58.9% of the total original vegetation cover in the county (Table 1). Oak woodlands represent the largest acreage with 107,900 acres, while oak openings accounted for 24,600 acres. Where the canopy was one-half or more open, surveyors frequently recorded the vegetation density qualitatively as “thinly timbered” or “scattering”, descriptive of the oak savanna transition from grassland to forest. Because the field notes do not consistently note the spacing

between trees, it is possible that areas of what had been mapped as oak forest may have been in fact open woodlands and oak openings (Finley 1976).

In the four survey townships that were examined, survey section lines intersected with 17 species of trees (Table 2). Three species of *Quercus* account for 92% of the total number of trees recorded as line and bearing trees. These include *Q. velutina*, 24.5%; *Q. alba*, 31.9%; and *Q. macrocarpa*, 35.6%.

The field notes do not contain any records for northern red oak (*Q. rubra*) in any of the four townships examined. The species is, however, documented in every Wisconsin county except Shawano County, and it is not uncommon in Green Lake County (Online Virtual Flora of Wisconsin 2024). Likewise, Tans (1976) did not report any northern red oak recorded in the original survey field notes for Columbia County, bordering Green Lake County to the south.

Trees in three genera are identified in the field notes to genus only: *Populus*, *Ulmus*, and *Salix*. The field notes record "Aspen," which refers to *Populus tremuloides* or *P. grandidentata*; "Elm" and "White elm" which probably refers to *Ulmus rubra* and *U. americana*, respectively; and "Willow," which could refer to any number of native, larger diameter *Salix* species. Given the same area and wet habitat as black ash (*Fraxinus nigra*), it is probable that green ash (*Fraxinus pennsylvanica*) was misidentified as white ash (*Fraxinus americana*), which is not documented for Green Lake County.

Tallgrass prairie occupied 32,700 acres on the uplands south of Green Lake (Green Lake County Land Use Planning and Zoning Department 2023). The field notes for SE LAKE and SW LAKE contain 44 entries of "Prairie" as line and bearing points. In the notes for SE LAKE, an entry for a corner section stated "Set post corner to sections 23 24 25 26 Made a mound of Earth and sods 3 feet square at base & 3 feet high Land rolling second rate South part thinly timbered with Blk W & Bur oak North part prairie." Another entry states "Set post corner to sections 11 12 13 14 in prairie Made a mound Land rolling good prairie."

Elsewhere where the loamy clay topsoil was thin, the field notes provided a brief description: "Land rolling second rate dry prairie." Occasionally specific prairie flora was recorded, as for example: "Prairie level second rate Red root [also named New Jersey tea, *Ceanothus americanus* L.] rosin-weed [*Silphium integrifolium* Michx.] rose [*Rosa* spp.] willow [*Salix* spp.] etc."

Trees were also scarce in certain wetlands in the four survey townships surrounding Green Lake. The field notes record 17 entries identified as "Marsh." Marsh and sedge meadow, as along with other wetland communities, occupied 56,500 acres throughout the county's Central Plain, with the majority of the acres associated with the Fox River, Lake Puckaway, and the White River Marsh Wildlife Area. Major wetlands immediately adjacent to Green Lake included areas of Silver Creek (Sections 23, 24 & 26 T16N R13E), Norwegian Bay (Sections 35 & 36 T16N R12E), and Dodge Memorial County Park (E ½ Section 15 T15N R12E).

Marsh and swamp habitats were associated with Green Lake's main tributary, Silver Creek, on the east end of the lake. In SE LAKE between sections 13 and 24, the field notes states "Set quarter section post in marsh no trees too wet for mound." The field notes summarized the area where the post corner was placed



FIGURE 5. A remnant bur oak opening near the east end of Green Lake. Note the spacing of trees, open canopy, and sunlit ground cover. Photo by the author.

TABLE 1. The pre-Euro-American presettlement vegetation cover in Green Lake County. Map prepared by Green Lake County Land Use Planning and Zoning Department (2023).

Vegetation Cover Type	Acres	Percentage of County
Oak woodland	107,900	47.3
Oak opening	26,400	11.6
Prairie	32,700	14.3
Marsh and sedge meadow	56,500	24.7
White pine, red pine	1,900	0.83
Sugar maple, basswood	1,600	0.70
Swamp conifer (tamarack)	1,300	0.57
Totals	228,300	100

TABLE 2. Summary of trees intersected by the interior survey lines during the original land survey for the four townships surrounding Green Lake (T15N R12E – SW LAKE, T15N R13E – SE LAKE, T16N R12E – NW LAKE, T16N R13E – NE LAKE) (Wisconsin Board of Commissioners of Public Lands 2023).

Common Name	Scientific Name	No. of Trees	% of Total
B. Oak, Blk. Oak	<i>Quercus velutina</i> Lam.	193	24.5
W. Oak	<i>Quercus alba</i> L.	252	31.9
Bur Oak	<i>Quercus macrocarpa</i> Michx.	281	35.6
Aspen	<i>Populus</i> spp.	8	1.0
Elm, white elm	<i>Ulmus</i> spp.	6	0.76
B. Ash, Black Ash	<i>Fraxinus nigra</i> Marshall	10	1.3
W. Ash, White Ash	<i>Fraxinus americana</i> L.	3	0.38
Sugar Maple	<i>Acer saccharum</i> Marshall	1	0.13
Lynn [Basswood]	<i>Tilia americana</i> L.	4	0.51
Butternut	<i>Juglans cinerea</i> L.	1	0.13
Hicky [Hickory]	<i>Carya ovata</i> (Mill.) K. Koch	2	0.25
Cherry [Black cherry]	<i>Prunus serotina</i> Ehrh.	1	0.13
Willow	<i>Salix</i> spp.	3	0.38
Iron wood [Ironwood]	<i>Ostrya virginiana</i> (Mill.) K. Koch	1	0.13
Red Cedar	<i>Juniperus virginiana</i> L.	1	0.13
Hasel [American hazelnut]	<i>Corylus americana</i> Walter	2	0.25
Tamk [Tamarack]	<i>Larix laricina</i> (Du Roi) K. Koch	20	2.5
Totals		789	100

at sections 22 23 26 27: “Land first part swamp. Last part except marsh rolling second rate thinly timbered with W B & Bur oak.” Trees recorded in swamp areas included black ash (*Fraxinus nigra*), white ash (probably green ash, *F. pennsylvanica*), aspen (probably quaking aspen, *Populus tremuloides*), elm (probably red or slippery elm, *Ulmus rubra*) and willow (*Salix* spp.).

For the area west of Green Lake near Lake Puckaway and the Fox River, in SW LAKE between sections 16 & 17, we read this: “Set quarter section post in marsh no trees” and “Set corner sections 8 9 16 17 in marsh Tamk [Tamarack, *Larix laricina*] 14 [tree diameter] S65E [compass bearing] 7.74 [774 links] no other [trees].” Willow (*Salix* spp.) and aspen (*P. tremuloides*) were also recorded. A brief summary description following a quarter section post placed between sections 29 and 30 noted: “Land level marsh Grasses Bushes Flaggs [blue flag, *Iris versicolor* L. and/or *I. virginica* L.]”

In a study of the presettlement vegetation of Columbia County, Tans (1976) suggested that “It is probable that the surveyors selected oaks more often as bearing trees, and it is likely, too, that the oak forests were simply oak savannas which had become closed communities by growth of root sprouts in the absence of regular fires; they represented an early successional stage of forests.” This assessment is consistent with early anecdotal observations (Gillespy 1860; Sherwood 1854).

The size class distribution of the 776 line and bearing recorded during the original survey for the four townships surrounding Green Lake shows that the median size tree was in the 14–16-inch size class (Figure 6). The mean diameter

of the black, white, and bur oaks combined for the four townships was 13-inches.

In township SW LAKE, along the southwest and west sides of the lake, 87 interior line and bearing trees were recorded for *Q. macrocarpa*, or 51% among the three oak species recorded. *Q. macrocarpa* is a reliable indicator for the presence of oak openings (Table 3). Aldo Leopold (1949) wrote in his “Bur Oak” essay for April from “A Sand County Almanac,” “Most of these groves of scattered veterans, known to the pioneers as ‘oak openings,’ consisted of bur oaks.” In comparison, for all Columbia County townships, oak openings were dominated by bur oak with 63–64% of the trees in the community (Tans 1976).

The ratios for the three species, black oak to white oak to bur oak, for the survey townships bordering Green Lake are: SW LAKE 1:1:4; SE LAKE 1:2:2; NW LAKE 1:1:1; and NE LAKE 1:2:2. In comparison to bur oak dominance in SW LAKE, oak savanna is most homogeneous in SW LAKE along the northwest side of the lake, with *Q. alba*, *Q. macrocarpa* and *Q. velutina* each represented by 33% of the total oaks.

The number of section corner and quarter samples, the mean number of links from post to tree, and the mean number of trees per acre for each of the four survey townships surrounding Green Lake are summarized in Table 4. The mean links from post to tree for townships SW LAKE (189 links) and SE LAKE (159) included one and two trees per acre, respectively. The canopy cover varied from 3% to 5% between the two townships.

The mean links from post to tree for townships NW LAKE (102 links) and SE LAKE (102 links) each included five trees per acre with a canopy cover of 13%. With a selection bias by surveyors for oaks used as bearing trees notwithstanding (Tans 1976), it is apparent that the vegetation cover in the townships surrounding Green Lake during the early survey was mostly open and thinly timbered oak savanna.

Depending upon soil substrate and moisture content, the canopy cover of oak openings and open woodlands would have ranged from a widely used criteria of 5%–30% or 5%–50%, thus representing a successional continuum from prairie to forest (Henderson and Epstein 1995). Cochrane and Iltis (2000) stated that a more contemporary definition of oak savannas used by ecologists are communities dominated by oaks with a mean canopy of more than 10% but less than 80%. The ground layer would have included grasses and sedges associated with mesic to dry prairies, but were largely forb-dominated, except in very sandy soils or in microhabitats with the greatest sun exposure (Leach and Givnish 1999).

Oak savannas are remarkably diverse. At small and larger spatial scales, the ground layer diversity of oak savannas exceeds that of prairies and forests (Leach and Givnish 1999). A floristic survey of 22 oak savanna remnants by Leach and Givnish (1999) reported 507 native plant species, or about 27% of the 1,873 species (Dr. John Zaborsky, personal communication) in Wisconsin’s native vascular flora (Spalink et al. 2018).

From the Wisconsin Plant Ecology Laboratory studies completed during the 1940s and 1950s, data from original point samples of various plant communities were used to assess how changes in the surrounding landscape affected the floristic composition (Curtis 1959). A set of 47 species prevalent in oak openings

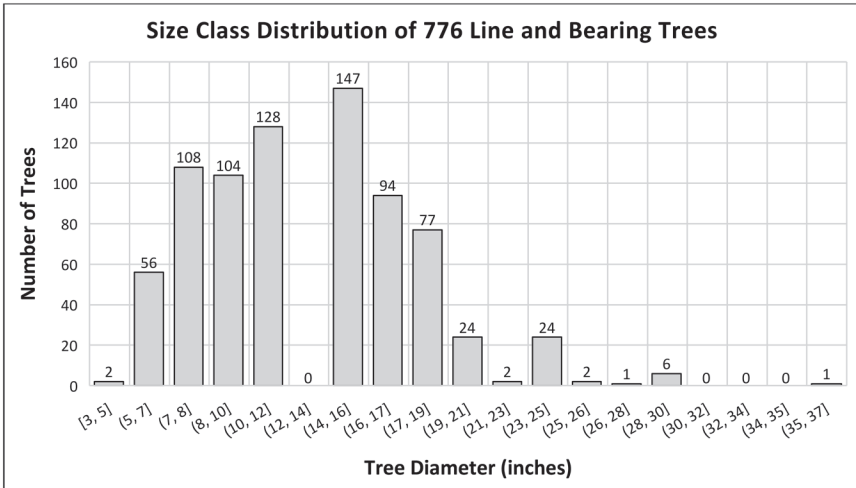


FIGURE 6. Average diameter of trees intersected by interior line and bearing trees for the four survey townships surrounding Green Lake. Data obtained from the original survey field notes (Wisconsin Board of Commissioners of Public Lands 2023).

and their mean frequencies are listed by Curtis (1959). All 47 species have been documented to occur in Green Lake County (Eddy 1996, 2018), including three modal species whose occurrence are greater in oak openings than in any other Wisconsin plant community (Curtis 1959). These modal species are *Heliopsis helianthoides* (L.) Sweet, *Ranunculus fascicularis* Muhl. ex J.M. Bigelow, and *Anticlea elegans* (Pursh) Rydb. (synonym *Zigadenus elegans* (Pursh) Rydb.).

Prior to Euro-American settlement, oak savannas in southern Wisconsin accounted for approximately 5.5 million acres (Curtis 1959). Fire disturbance caused by lightning strikes and human activities are estimated to have occurred at 1–10-year intervals, maintaining a dynamic oak savanna ecology (Abrams 1992). By the latter half of the nineteenth century, the implementation of intensive agriculture, overgrazing, fire suppression, invasion of weedy native plants and aggressive exotics, and habitat fragmentation reduced the amount of intact remnant oak savanna that is reported as extant in the Wisconsin State Natural Heritage Inventory to approximately 500 acres of the original 5.5 million acres, or a mere 0.01% currently remaining (Henderson and Epstein 1995).

Curtis (1959) recognized the loss of oak savanna ecosystems, stating that “an oak savanna with an intact ground layer is the rarest plant community in Wisconsin today.” According to the Wisconsin DNR (2017b), the NatureServe Global Conservation Status global rank for oak opening is G1: Critically Impaired. The state ranking, S1, also indicates the status at the state level. Oak savannas remain one of the most endangered ecosystem types on earth.

The genus *Quercus* is represented by approximately 464 species worldwide, of which 91 species occur in North America, making it the largest tree genus in the northern hemisphere (Global Tree Campaign 2020). Tallamy (2021) asserts

TABLE 3. Summary of the number of line and bearing trees for *Quercus* species recorded for oak woodlands and oak openings in the four survey townships surrounding Green Lake (Wisconsin Board of Commissioners of Public Lands 2023).

Township	Common Name	Scientific Name	No. of Trees	% of Total
T15N R12E SW LAKE	Black oak	<i>Q. velutina</i>	41	24.3
	White oak	<i>Q. alba</i>	41	24.3
	Bur oak	<i>Q. macrocarpa</i>	87	51.5
Total			169	100
T15N R13E SE LAKE	Black oak	<i>Q. velutina</i>	26	22.8
	White oak	<i>Q. alba</i>	50	43.9
	Bur oak	<i>Q. macrocarpa</i>	38	33.3
Total			114	100
T16N R12E NW LAKE	Black oak	<i>Q. velutina</i>	80	33.6
	White oak	<i>Q. alba</i>	79	33.2
	Bur oak	<i>Q. macrocarpa</i>	79	33.2
Total			238	100
T16N R13E NE LAKE	Black oak	<i>Q. velutina</i>	46	22.4
	White oak	<i>Q. alba</i>	82	40.0
	Bur oak	<i>Q. macrocarpa</i>	77	37.6
Total			205	100

that oaks are vital keystone community members in the local food web, providing habitat and food for a diversity of animals, particularly insects. Apart from pests and diseases, land use development, non-regenerative agricultural practices, and the longevity and slow growth of oaks may make them more vulnerable to climate change (Global Tree Campaign 2020).

TABLE 4. Number of corner and quarter section samples, mean links from post to tree, and trees per acre for each of the four survey townships surrounding Green Lake (Wisconsin Board of Commissioners of Public Lands 2023).

Survey Township	Corner Section Samples	Quarter Section Samples	Mean Links Post to Tree	Trees/Acre
T15N R12E SW LAKE	52	89	189	1
T15N R13E SE LAKE	37	61	159	2
T16N R12E NW LAKE	71	59	102	5
T16N R13E NE LAKE	49	107	102	5

Historical Narratives

The historical record of the vegetation cover surrounding Green Lake based on the original survey field notes is further supported by studies of Native American influences on the vegetation and eyewitness accounts by early pioneers and settlers through published and unpublished narratives.

Native Americans were the earliest humans to influence the vegetation in ways mostly related to obtaining food (Curtis 1959). Strong circumstantial evidence suggests that use of fire by the Ho-Chunk Nation, the primary inhabitants of the region, indirectly and directly influenced the vegetation cover (Dorney 1981; Dorney and Dorney 1989). Controlled fires were used to drive wild game, clear land for gardens and to create buffers that protected campsites from wild-fires in the spring and fall. Fire disturbance, caused naturally or by human activities maintained a dynamic mosaic of oak openings and open woodlands, prairie, and wetlands. These plant communities are fire-dependent and required periodic conflagrations for their perpetuation.

In June 1840, pioneer Anson Dart and his three sons, Putnam, Charles, and Richard, become the first permanent Euro-American settlers to row across Green Lake and stake their land claim one-half mile south of Sandstone Bluff near Twin Lakes, Green Lake Township, Sections 32 and 33, T16N, R13E (43.81751, -88.96514) (Heiple and Heiple 1976).

The landscape that included the original 80 acres acquired by Anson Dart in the NE $\frac{1}{4}$ section 5, T15N R13E was reconstituted from memory by Richard Dart (1910) when he explained: "There were no settlers there as yet, only wigwams of the Winnebago [Ho-chunk] grouped or scattered around the lake. There was no timber then, but oak and clay openings, with Green Lake prairie to the south."

From 1843 and on, accelerated settlement resulted in significant changes in the vegetation. Even though commercial logging did not occur on any appreciable scale, oak woodlands played a vital role in the development of farming by furnishing fuel and the materials for building homes, barns, fences, and bridges. Richard Dart (1910) explained how the local timber resources were utilized when his family arrived in 1840:

We soon crossed the lake and reached our land [Section 5 T15N R13E], of which my father recognized the quarter-section corner. We lugged our stuff up by hand from the lake [near Sandstone Bluff], erected a shanty for shelter, and at once went to work to build a plank house. We split and hewed white oak [Quercus alba] planks, about two inches thick by six feet long, and set them upright, two lengths end-to-end twelve feet high, held together by grooved girts or stringers. We used poles for rafters and "shakes" for shingles, the latter shaved out of green oak.

Following settlement, the suppression of fire on landscapes resulted in significant changes in the vegetation cover. In a study of the factors that contributed to changes in vegetation patterns in presettlement southern Wisconsin, Leitner et al. (1991) reported that "alteration of the fire regime was most evident in the ecotones between prairie and forest, where savanna remnants were soon converted into closed *Quercus* [oak] forest."

Anecdotal observations detailed by Gillespy (1860) of the county's oak openings during early Euro-American settlement describe changes in vegetation cover that coincides with fire suppression and early farming:

The general face of the country, is undulating; neither hilly or extensive plains, (with the exception of high, broken lands around the marshes, in the south part of the county,) handsome rolling lands. The openings, in the first settlement of the county, were kept free from underbrush, by annual fires, which now are not frequent. Lands, which but a few years ago, presented the appearance of a well kept lawn, are now filling up with a thick underbrush. These openings are some of the finest lands in the State. Although the prairies are considered the most productive, yet by many of the settlers, the openings are considered more reliable, one year with another, for a crop; and in consideration of wood, water, with many other advantages they afford over the prairie, often selected in preference.

In Brooklyn Township, which includes portions of northern and eastern Green Lake shores, Gillespy (1860) reiterates a description of a dense undergrowth caused by the cessation of annual fires:

Lands covered, generally, with a thrifty growth of oaks, and as in most all other localities, a dense growth of underbrush, since the annual fires have ceased destroying young and tender plants sprouting from year to year.

In the present-day City of Green Lake between sections 21 and 28, T15N R13E, near the west end of Illinois Avenue and the former Oakwood Resort (43.8370, -88.9587), the field notes recorded "Land rolling second rate Thinly timbered with W B & Bur oaks". Numerous field note entries record survey line summaries with the similar verbiage, e.g., at the corner sections 16, 17, 20 and 21, T15N R13E, one quarter mile east of the junction of State Highway 23 and North Street, near the Dartford Cemetery (43.8525 -88.9654): "Land rolling second rate Thinly timbered with W B and Bur oaks".

The eyewitness account by Richard Dart (1910) noted the lack of forested lands around most of Green Lake in the mid-nineteenth century:

There was at this time no heavy timber around the lake, except at the foot [Silver Creek inlet], in the marshes—only what were called "clay openings," burned over each autumn by the prairie fires.

The "clay openings" are a reference to exposed clay loam on till plains and moraines where the soil layer is erodible and thin, ranging from depths of 0–5 feet and 5–50 feet above the dolomitic bedrock (Schmidt 1987).

Tallgrass prairie covered the level and rolling uplands in southeastern part of Green Lake County. Remnants of this prairie would later be named for the civils townships where they occur, Green Lake and Mackford prairies. Dart (1910) stated:

All the while, we were clearing and breaking land. It was thin and poor in the clay openings, and as yet we did not know how to farm to advantage. Father used to repair grist-mills and sawmills as far off as Watertown, leaving us boys to run the farm. Finally we got enough money together to go up on the prairie and buy a "forty" of better land, with richer soil.

Prairie and oak openings that bounded wetlands were frequently mentioned by early settlers and visitors in letters and journals. Julia Peck Sherwood, in a letter to her sister Harriet Sage and family dated August 28, 1854, described a trip from Dartford (renamed Green Lake in 1907) to Ripon.

Last Friday I went with Mr. S [William C. Sherwood] to Ripon, a village about seven miles from Dartford that was the farthest I have rode since I arrived here and the first time that I have past over any green prairie [State Highway 23 between Green Lake and Ripon]. It was a beautifully grand prospect to see one uninterrupted, unbroken undulating meadow as far as the eye could extend towards the Missippie [sic] with occasionally a herd of cattle of thirty or forty, they always keep in companys [sic]. The land was cultivated along where the road passed, or some of it was, but it looks strange to see so few fences where the country looks as if it had been cleared. Mr. S has no prairie, he has one large marsh that serves him for a meadow [wetlands bordering Green Lake Mill Pond], but all the cattle in the vicinity feed on it if they choose, but there is good pasturage in the woods here, the trees are so small and scattering. They are all oaks, and there are places that they call oak openings of many acres that there are no trees or stumps (Sherwood 1854).

From her description, it is plausible that Julia Peck Sherwood had observed oak grubs, small oaks with multiple stems that arise from oak seedlings whose tops are killed by fire. Oaks are uniquely adapted to fire and the grubs may remain alive for many years without growing into saplings. Johnson et al. (2019) reported that oak grubs may develop extensive root systems that are many years older than their living stems and can produce saplings when environmental conditions change that allows for sprout growth.

Trees, notably oaks, were harvested for lumber and fuel while savanna was converted to cropland. It was common practice to “green up the woods” for pasture by burning. These routine fires were started and left unattended to burn where they would. In some instances, controlled burns were practiced for safety precautions, as described by Dart (1910): “Every fall we had to burn round everything—house, sheds, and stacks—to save them from these fires that annually swept the prairies.”

Gillespy (1860) noted the lands utilized for pastures and farming:

The sandy lands of Brooklyn, St. Marie, Princeton, Marquette, Kingston, Seneca and part of the town of Berlin, with their never ending supply of hay and pasturage, are a paradise for cattle, and when the prairies and burr [bur] oak openings, by continual cropping and plowing, becomes exhausted, these lands will be sought for, with avidity, and realize what God has decreed, that the marshes are to be a never ending source of wealth to the owner.

The presence of prairies and savannas are frequently inferred or explicitly stated in the early land surveys throughout the survey townships in the Green Lake region. From the field notes of December 1834 for the area two miles southwest of Center House (43.7916, -88.9557), at the corner post of sections 16, 17, 20, and 21, T15N R13E, the record states “Land rolling second rate Mostly prairie.” Further south, in what would later be referred to as part of Mackford prairie, between sections 27 and 34, T15N R13E, the land is described as “. . . level 1st rate Prairie.” Where line and bearing trees were absent, an earthen mound was prepared: “Set post & erected on mound of earth and rocks.”

Further evidence of a prairie and savanna-dominated landscape is apparent

from Richard Dart's memory of the Green Lake prairie flora described decades later:

I wish I could adequately describe the prairie flowers. Every month during spring and summer they grew in endless variety—such fields of changing beauty, I never saw before. It was a flower-garden everywhere. You could gather a bouquet any time, that couldn't be equalled [sic] in any greenhouse of New York or Chicago. There were double lady-slippers, shooting-stars, field-lilies, etc., etc. Some of them still linger beside the railway tracks. We tried over and over to transplant them, but only the shooting-stars would stand the change. There was also the tea-plant, whose leaves we dried for tea. When in blossom, the oak and clay openings, for miles around, were white with it, like buckwheat. We also had splendid wild honey from the bee-trees (Dart 1910).

Forested habitats were afforded some protection from fire where they occurred in wet floodplains and stream valleys. Prior to the damming of the Puchyan River, Green Lake's outlet, lake levels were considerably lower. The lake's main tributary, Silver Creek, was not the wide inundated estuary with floating and submergent vegetation that it is today, but rather a diminutive meander that flowed through marsh, sedge meadow, lowland forest, and swamp. Among trees present in the timbered floodplain as recorded in the field notes were black ash (*Fraxinus nigra*), white ash (probably green ash, *F. pennsylvanica*), elm and white elm (*Ulmus rubra* and *U. americana*), cherry (probably *Prunus serotina*), sugar maple (*Acer saccharum*), aspen (*Populus tremuloides*), various willows (*Salix* spp.), and red-osier dogwood (*Cornus sericea*).

In 1844 Anson Dart, his son Richard, and Smith Fowler constructed the original Mill Pond dam to power a lumber mill, then later a gristmill (Heiple and Heiple 1976). The dam significantly modified Green Lake's littoral zone and adjacent wetlands by raising the lake level and flooding Silver Creek east off County Road A and opposite of Sunset County Park, SW ¼ Section 26, T16N R13E (43.8277, -88.9274).

Another early resident in the area, S. D. Mitchell, reported lowland forest occupying the east end of Green Lake when Silver Creek was a diminutive flowage.

It might be well to state here that the intire [sic] shoar [sic] line of the lake was changed by the building of a dam across the out let [outlet] called the Puchyann [Puchyan] River at Dartford in the year 1844. This dam Raised the level of the lake some Four feet or more flooding a large tract of very heavy timber...some years since parties removed the over flowed stumps in the shallow watter [sic] between this [Silver Creek inlet, SW ¼ section 26; 43.82511, -88.92336] and the Lake. (State Historical Society of Wisconsin 1888).

Mitchell's reference to sugar maple emphasized the dependence of Native Americans and early settlers on a nearby tract of maple-basswood forest in and around Mitchell Glen (43.8159, -88.9154), a present-day conservancy property. Approximately one mile northwest of Mitchell Glen, another conservancy land, Sugar Island (43.8274, -88.9238), served as a peninsular campsite along Silver Creek by the Ho-Chunk. Mitchell wrote:

[A] small island [SW ¼ section 26 T16N R13E] known as sugar creek island this is surrounded on the north and west by silver creek and on the south and east by swamps this is-

land formerly was covered with heavy maple timber here again was shown the hacking gouging present of the Indians mode of tapping [sic] the maple with his rude implements...(State Historical Society of Wisconsin 1888).

In the survey field notes for the area north between sections 26 and 27, T16N R13E, along what is today referred to as “Inlet Road” (County Road A), “Lynn [basswood] with a 16” diameter is reported. In the same notes is the following passage: “Land first part swamp Last part except marsh rolling second rate thinly timbered with W B & Bur oak.” For the area that is less than a mile northeast, where South Street passes the Sunnyside entrance, the field notes state “Random between Sections 23 & 26”, a “Stream” (Silver Creek) is crossed, then “Enter heavy timbered land.”

Land First part rolling 2nd rate

Scattering W. B & Bur oak

Last part timbered with W. B & Bur oak

Maple Sugar with thick undergrowth of Briars [Rubus sp.] Hasle [Corylus americana]

West corrected between Sections 23 & 26

Set quarter section post B Ash W Ash

The vegetation cover for most of the immediate area surrounding Mitchell Glen was oak savanna. Upland tallgrass prairie, which transitioned to oak opening, flanked the southern margin, while extensive oak openings occupied the areas southwest and northeast of Mitchell Glen. Historically, recurrent fires greatly influenced the vegetation cover by diminishing woody succession and favoring oak savanna. Although most of the prairies and oak openings were placed into cultivation during the latter half of the 1800s, the dominant vegetation cover for Mitchell Glen remains maple basswood forest (Eddy 1999).

In contrast, based on the field notes for areas near the shores around Green Lake, forested tracts of land were evidently sparse and widely scattered. For example, north between sections 33 and 34 T16N R13E:

36.00 Set post on Green Lake

W. oak 24 S66W 1.48

Bur oak 6 N71E .46

Land rolling thinly timbered with W B & Bur oak

Immediately west of Sandstone Bluff, north between sections 33 and 34 T15N R13E, “Land rolling second rate scattering W B & Bur oak.” Continuing west near present-day Emerald Shores, between sections 6 and 7, white oak and red cedar are recorded, while the area included as part of Tuleta Hill, between sections 6 and 7 T15N R12E, “Land rolling second rate Blk W & Bur Oak.”

Further west, at Tichora Conservancy, between sections 11 and 12, T15N R12E the entry reads: “Fell into line North side of [Spring] Lake Hickory 12.” Then approaching the Green Lake shore: “Larger Lake. A Red Cedar 12 on South Bank.” Continuing west, between sections 14 and 15, T15N R12E, where another conservancy property, Blackbird Point (43.7839, -89.0402) is located: “Set quarter section post in Marsh no trees” and at section corners 10, 11, 14 and 15 bur oaks with 18- and 20-inches diameter were recorded.

At the west end of the lake, what is locally referred to as Green Lake Terrace

(43.7798, -89.0621), off Lake Shore Drive, north between sections 9 and 10, T15N R12E: “Land hilly third rate scrubby Blk W & Bur Oak.” The description is suggestive of well-drained sandy soils and recurring fires on the landscape.

Following the lakeshore to Sugarloaf (43.8070, -89.0348), a dolomitic-capped peninsula between sections 1 and 2, T15N R12E the land is “rolling second rate Oak Lynn [basswood] Iron wood [ironwood] Cedars [red cedar].”

Having gone full circle around the lake and ending on the eastern side of the Green Lake Conference Center (43.8372, -89.0088), west between sections 19 and 30, T16N R12E, again oak savanna is recorded: “Land rolling poor Second rate Scattering B W & Bur Oak.”

CONCLUSIONS

It has been 184 years since Anson Dart and his sons arrived at Green Lake (Heiple and Heiple 1976). The evidence gathered from the survey field notes, historical narratives and eyewitness accounts record a pre-Euro-American vegetation cover dominated by oak savanna that surrounded most of Green Lake. The presettlement landscape and vegetation cover witnessed by Anson Dart and other early settlers who sustained a livelihood by farming the prairies and oak openings provided a sense of place for these land-hungry pioneers.

Shaped by climate and fire, influenced by Native Americans and then later by early settlers, the landscape today contains only fragmented remnants of original oak savanna. Fire suppression and ecological succession abetted an increase in the acreage and distribution of woodlands, from farm woodlots and hedgerows to dry timbered escarpments and tracts of lowland forest and swamp.

According to WisconsinForestry.org (2023):

After heavy logging early in the 20th century, much land was burned and converted to agriculture. But, since the 1930s, much marginal crop and pastureland has been planted with trees so the state now has more forestland than at any time since inventories began in 1936.

Decades of tree plantings have occurred since settlement. Red and white pine plantations were established to stabilize soils, some later harvested for lumber and pulpwood. Public and private lands have been planted and managed for wildlife habitat. Landscape plantings by municipalities and private individuals include Wisconsin native trees, but not native to Green Lake County, such as river birch (*Betula nigra*), white cedar (*Thuja occidentalis*), white spruce (*Picea glauca*), sycamore (*Platanus occidentalis*) and American beech (*Fagus grandifolia*), to name a few.

In addition, numerous exotic cultivars have been introduced: Norway spruce (*Picea abies*), blue spruce (*Picea pungens*), northern catalpa (*Catalpa speciosa*), ginkgo (*Ginkgo biloba*) and weeping willow (*Salix babylonica*). Other nonnative species such as black locust (*Robinia pseudoacacia*), Norway maple (*Acer platanoides*), European buckthorn (*Rhamnus cathartica*) and glossy buckthorn (*Frangula alnus*) are introductions that are naturalized and ecologically invasive.

While not native to Wisconsin, American chestnut (*Castanea dentata*), a species devastated by the exotic chestnut blight, was introduced and established in the Green Lake Conference Center and at certain private residences as well.

The mature trees viewed today are less than 125 years old (WisconsinForestry 2023). The forested shores of present-day Green Lake are not entirely original—they are a result of natural dispersal and deliberate and accidental introductions accompanied by fire suppression and woody succession.

Upon reconsideration of George L. Richards' lithograph "Birds Eye View of Green Lake Wis. 1875," one landscape depiction is truer now than in 1875. Today there are indeed sylvan shores encompassing a majority of Green Lake shores, and they will likely continue to grace Wisconsin's deepest inland natural lake for many years to come.

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