2. Forest type, size class, age class, and successional stage
This indicator interprets successional and structural development trends based on characteristics and changes in forest cover types, size class, and age class.

Many native forest associated species prefer habitat characteristics that vary with forest composition and structure. The mix of successional and developmental stages across forested landscapes indicates potential habitat and biodiversity. A landscape management approach that accounts for all characteristic successional and developmental stages with forest stands ranging from small to large will facilitate biodiversity conservation. Silvicultural systems that more closely emulate natural disturbance and stand development processes are more likely to sustain ecological complexity and biodiversity (Crow et al. 1994, Niemela 1997, Seymour and Hunter 1999, OMNR 2002, Franklin et al. 2007, MFRC 2007, National Commission on Science for Sustainable Forestry 2007).

Ecological simplification of forest ecosystems refers to the loss of species and structural diversity, and increased dominance of fewer species. At the landscape scale, simplification and homogenization occur when forest patches become similar in size, shape, and composition, providing less habitat diversity. Traditional forest management systems risk creating simplified ecosystems unless mitigating measures are taken. Even-aged rotational harvest methods might not include the retention of significant structural legacies that typically persisted following natural stand replacement disturbances. For these even-aged management systems, the retention of compositional and structural legacies is critical to the development and implementation of adaptive silvicultural methods that strive to integrate the conservation of biodiversity (Crow et al. 1994, Seymour and Hunter 1999, Hammond et al. 2004, Franklin et al. 2007, MFRC 2007).

In forests managed for timber production, variable retention harvesting retains biological legacies from the harvested stand for integration into the new stand to achieve ecological objectives (Helms 1998). Structural legacies selected for retention may include large reserve trees, large snags, and large down logs that provide refugia and structurally enrich the new stand (Crow et al. 1994, Christensen et al.1996, Fridman and Walheim 2000, OMNR 2002, Hammond et al. 2004, Hyvarinen et al. 2006, Franklin et al. 2007). Large structures take time to develop and are not easily replaced. Important characteristics of reserve trees selected as biological legacies are: species diversity; size class representation, especially very large trees; tree health, including both healthy and decadent trees; and heterogeneous distribution as dispersed individuals and aggregated patches.

Silvicultural practices are designed to manipulate vegetation to achieve management objectives (Smith 1962, WDNR 1990, Nyland 1996). At its foundation, silviculture is based on understanding and working with ecological processes. Most natural disturbance regimes and events retain compositional and structural legacies in heterogeneous patterns and create ecological complexity. Adaptive silvicultural methods in managed stands can promote stand level heterogeneity, compositional and structural complexity, and the conservation of biological diversity.

2.1 Forest cover type

Forest land area slowly increased from 1983 to 2007 (Table 2.a and Table 2.b). During this same period, timber growing stock volumes increased by over 30% (Table 2.c).

Forest tree composition is dynamic, changing over time within stands and across landscapes. Forest change often is slow, but can also be abrupt and drastic. Some important factors that influence changing forest composition include environmental variables such as climate and soil; forest disturbances such as fires, storms, insects, diseases, and tree cutting; regenerative strategies of nearby tree species; and forest management practices. Tree composition influences the composition of other plants and animals and how the forest ecosystem functions, thereby influencing biodiversity.

Maple-beech-birch is the most common forest cover type in Wisconsin, representing over a quarter (27%) of all forest land. Total acreage of this type increased significantly in the 1980's and 1990's, but leveled off in the last decade. The maple-beech-birch type (roughly analogous to maple-basswood and northern hardwood cover type classifications) is characterized by the dominance of sugar maple. Hard maple (mostly sugar maple) accounts for 11% of statewide growing stock volume. Soft maple (mostly red maple with some silver maple) accounts for 12%. Both sugar and red maple have shown significant increases in volume since the 1980's, with red maple increasing most steadily and dramatically. Red maple gains are related to its occurrence within other forest types. A major change in overstory composition is the reduction in the representation of hemlock, white pine and yellow birch. (Although the growing stock volume of hemlock reported in Table 2.c is going up, that is attributed to small trees growing larger, not to an increase in hemlock acreage.)

Maple-beech-birch is a late-successional forest type, but most Wisconsin stands are in the early stages of stand development and recovery from the Cutover. Structurally, they are comparatively simple. Most are even-aged, in the stem exclusion stage, lack large structures (trees, snags, woody debris), and exhibit relatively homogeneous canopies. Few maple-beech-birch forests possess the ecological complexity of pre-settlement forests.

Oak-hickory is the second most common forest cover type in Wisconsin, representing about one-fifth (21%) of all forest land. Total acreage of this type has remained relatively stable since the 1980's. In Wisconsin, the oak-hickory type is characterized by the dominance of oaks. Northern red oak accounts for about 8% of statewide volume. Since the 1980's, volume first increased somewhat but then declined. The number of red oak trees has been declining more rapidly than volume. Declines have been greatest on mesic and dry-mesic sites.

Historically, forests dominated by oak occupied about 5.0 million acres or 20% of forest land area. These forests occurred almost entirely in southern Wisconsin (Province 222) and were fire driven systems, largely intermingled with oak savannas. Current oak-hickory forests are distributed somewhat more widely and characterized by the passage of older oaks and absence of renewal with the cessation of fire as a natural process, the in-growth of shade tolerant trees like red maple or invasive shrubs, and excessive animal browsing.

Aspen-birch is the third most common forest cover type in Wisconsin, representing about one-fifth (20%) of all forest land. Based on Public Land Survey data from the mid-to-late 1800s, aspen- and white birch-dominated forests occupied about 0.4 million acres or 2% of forest land area historically. The aspen-birch type expanded dramatically after the Cutover, but today the total acreage is slowly and steadily declining. About 8% of the total acres present in the early 1980's have converted to other vegetation types.

Aspen (including cottonwood, a relatively minor species in the state) accounts for about 12% of statewide volume. Since the early 1980's, volume has declined slowly and steadily, at a rate similar to the decline in type acres. White birch is also declining in volume. These species are primarily associated with fire driven disturbance regimes. Current aspen-birch forests are mostly coppice origin from commercial timber harvests and no longer associated with fire.

The aspen-birch type has many associated wildlife and economic benefits. It is, for example, favored habitat by ruffed grouse and woodcock and is a mainstay of the state paper industry. The expansion of aspen-birch following the Cutover demonstrates that site conditions in Wisconsin can support more of the type than was present in pre-settlement times. The degree and extent of active management (involving fairly intensive harvest techniques) to promote aspen-birch is a public policy question to be addressed in the broader forestry community.

Pine (white, red, jack) is dominant on about 9% of all forest land. Total acreage has remained relatively stable since the 1980's. Historically, white pine and red pine dominated forests occupied about 1.9 million acres or 8% of forest land area. Since the early 1980's, the volume of white and red pine has steadily and significantly increased, more than doubling. Most red pine is grown in plantations. Natural white pine regeneration is advancing due to its shade tolerance and the absence of fires. The volume of fire-dependent jack pine, on the other hand, has decreased dramatically since the early 1980's, with over one-half of its acres converting to other forest types.

Historically, pinelands were most common on dry outwash sands landscapes. Jack pine-scrub oak forests and barrens often occurred within the most droughty or fire prone portions of these landscapes. These pine forests were compositionally and structurally complex because of variable, natural fire patterns and species adaptations. Today, plantations are common but have simple composition and structure. Older stages of pine forests are poorly represented, and fire has been removed as a natural process.

Elm-Ash-Cottonwood dominated forests represent about 9% of all forest land, compared to1% historically. Total acreage has been steadily increasing in the absence of fires that once prevented encroachment of trees into more open wetlands. This forest type is highly variable with mostly hardwoods growing on floodplains, and wet soils. Ash is a dominant species in this forest type and its volume has been steadily and significantly increasing. That trend could be upset by emerald ash borer, an exotic, invasive insect expected to sweep up river corridors killing ash trees. Red and silver maples are important species in this forest type and have shown steady and significant increases in volume sine the 1980's. Elms are also present, but the exotic Dutch elm disease has curtailed their development and dominance. Cottonwood is an uncommon type component in

Wisconsin.

Spruce-Fir dominated forests are a northern type that represent about 9% of all forest land in Wisconsin. Total acreage remained relatively stable since the 1980's, but is down from historical levels and could be further threatened in a warming climate. In the mid-to-late 1800s, swamp conifers occupied about 13% of the forest land area and boreal forest occupied about 2%. Since the 1800s, some stands have converted to aspen-birch, lowland hardwoods, and lowland brush.

Table 2.a: Forest land area by forest type, 1996 and 2007		
Forest Cover Type Group	1996 acres	2007 acres
Maple-Beech-Birch	4,694,776	4,501,073
Oak-Hickory	3,519,328	3,500,645
Aspen-Birch	3,442,490	3,244,378
White-Red-Jack Pine	1,479,033	1,532,014
Elm-Ash-Cottonwood	996,835	1,443,141
Spruce-Fir	1,319,605	1,398,094
Oak-Pine	332,100	588,820
Nonstocked	156,493	153,262
Exotic Softwoods	10,343	24,154
Pinyon-Juniper	8,718	17,829
Exotic Hardwoods	998	4,562
Oak-Gum-Cypress	2,300	0
Total	15,963,019	16,407,970
(USFS FIA, 2007) This table reflects the most recent forest cover type groups that FIA uses. This is a change from the 1983 cover types. 1996 acres were adjusted in table 2.a to match cover types used in 2007.		

Table 2.b: Forest land area by forest type, 1983 and 1996		
Forest Cover Type Group	1983 acres	1996 acres
Maple-Basswood	4,052,200	5,348,592
Aspen-Birch	3,988,700	3,440,750
Oak-Hickory	2,904,600	2,927,863
Bottomland Hardwood	1,318,700	1,558,713
Pine	1,281,300	1,187,591
Spruce-Fir	991,900	729,456
Other Softwoods	638,400	650,230

Nonstocked	175,500	119,824
Total	15,351,300	15,963,019
(USFS FIA, 2007) 1996 acres in Table 2.b reflect the same cover types as 1983.		

Table 2.c: Growing stock volume by species group on forest land (Growing stock volume is the net volume in cubic feet of growing stock trees 5.0 inches DBH and over, from 1 foot above the ground to a minimum 4.0-inch top diameter)			
Species Group	**1983**	**1996**	**2007**
White and Red Pine	1,338,559,042	1,938,290,578	2,842,867,878
Aspen and Cottonwood	2,726,931,006	2,611,712,484	2,485,668,933
Soft Maple	1,231,201,714	1,937,001,241	2,448,877,831
Hard Maple	1,513,617,899	2,189,431,303	2,270,873,673
Select Red Oaks	1,437,153,202	1,772,161,629	1,717,657,267
Ash	748,298,152	1,002,936,127	1,247,113,898
Basswood	848,732,720	1,108,647,394	1,105,217,255
Select White Oaks	647,968,694	937,787,616	1,044,283,683
Other Red Oaks	638,147,621	662,332,274	891,170,596
Spruce and Fir	883,334,967	880,520,703	858,087,747
Hemlock	290,338,433	411,735,400	435,094,216
Jack Pine	632,104,349	385,159,336	293,083,752
Yellow Birch	209,518,111	269,772,710	278,586,799
Hickory	196,038,054	220,523,339	267,459,080
Black Walnut	23,131,967	48,496,739	89,447,969
Beech	28,704,134	49,088,414	31,997,093
Other Yellow Pines	3,044,078	7,088,194	17,714,340
Other Eastern Hardwoods	1,770,088,265	1,463,970,146	1,479,099,696
Other Eastern Softwoods	615,053,264	905,249,148	1,035,945,335
Total	15,781,965,672	18,801,904,775	20,840,247,041
(USFS FIA, 2007)			

Aquatic Resources

Trees and forests are critical to the health and proper function of watersheds. Clean water is one of our most important and valuable forest products. Forests protect municipal water supplies, reduce flooding, replenish groundwater aquifers, and provide critical aquatic fish and wildlife habitat.

Today, Wisconsin enjoys 84,919 miles of rivers and streams plus 1,862,421 acres of lakes, ponds and reservoirs. In respect to wetlands, DNR estimates that Wisconsin has only about half of the 10 million acres that were present in 1848 due to farm drainage and filling for development and roads. Laws have slowed their loss, but wetlands continue to be destroyed and degraded. Invasive plants, like purple loosestrife and reed canary grass, are crowding out native plants and harming habitat. Overuse of groundwater and increasing storm water from development can also either starve or drown wetlands plants.

As the case for historic forest cover, the earliest information available on Wisconsin's wetlands comes from the original government land survey of the state that occurred between 1832 and 1866 (see Appendix A). The surveyors mapped about 5 million acres of wetland. Although the survey gives a good distribution and extent of Wisconsin's original wetlands, it does not provide accurate statistics. Survey methods and mapping were primitive and different surveyors had different interpretations of what constituted a wetland. Some of the work was done in the winter when wetlands were covered by ice and snow. Wetland boundaries were mapped more accurately along survey section lines, and when survey maps were drawn the land cover between the section lines was only estimated.

An analysis of wet soils in Wisconsin provides a more accurate image of the state's original wetland acreage. Soil scientists estimate that Wisconsin has approximately 10 million acres of wet soils (somewhat poorly, poorly and very poorly drained), which is a much more accurate approximation of Wisconsin's pre-settlement wetland acreage. A Wisconsin Wetland Inventory was completed for the state in 1985. Based on aerial photography from 1978-79, it shows approximately 5.3 million acres of wetlands remaining in the state representing a loss of about 47% of original wetland acreage. This figure does not include wetlands less than 2 or 5 acres in size, which are the smallest mapping units used by various counties. (Simon, 2008)

Wetland areas continue to change, and so the State Legislature authorized the DNR to update the Wisconsin Wetland Inventory on a 10 year cycle. Budget constraints and lack of staff have, however, slowed the process to a 24 year cycle at best. Changes related to wetland losses controlled by permits in recent times are tracked under Section 404 of the Clean Water Act, which establishes a program to regulate the discharge of dredged and fill material. A DNR review of U.S. Army Corps of Engineers (COE) individual permit decisions from 1982 - August, 1991 showed wetland losses of approximately 10,800 acres statewide (1,200 acres/year average). Another DNR review of COE individual and nationwide permit decisions from August, 1991 - April, 1998 revealed wetland losses of approximately 2,053 acres statewide (312 acres/year average). The second review showed that permitted wetland losses declined by 460% (1,128 acres/year average). The marked improvement is attributed to the adoption of state wetland water quality standards on August 1, 1991. These wetland acreage loss figures are estimates only and do not reflect total wetland acreage changes. Wetland losses due to illegal wetland filling and wetland drainage are not known. New wetlands have also been created under efforts of the federal Wetland Preserve and Conservation Reserve Programs, state Department of Transportation wetland mitigation projects, and restoration work under the North American Waterfowl Management Program. (Simon, 2008)

Additional details about Wisconsin’s aquatic resources can be found under Criterion Four: Conservation & Maintenance of Soil and Water Resources.

2.2 Size class

Most forests in Wisconsin are comprised of trees of medium diameter (poletimber) to large diameter (sawtimber), although stands of small diameter trees are also abundant (Table 2.d). Acreage with 5-17 inches diameter trees is most prevalent. Spruce-fir and aspen-birch types have the most small-medium sized trees. Maple-beech-birch, oak-hickory, and pine types have the most

large trees. During the last decade, the proportion of large diameter stands increased, and the proportion of small diameter stands decreased. Wisconsin's forests are maturing, but are still relatively simple structurally, as most are in the stem exclusion stage of stand development.

Table 2.d: Forest type group timberland acres, % by size class 1996 and 2007						
Forest Cover Type Group	Small Diameter (<5" dbh)		Medium Diameter (5-9/11" dbh)		Large Diameter (>9/11" dbh)	
	1996	2007	1996	2007	1996	2007
Maple-Beech-Birch	19	10	48	42	33	48
Oak-Hickory	20	12	36	28	43	61
Aspen-Birch	49	40	41	46	10	15
White-Red-Jack Pine	23	18	34	26	43	56
Elm-Ash-Cottonwood	32	21	44	49	24	30
Spruce-Fir	53	44	31	38	15	18
Oak-Pine	52	25	29	32	19	43
Exotic Softwoods	59	27	25	27	15	46
Pinyon-Juniper	100	17	0	60	0	23
Exotic Hardwoods	100	100	0	0	0	0
Oak-Gum-Cypress	0	0	0	0	100	0
Total	31	22	41	38	29	40
(USFS FIA, 2007)						

2.3 Age group

Forest trees and stands regenerate, grow and mature, and senesce. As forests mature they change structurally (e.g. stand initiation, stem exclusion, demographic transition, old multi-aged) and develop different attributes (e.g. age structure, tree density, tree size). Successional changes in tree composition often occur as forests mature. Some tree species like aspen grow rapidly and typically live less than a century. Others, such as sugar maple, grow more slowly and can live for several centuries.

In Wisconsin, most forests were cut over and many acres burned in the late 1800's and early 1900's. Following the Cutover, many areas were temporarily farmed and pastured. Most of today's forest originated on open land and developed into even-aged stands with all trees at about the same age. Some of these stands, particularly those dominated by shorter lived and faster growing tree species, have been harvested for timber and regenerated. Many stands continue to grow and age—most are still even-aged and maturing within the stem exclusion stage of structural development, but some are approaching old age (senescence) and demographic transition.

Current forests are homogeneous (simplified) in terms of age class diversity. Most forests in Wisconsin are 40-80 years old and even-aged (Table 2.e and 2.f). Approximately 10% of Wisconsin forests are under 20 years of age, and 4% are over 100 years of age. Average forest age

is slowly increasing as predominantly young forests mature. The forest types proportionally best represented in the younger age classes are aspen, pine, and oak-pine, with the latter two predominantly associated with dry sites.

Older forests (greater than 100-120 years old) that were more common prior to the Cutover are rare and continue to decline in extent due to type succession, age-related mortality, pests, invasive species, herbivory, the lack of seed sources, harvesting and other factors. This decline has continued from earlier inventories. The forest types proportionally best represented in the over 100 age classes are spruce-fir, pine, and oak-hickory. These older forests offer unique habitat, including compositional, structural, and functional attributes. Better data on acres, distribution, and types of older forests would be helpful.

Table 2.e: Forest type group timberland acres, % by age class, 2007

Forest Cover Type Group	Age Class (years)						
	≤19	20-39	40-59	60-79	80-99	100-119	≥120
Maple-Beech-Birch	4	8	26	41	17	3	1
Oak-Hickory	5	8	24	38	18	5	2
Aspen-Birch	22	30	29	16	3	<1	<1
White-Red-Jack Pine	15	28	31	13	6	3	4
Elm-Ash-Cottonwood	5	15	32	28	15	4	1
Spruce-Fir	4	12	29	31	16	5	3
Oak-Pine	16	19	36	22	5	1	1
Exotic Softwoods	24	29	38	9	0	0	0
Pinyon-Juniper	0	14	75	11	0	0	0
Exotic Hardwoods	100	0	0	0	0	0	0
Total	10	16	28	30	13	3	1

(USFS FIA, 2007)

Table 2.f: Forest type group timberland acres, % by age class, 1996

Forest Cover Type Group	Age Class (years)						
	≤19	20-39	40-59	60-79	80-99	100-119	≥120
Maple-Beech-Birch	9	12	31	30	12	4	2
Oak-Hickory	9	14	24	31	13	6	3
Aspen-Birch	28	25	31	13	2	<1	<1
White-Red-Jack Pine	15	29	30	9	9	5	2
Elm-Ash-Cottonwood	10	22	35	19	12	2	1
Spruce-Fir	6	15	33	26	8	7	5
Oak-Pine	36	21	25	12	2	2	2
Total	15	18	29	23	9	4	2

(USFS FIA, 2007)

Vegetation present at the time of Euro-American settlement (mid-to-late 1800's)

Studies of Wisconsin's pre-settlement vegetation including *Ecological History of Wisconsin's Forests* (Appendix A) provide a useful picture of what vegetative types different parts of the state were capable of supporting. The purpose in presenting pre-settlement vegetation information is not to suggest that Wisconsin's forests should be restored to those historic conditions. Rather, management efforts will be most effective when they consider the natural variability that climate, soils, wildlife and Native American culture (including use fire) defined in the absence of logging, farming, urban expansion and other disturbances brought by settlers.

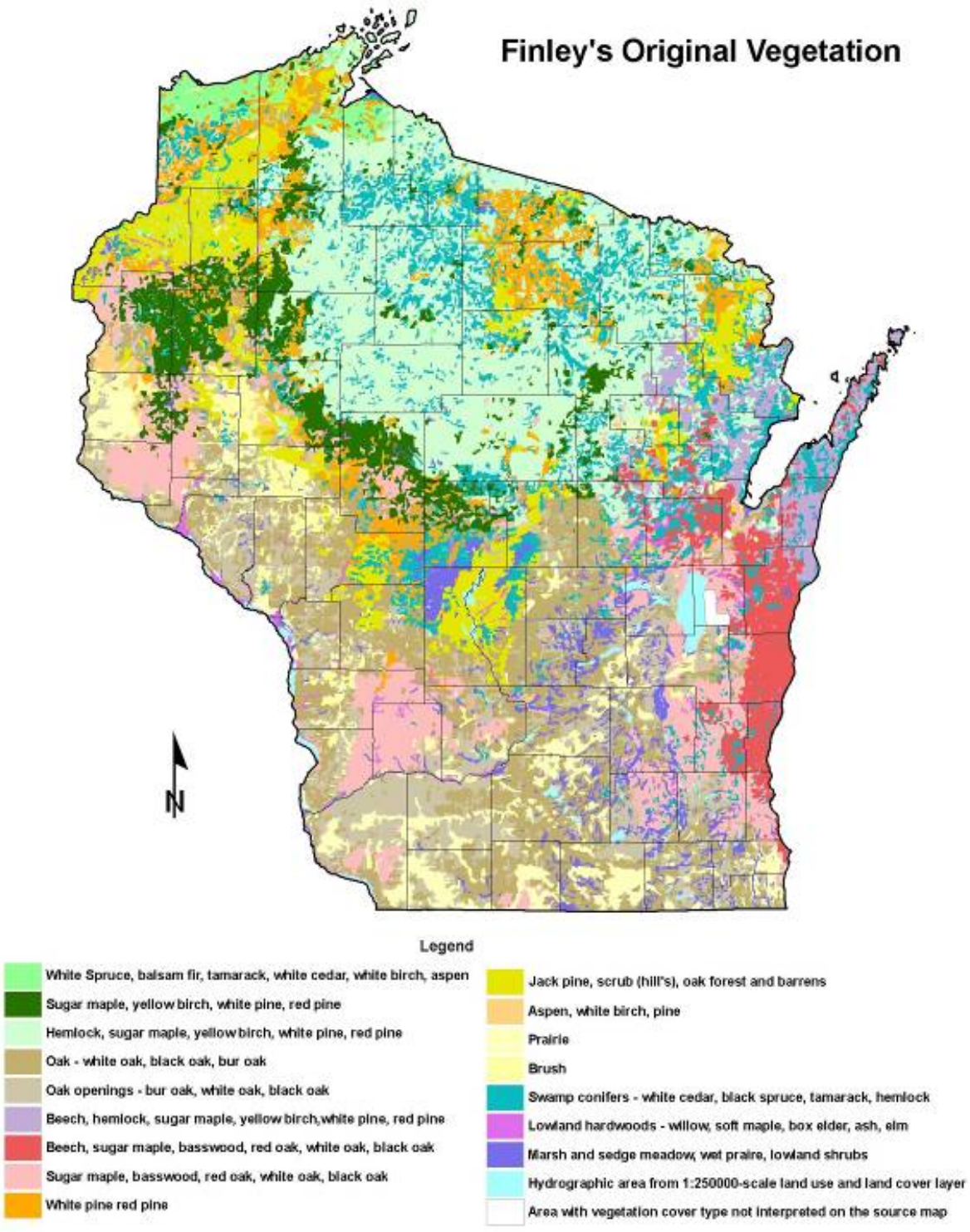
An interpretation of pre-settlement vegetation cover by Robert Finley, which preceded the spatial model in Appendix A, is presented in Table 2.g. It shows that forest land covered about 25.5 million acres or 73% of the total land area in Wisconsin. Jack pine-scrub oak forests and barrens, and oak openings (savannas) represented another 17% of land area. Open land represented about 10% of statewide land area.

Forests dominated by hemlock, sugar maple, beech, and yellow birch occupied about 13.9 million acres or 54% of forest land area. About two-thirds of these forests occurred in northern Wisconsin (Province 212). Here, conifers played a dominant role, particularly hemlock. Most stands were old and multi-aged, and compositionally and structurally complex. In southern Wisconsin, these forests were mostly dominated by hardwoods (maple, basswood, oak). See Map 2.a for a visual representation of Finley's original vegetation.

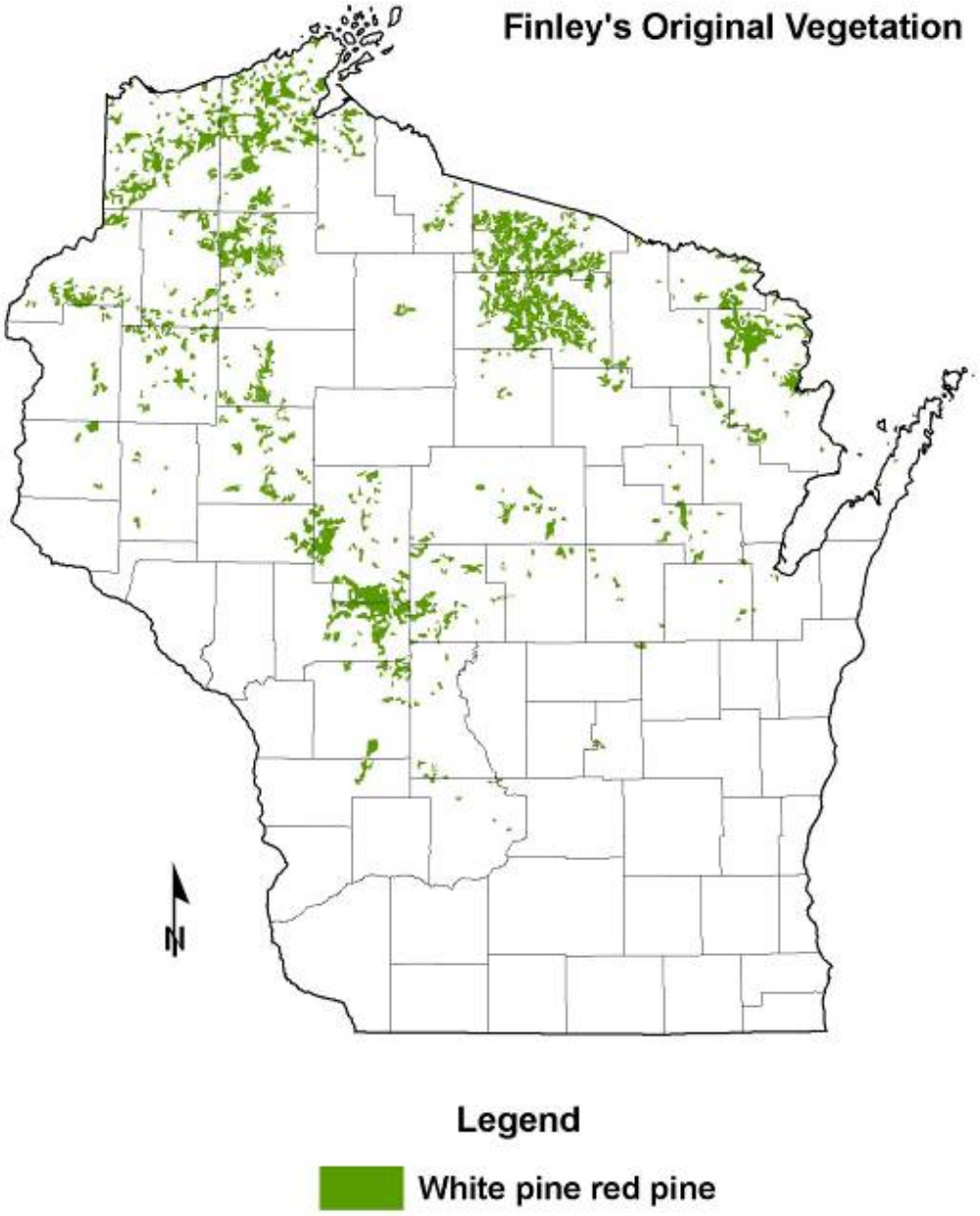
Table 2.g: Land area by vegetation cover type and ecological province

Vegetation Cover Types	Total Acres	% of Total Acres	% of Cover Type Acres by Province	
			Prov. 212	Prov. 222
Boreal Forest: White Spruce, Black Fir, Tamarack, White Cedar, White Birch, Aspen	547,549	2	100	0
Beech, Hemlock, Sugar Maple, Yellow Birch, Pine	959,320	3	100	0
Hemlock, Sugar Maple, Yellow Birch, Pine	6,250,578	18	99	1
Sugar Maple, Yellow Birch, Pine	2,207,300	6	89	11
White Pine, Red Pine	1,946,337	6	83	17
Aspen, White Birch, Pine	397,426	1	67	33
Jack Pine-Scrub Oak Forests and Barrens	2,388,105	7	64	36
Beech, Sugar Maple, Basswood, Oaks	1,305,995	4	74	26

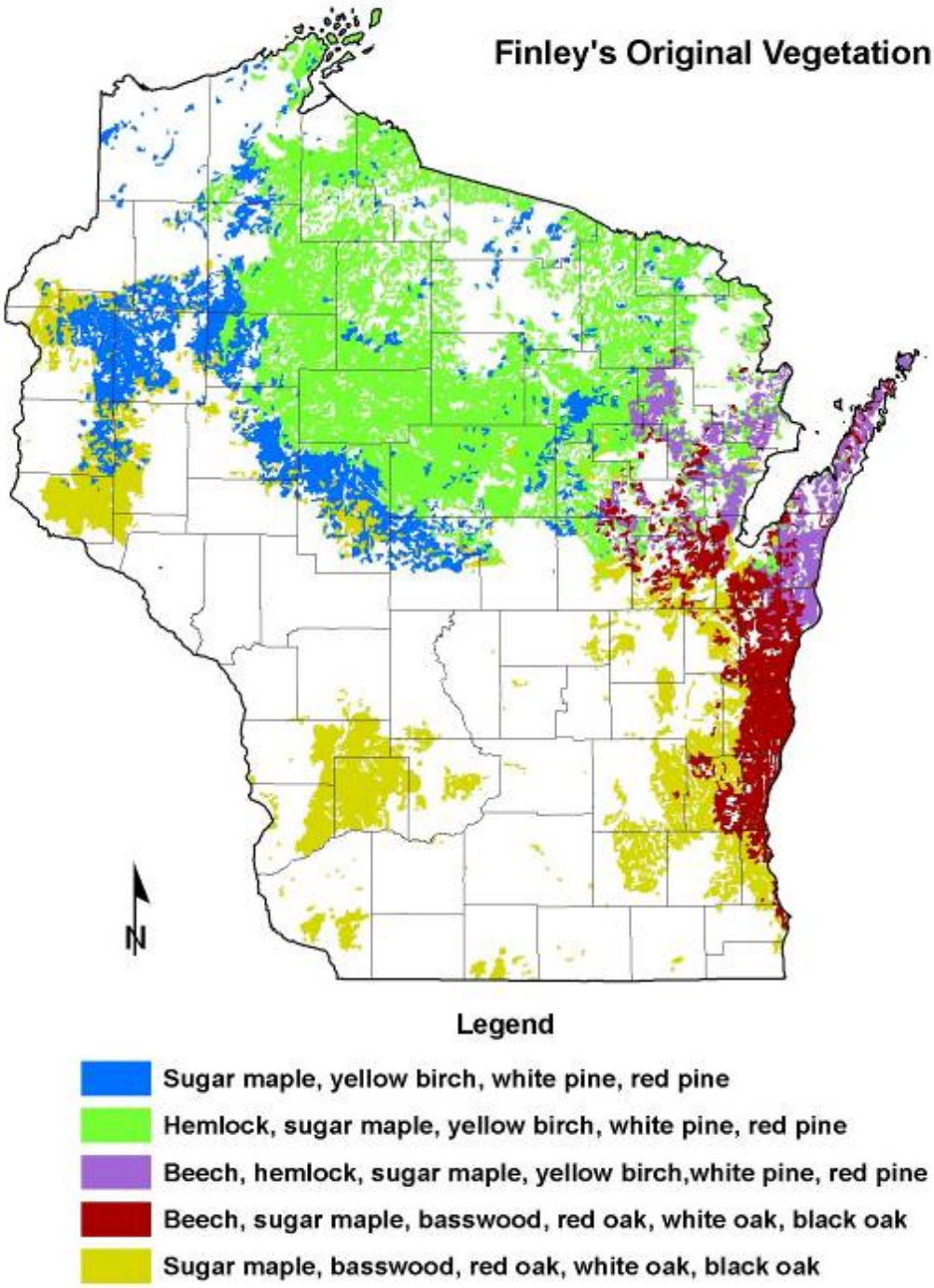
Sugar Maple, Basswood, Oaks	3,130,531	9	22	78
Oak – White, Black, Burr	5,030,763	14	6	94
Oak Openings	3,439,484	10	1	99
Swamp Conifers	3,398,502	10	80	20
Lowland Hardwoods	312,743	1	28	72
Brush	806,602	2	10	90
Marsh and Sedge Meadow, Wet Prairie, Lowland Shrubs	1,193,673	3	6	94
Prairie	1,691,625	5	1	99
Total	35,006,536		52	48
Source: Finley, 1976				



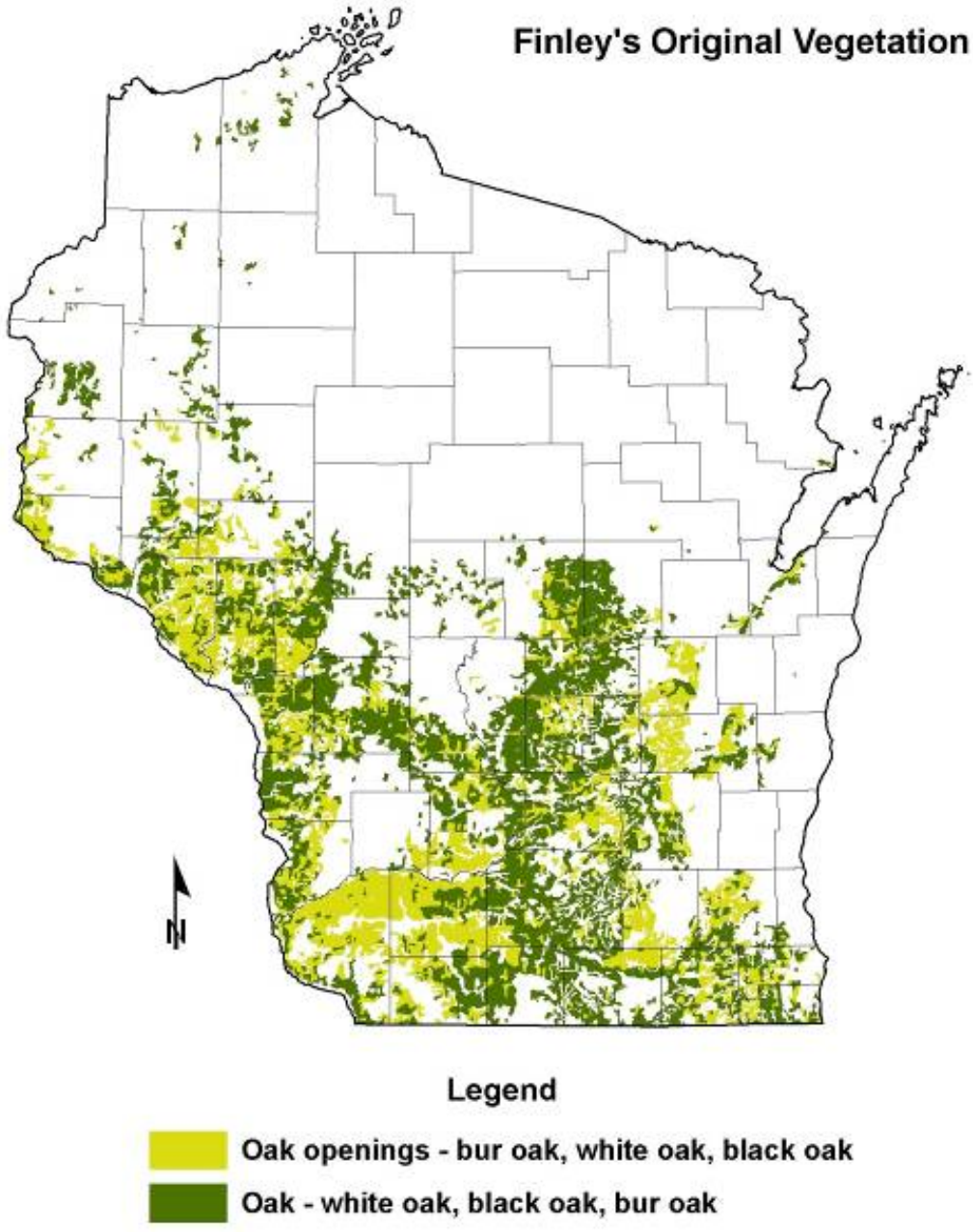
Map 2.a: Original vegetation cover of Wisconsin
Source: Finley, 1976



Map 2.b: Original vegetation of Wisconsin: northern hardwoods (maple/beech/birch) and hemlock
Source: Finley, 1976



Map 2.c: Original vegetation of Wisconsin: oak
Source: Finley, 1976



Map 2.d: Original vegetation of Wisconsin: pine
Source: Finley, 1976