Community Conservation Assessment for the Lowland Northern White Cedar Plant Community

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This Conservation Assessment/Approach was prepared to compile the published and unpublished information on the subject taxon or community; or this document was prepared by another organization and provides information to serve as a Conservation Assessment for the Eastern Region of the Forest Service. It does not represent a management decision by the US Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service Threatened and Endangered Species Program at 310 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This Conservation Assessment provides a review of published and unpublished literature pertaining to the life history, community ecology, associated rare/threatened plant species, distribution and abundance, potential threats and summary of existing habitat protection for the lowland northern white cedar ecosystem within the Chippewa National Forest, Chequamegon-Nicolet National Forest, Huron-Manistee National Forest, Ottawa National Forest, and Superior National Forest .

The presence of northern white cedar in forest communities ranges from exposed ledge rock shores of Lake Superior to flat glacial lake plains and outwashes. *Thuja occidentalis* seedlings have a wide physiological tolerance to varying moisture conditions. Community associates vary on upland versus lowland sites, but generally include *Abies balsamea*, *Fraxinus nigra*, and *Picea glauca* and *P. mariana.* Shrub associates on good sites include *Alnus rugosa, Acer spicatum, Cornus stolonifera*, and *Lonicera canadensis. Ledum groenlandicum, Vaccinium* spp. and *Gaultheria procumbens* occur on poorer sites. *Gaultheria hispidula* occurs on both rich and poor sites (Johnston 1990). Herbaceous layer may include: *Rubus pubescens, Maianthemum canadense, Dryopteris* spp.*, Cornus canadensis, smilacina* spp. and *Sarracenia purpurea* (Johnston 1990). Ground cover generally includes sphagnum, liverworts, decaying logs and leaf litter.

Northern white-cedar is characterized as a monoecious conifer with a narrow crown, small to medium sized tree typically growing 40 to 50 feet tall and ranging in diameter from 12 – 24 inches. This species is extremely slow growing; after 50 years, it might reach 40 feet on good sites or less than 20 feet on poor sites (Johnston 1977). Shade tolerant, northern white-cedar has the potential to be long-lived and individual stands may extend beyond 500 years of age. Trees are documented as 1,397 years of age on the Niagara Escarpment in southern Ontario (Kelly 1993).

Northern white-cedar can reproduce by seed, with cones developing on trees as young as 6 years of age, with suitable seed source for regeneration by 30 years of age and maximum production occurring after 75 years of age. Seed crops are frequent, occurring on a 2-5 year interval. Seeds can disperse up to 200 ft by wind (Johnston 1990).

The general distribution of Northern White Cedar occurs throughout southeastern Canada and the adjacent northern forest regions in the US. It extends south to northern Illinois and the northwestern region of Indiana, through the Upper and Lower Peninsula of Michigan and to the New England States. Populations exist in the Appalachian Mountains in western Pennsylvania, West Virginia, Virginia, and Tennessee.

In Michigan, the Forest Inventory and Analysis (FIA) database reveals a trend of decline in Cedar acreage on federal land, and an increase on state, county and private lands. Wisconsin's data show a similar decline on federal land, but Private, County and municipal cedar acreage has declined as well. State land appears to have a 40,000 acre increase from the 1996 to the 2000 sampling period. This data may be reflective of

inventory format changes or land acquisitions. There is no specific reference or reason for this dramatic increase. Minnesota's data show relatively stable acreage on federal land, with an increase in cedar acreage on state land. County and municipality land had a peak of 111,900 acres in 1993 with nearly half the acreage reported in 2000. Cedar acreage on private lands have declined as well.

The primary threats to the Northern White Cedar Community include herbivory, environmental conditions, hydrologic change, non-native invasive plants, drought and fire impact, and land use changes. Predominantly wet soils and relatively shallow root systems make trees more susceptible to windthrow.

Several working groups in the Great Lakes region are discussing and reviewing Cedar inventories to determine potential for old growth classification and the future of Cedar regeneration. In reviewing the current age distribution of Cedar, trends suggest that if current management of northern white cedar does not change stands in reserve will age without recruitment to replace the natural mortality.

The wood products value of Northern White Cedar is still important, even with Federal agencies practicing no-harvest policies. As cedar stands decline, the financial pressure on private markets may impact the harvesting rate. Management activities include market assessment, and stand assessment to ensure maximum resource use with regard for regeneration.

Several studies have been conducted reviewing seedbed requirements for *Thuja occidentalis* and the impact of herbivory on stand regeneration. Future management may see the increased use of broadcast burning to reduce slash and improve seedling survival as well as the construction of exclosures or deer control measures to reduce herbivore pressure in areas of critical cedar density.

ACKNOWLEDGEMENTS

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- Michigan Natural Features Inventory
- Wisconsin Biomapper
- Wisconsin Department of Natural Resources Natural Heritage Inventory
- University of Minnesota – J. F, Bell Museum of Natural History Herbarium
- Linda Parker, Forest Ecologist Chequamegon-Nicolet National Forest
- Susan Trull, Forest Botanist, Ottawa National Forest
- James Meunier, Timber Staff Officer, Ottawa National Forest
- Jack Greenlee, Forest Plant Ecologist, Superior National Forest (also provided Chippewa National Forest data)
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- Steve Ludwig, Chippewa National Forest
- Rick Klevorn, Minnesota DNR – Division of Forestry
- Steve Peterson, Wisconsin DNR- Superintendent Brule State Forest

This Conservation Assessment provides a review of published and unpublished literature pertaining to the life history, community ecology, associated rare/threatened plant species, distribution and abundance, potential threats and summary of existing habitat protection for the lowland northern white cedar ecosystem within the Chippewa National Forest, Chequamegon-Nicolet National Forest, Huron-Manistee National Forest, Ottawa National Forest, and Superior National Forest.

COMMUNITY CLASSIFICATION SYSTEM AND SYNONYMS

Scientific Name:	*Thuja occidentalis*
Kingdom:	*Plantae*, the Plants
Division:	*Coniferophyta*, the Conifers
Class:	*Pinopsida*
Order:	*Pinales*
Family:	*Cupressaceae*, the Cypress, Cedars, and Junipers
Genus:	*Thuja*, the North American Cedars
Species:	*occidentalis* Northern White-Cedar
Common Name:	Northern White-Cedar

Other Regional Synonyms (as referenced by Little – 1979):

Arbor vitae
Eastern White Cedar
Canoe wood
Swamp Cedar
Gijikandug (Ojibwa)
Cèdre blanc (Quebec)
Balai (Quebec)

Associated Communities with a Cedar component categorized by Resource Agencies:

Wisconsin Natural Heritage Inventory: (Epstein et al. 2002)

- Mesic Cedar Forest
- Northern Wet-Mesic Forest
- Boreal Forest
- Bedrock Shore
- Lowland Conifer

Wisconsin State Herbarium Habitat Descriptions (Judziewicz, E. 2002)

- Northern Lowland Forest
  - Northern Wet-Mesic Forest ("Cedar Swamp")
- Northern Upland Forest
  - Mesic Cedar Forest
- Bog and Fen
  - Calcareous Fen
  - Boreal Rich Fen
- Boreal Forest

NatureServe Explorer: Ecological Communities Search -*Thuja occidentalis*
(http://www.natureserve.org/explorer/)

Thuja occidentalis / Abies balsamea - Acer spicatum Forest
Thuja occidentalis - (Betula alleghaniensis, Tsuga canadensis) Forest
Thuja occidentalis - (Larix laricina) Seepage Forest
Thuja occidentalis - (Picea mariana, A. balsamea) / Alnus incana Forest

Minnesota DNR – Ecological Division of Ecological Services
(Minnesota Natural Heritage Program 1993)

Upland White Cedar Forest
Upland White Cedar Forest (Lake Superior)
Upland White Cedar Forest (Lake Superior) Mesic Subtype
Upland White Cedar Forest (Lake Superior) Wet-mesic Subtype
Upland White Cedar Forest (Northern)
Upland White Cedar Forest (Northern) Mesic Subtype
Upland White Cedar Forest (Northern) Wet-mesic Subtype
Upland White Cedar Forest (Southeast)
Lowland Conifer Swamp
White Cedar Swamp
White Cedar Swamp Seepage Subtype

US Forest Service Ecological Sub regions
(http://www.fs.fed.us/land/pubs/ecoregions/toc.html):

Laurentian Mixed Forest Ecological Province

- 212 H--Northern Great Lakes Section
- 212J--Southern Superior Uplands
- 212L--Northern Superior Uplands Section
- 212M--Northern Minnesota and Ontario Section
- 212N--Northern Minnesota Draft and Lake Plains Section
- 212O-- Lake Michigan Section
- 212P-- Lake Huron Section

Eastern Broadleaf Forest (Continental) Ecological Province

- 222N--Lake Agassiz, Aspen Parklands

FIA Data Codes
Code 127 – Northern White-Cedar
Code 241 – Northern White-Cedar
Other Softwoods (#2 – Major Group)
Other Eastern Softwoods (# 9- Species Group)
US Forest Service Timber Type Data
Timber Type 14 – Lowland (Wetland) Cedar
Timber Type 19 - Upland Northern White Cedar

U.S. National Vegetation Classification and International Classification of Ecological Communities From Plant Communities of the Midwest: Classification in an Ecological Context (Faber-Langendoen, D., editor. 2001)

Michigan Subset

- Wooded Swamps and Floodplains
  - *Thuja occidentalis – (Larix laricina* – Seepage Forest)
  - *Thuja occidentalis – (Picea mariana, Abies balsamea/Alnus incana* Forest)
  - *Thuja occidentalis – (Fraxinus nigra* Forest)
  - *Thuja occidentalis – (Larix laricina/Sphagnum* Forest)
- Rocky Uplands (Glades, Rock Barrens, Outcrops and Alvars)
  - *Thuja occidentalis*- Limestone Bedrock Woodland
- Cliffs, Talus, Buttes and Badlands
  - *Thuja occidentalis*- Carbonate Talus Woodland
- Forests and Woodlands
  - *Thuja occidentalis- (Betula alleghaniensis, Tsuga canadensis* Forest)
  - *Thuja occidentalis-(Betula alleghaniensis* Forest)
  - *Thuja occidentalis-(Abies balsamea – Acer spicatum* Forest)

Minnesota Subset

- Northern Rich Fens
  - *Thuja occidentalis* - (*Myrica gale*) / *Trichophorum alpinum* / *Drepanocladus* spp. Shrubland
- Wooded Swamps and Floodplains (Northern Laurentian)
  - *Thuja occidentalis* - (*Larix laricina*) Seepage Forest
  - *Thuja occidentalis* - (*Picea mariana*, *Abies balsamea*) / *Alnus incana* Forest
  - *Thuja occidentalis* - *Larix laricina* / Sphagnum spp. Forest
- Cliffs, Talus, Buttes and Badlands
  - *Thuja occidentalis* Cliff Woodland
- Forests and Woodlands
  - *Thuja occidentalis-(Betula alleghaniensis* Forest)
  - *Thuja occidentalis-(Abies balsamea – Acer spicatum* Forest)

Wisconsin Subset

- Wooded Swamps and Floodplains (Northern Laurentian) Northern Rich Conifer Swamps
  - *Thuja occidentalis* - (*Larix laricina*) Seepage Forest
  - *Thuja occidentalis - (Picea mariana, Abies balsamea) / Alnus incana* Forest
  - *Thuja occidentalis - Larix laricina* / *Sphagnum* spp. Forest

- Northern Mesic Conifer-(Hardwood) Forests
  - *Thuja occidentalis* - (*Betula alleghaniensis, Tsuga canadensis*) Forest
  - *Thuja occidentalis - Betula alleghaniensis* Forest
  - *Thuja occidentalis / Abies balsamea - Acer spicatum* Forest

- Cliffs, Talus, Buttes and Badlands (Northern Alkaline Cliffs)
  - *Thuja occidentalis* Cliff Woodland

- Northern Acid Cliffs
  - *Acer spicatum - Thuja occidentalis - Betula papyrifera / Taxus canadensis* Shrubland

DESCRIPTION OF COMMUNITIES

The presence of northern white cedar in forest communities ranges from exposed ledge rock shores of Lake Superior to flat glacial lake plains and outwashes. Habeck (1958) references northern white cedar in uplands dominated by limestone bedrock, shallow soil overlying limestone substrates or mesic lowlands with a pH range of 6.0 – 8.0. Basic mineral soils may produce more rapid decomposition than other lowland conifer sites resulting in the nutrient rich soils associated with cedar. Cedar trees found on ledge rock generally have in poorly formed and twisted boles with multiple leaders, in contrast to lowland cedar on sites where trees have better defined trunks. Briand et al. (1991) reviewed tree and seed morphology and found no evidence of variations between upland and lowland sites; data showed more variation within a single site than between lowland and upland sites. Collier and Boyer (1989) compared the response of *Thuja occidentalis* seedlings to moisture availability. According to their data, *Thuja occidentalis* seedlings have a wide physiological tolerance to varying moisture conditions.

Community associates vary on upland versus lowland sites, but generally include *Abies balsamea*, *Fraxinus nigra*, *Picea glauca, and P. mariana* among the many potential canopy associates. Shrub associates on good sites include *Alnus rugosa, Acer spicatum, Cornus stolonifera, and Lonicera canadensis. Ledum groenlandicum, Vaccinium spp.* and *Gaultheria procumbens* occur on poorer sites. *Gaultheria hispidula* occurs on both good and poor sites (Johnston, 1990). Herbaceous layer may include

Rubus pubescens, Maianthemum canadense, Dryopteris spp., Cornus canadensis, milacina spp. and Sarracenia purpurea (Johnston 1990). Ground cover generally includes sphagnum, liverworts, decaying logs and leaf litter.

Simonich (1990) states that *Iris lacustris*, a federally threatened species, is prevalent on the northern shores of Lake Michigan and Lake Huron in habitats associated with *Thuja occidentalis* on sandy/thin soils over limestone or bedrock. Habitat is generally restricted to long narrow strips bordering the high waterline of lake shores.

Wisconsin Natural Heritage Inventory: (Epstein et al. 2002)

Text taken directly from *Wisconsin Natural Heritage Inventory Natural Community Description, Wisconsin DNR.*
http://www.dnr.state.wi.us/org/land/er/rare/natcomm_descripts.htm#N

Mesic Cedar Forest
This is a rare upland forest community of mesic sites in northern Wisconsin, characterized by *Thuja occidentalis* and various associates including *Tsuga canadensis, Abies balsamea, Betula alleghanensis, Pinus strobus*. The herb layer may contain *Maianthemum canadense*, *Linnaea borealis*, clubmosses (*Lycopodium* spp.). More information is needed on this community type.

Northern Wet-Mesic Forest (revised from Curtis 1959), with Northern Hardwood Swamp split out
This forested minerotrophic wetland is dominated by *Thuja occidentalis*, and occurs on rich, neutral to alkaline substrates. *Abies balsamea*, *Fraxinus nigra*, and *Picea glauca and P. mariana* are among the many potential canopy associates. The understory is rich in sedges (such as *Carex disperma* and *C. trisperma*), orchids (*e.g., Platanthera obtusata and Listera cordata*), wildflowers such as *Coptis trifolia, Polygala pauciflora*, and *Mitella nuda*, and trailing sub-shrubs such as *Linnaea borealis* and *Gaultheria hispidula*. A number of rare plants occur more frequently in the cedar swamps than in any other habitat.

Boreal Forest
In Wisconsin, mature stands of this forest community are dominated by *Picea glauca* and *Abies balsamea*, often mixed with *Betula papyrifera*, *Thuja occidentalis*, *Pinus strobus*, *Populus balsamifera* and *Populus tremuloides*. Mountain-ash (*Sorbus* spp.) may also be present. Common understory herbs are *Aster macrophyllus*, *Clintonia borealis*, *Maianthemum canadense*, *Aralia nudicaulis*, and *Cornus canadensis*. Most Wisconsin stands are associated with the Great Lakes, especially the clay plain of Lake Superior, and the eastern side of the northern Door Peninsula on Lake Michigan

Bedrock Shore
Wave-splashed bedrock shoreline ledges are best developed on sandstone in the Apostle Islands of Lake Superior. Stunted trees of *Thuja occidentalis*, *Betula papyrifera*, *Sorbus decora* and *Alnus crispa* are often present in crevices. Common herbs are *Agrostis hyemalis*, *Epilobium angustifolium*, and *Solidago canadensis*, but the flora often includes unusual plants such as *Primula mistassinica*, *Lobelia kalmii*, and *Potentilla tridentata*.

Wisconsin State Herbarium Habitat Descriptions (Judziewicz 2002)

Text taken directly from C.E. Umbanhowar, Jr.'s revised "Vegetation of Wisconsin Habitats" as originally defined by J.T. Curtis edited by Epstein et al. 2002 and condensed and summarized for the Curtis-Umbanhowar classification by Judziewicz.

Northern Lowland Forest
Classic Northern Wet Forest is a northern, weakly minerotrophic conifer swamp dominated by *Picea mariana* and *Larix laricina*. In more well-drained sites, northern white cedar are common. These forested wetlands, often known simply as "cedar swamps," are dominated by *Thuja occidentalis*, and occur on rich, neutral to alkaline substrates. The understory is rich in sedges (such as *Carex disperma* and *C. trisperma*), orchids, wildflowers such as goldthread (*Coptis trifolia*), fringed polygala (*Polygala pauciflora*), naked mitrewort (*Mitella nuda*), the trailing sub-shrubs twinflower (*Linnaea borealis*) and creeping snowberry (*Gaultheria hispidula*), and many species of orchids, some rare.

Tentatively included here are the following Wisconsin Natural Heritage Inventory types: Northern Wet Forest, Northern Wet-Mesic Forest ("Cedar Swamp"), Black Spruce Swamp, Tamarack Swamp, Tamarack Fen, Floodplain Forest (in part), Northern Hardwood Swamp, Mesic Floodplain Terrace, Muskeg (in part), and White Pine - Red Maple Swamp.

Northern Upland Forest
This forest type ranges from dry to mesic sites, with coniferous trees usually dominant. Northern Dry Forests develop on nutrient-poor sites with excessively drained sandy or rocky soils. The primary historic disturbance regime was catastrophic fire, at intervals of decades to a century or so. Mesic Cedar Forests are a rare upland community of mesic sites in northern Wisconsin, dominated by white cedar (*Thuja occidentalis*).

Tentatively included here are the following Wisconsin Natural Heritage Inventory types Northern Dry Forest, Northern Dry-Mesic Forest, Northern Wet Forest, and Mesic Cedar Forest.

Bog and Fen

This open wetland type is a catch-all category for a number of open peatlands that are dominated by various combinations of sedges, sphagnum mosses, ericasceous shrubs, and insectivorous herbs. Typically, true Open Bogs are confined to northern Wisconsin and are cold, acidic, weakly minerotrophic wetlands with no through-flow of nutrient rich water in the substrate; all water inflows as precipitation. True bogs are dominated by *Sphagnum spp*. mosses that occur in deep layers with pronounced hummocks and swales. Plant diversity is very low. Trees (mostly black spruce, tamarack, and white cedar) are absent or achieve very low cover values as this community is closely related and intergrades with Muskeg. Muskegs are cold, acidic, sparsely wooded northern wetlands with the same dominants as the Open Bogs (*Sphagnum spp.* mosses, *Carex spp*., and ericaceous shrubs), but with scattered stunted trees of black spruce (*Picea mariana*) and tamarack (*Larix laricina*). Plant diversity is low, but the community is important for a number of boreal bird and butterfly species. Fen communities are minerotrophic, that is, there is percolating groundwater that carries nutrients through the system. The flora is often rich and distinctive, including many forbs and graminoids, and a few characteristic shrub species such as bog birch, shrubby cinquefoil, and certain willows. Calcareous Fens are related to Wet Prairies and occur throughout southern and eastern Wisconsin. Boreal Rich Fens are rare and restricted to cold peatlands in the far north. Coastal Fens are also rare, and are restricted to the estuaries of drowned river mouths along Lake Superior. Central Poor Fens are restricted to the bed of old glacial Lake Wisconsin in the central part of the state. They have floras of very low diversity, and are related to sedge meadows and open bogs.

Tentatively included here are the following Wisconsin Natural Heritage Inventory types: Open Bog, Bog Relict, Patterned Peatland, Muskeg (in part), Calcareous Fen, Boreal Rich Fen, Coastal Fen, and Central Poor Fen (in part).

Boreal Forest

In Wisconsin, mature stands are dominated by white spruce (*Picea glauca*) and balsam-fir (*Abies balsamea*), often mixed with white birch (*Betula papyrifera*), white cedar (*Thuja occidentalis*), white pine (*Pinus strobus*), balsam-poplar (*Populus balsamifera*) and quaking aspen (*Populus tremuloides*). Mountain-ash (*Sorbus spp*.) may also be present. Common understory herbs are large-leaved aster (*Aster macrophyllus*), bluebead (*Clintonia borealis*), Canada mayflower (*Maianthemum canadense*), wild sarsaparilla (*Aralia nudicaulis*) and bunchberry (*Cornus canadensis*). This community is best developed along the Lake Superior coast, near the tip of the Door Peninsula on the Lake Michigan side, and in the northern tier of inland counties at higher elevations (above about 1,500 feet).

NatureServe Explorer:

Text taken directly from *Ecological Communities -Thuja occidentalis Associations* (*in Minnesota, Michigan and Wisconsin*)(http://www.natureserve.org/explorer/)

Thuja occidentalis / Abies balsamea - Acer spicatum **Forest**
This sub-boreal upland cedar forest type occurs in the northern Great Lakes region of the United States and Canada. *Thuja occidentalis* is the most abundant tree and may occur in pure stands. Other canopy species include *Abies balsamea*, *Betula papyrifera*, *Picea glauca*, *Picea mariana*, *Populus tremuloides*, and *Pinus strobus*. There is usually an abundant shrub/sapling layer with saplings of *Thuja occidentalis* and *Abies balsamea* along with the shrubs *Acer spicatum*, *Corylus cornuta*, *Linnaea borealis*, *Lonicera canadensis*, *Rubus pubescens*, and *Sorbus decora*. The ground layer is typically diverse on mesic to wet-mesic stands and less so on steep drier stands. Wet-mesic stands can contain a hummock and hollow topography, with a seasonally saturated hydrology. Typical species include *Aralia nudicaulis*, *Aster macrophyllus*, *Clintonia borealis*, *Coptis trifolia*, *Cornus canadensis*, *Dryopteris carthusiana*, *Galium triflorum*, *Maianthemum canadense*, *Mitella nuda*, and *Trientalis borealis*. Mosses include *Drepanocladus uncinatus*, *Hylocomium splendens*, *Plagiomnium cuspidatum*, *Pleurozium schreberi*, *Ptilium crista-castrensis*, and *Rhytidiadelphus triquetrus* and, in wetter phases of the type, *Sphagnum* spp.

Thuja occidentalis - Betula alleghaniensis**, *Tsuga canadensis*** **Forest**
This white-cedar - hemlock evergreen forest type is found in the Upper Great Lakes region of the United States and Canada. Stands occur in Michigan and Wisconsin on the Menominee Drumlins, and in Ontario on moist to fresh sites.
The tree canopy contains at least 25% cover of *Thuja occidentalis*, with *Tsuga canadensis* the next leading dominant. Other associates include *Acer saccharum*, *Betula alleghaniensis*, *Fraxinus americana*, and *Pinus strobus*. The herbaceous layer may contain *Epipactis helleborine* (an exotic), *Maianthemum canadense*, and others. This type has not been well-characterized, and further survey work is needed. As an upland *Thuja occidentalis* type, this type has less of a boreal composition to it.

***Thuja occidentalis - Larix laricina Seepage* Forest**
This lowland white-cedar swamp forest is found in the central and upper midwestern United States and Canada (Great Lakes region). Stands occur where water seeps from the ground. The water is moderately to highly mineralized with circumneutral pH. Soils are usually organic but may be mineral. The canopy is heavily dominated by *Thuja occidentalis*, sometimes to the exclusion of other trees. Other tree species that may be present include *Acer rubrum, Betula alleghaniensis*, and *Larix laricina*. The understory contains *Cornus sericea*, *Cystopteris bulbifera, Drosera rotundifolia, Maianthemum canadense, Mitchella repens, Mitella nuda*, and *Rubus pubescens*. The ground layer may be dominated by mosses.

***Thuja occidentalis - Picea mariana, A. balsamea / Alnus incana* Forest**
This sub-boreal cedar - mixed conifer swamp forest is found in the northern Great Lakes region of the United States and Canada. Stands occur on level to gently sloping ground with wet, organic or mineral soil. It is typically along the margins of peatlands, in drainage courses, shores of lakes and rivers above flooding level, or in shallow depressions. The groundwater is moderately minerotrophic and has circumneutral pH. The canopy is often moderately dense to dense. The understory structure consists of high hummocks and deep, water-filled hollows, with fallen, moss-covered logs common. *Thuja occidentalis* is moderately to strongly dominant in the canopy, or *Picea mariana* may overtop the subdominant *Thuja occidentalis*. Other species include *Abies balsamea*, *Acer rubrum*, *Betula papyrifera, Fraxinus nigra, Larix laricina* and, more rarely, *Picea glauca* , or *Tsuga canadensis*. The shrub layer in this community is sparse to dense, in inverse proportion to the tree canopy. Species present in this stratum include *Alnus incana, Chamaedaphne calyculata, Cornus canadensis, Cornus sericea, Gaultheria hispidula, Ledum groenlandicum, Linnaea borealis, Rosa acicularis, Rubus pubescens, and Vaccinium myrtilloides. Nemopanthus mucronatus and Viburnum nudum var. cassinoides* are more common eastward. The most common herbaceous species are *Carex spp*. (including *Carex disperma*), *Coptis trifolia, Clintonia borealis, Dryopteris carthusiana, Galium triflorum, Maianthemum canadense, Mitella nuda, Trientalis borealis,* and *Viola renifolia.* Mosses include *Hylocomium splendens, Pleurozium schreberi, Ptilium crista-castrensis, Rhytidiadelphus triquetrus, Sphagnum capillifolium, Sphagnum girgensohnii, and Sphagnum magellanicum.* Moss cover may be thin where the canopy is very dense. Diagnostic species include *Thuja occidentalis* as a dominant/codominant species, with a combination of acidic and minerotrophic understory species, such as *Alnus incana* and *Cornus sericea*.

Minnesota DNR – Ecological Division of Ecological Services (MN Natural Heritage Program 1993)

Text taken directly from *Minnesota's Native Vegetation: A Key to Natural Communities, Version 1.5*. Biological Report 20.

Upland White Cedar Forest

Upland White Cedar Forest is a mesic to wet-mesic coniferous forest of upland sites. It occurs almost exclusively in the conifer-hardwood forest zone of north-central and northeast Minnesota (there are two known outlying stands in the Mississippi River Valley in extreme southeastern Minnesota). Within the conifer-hardwood forest zone, the community is most common in northeastern Minnesota, especially near the north shore of Lake Superior.

The canopy of Upland White Cedar Forest is dominated by white cedar, which may occur in extensive, nearly pure stands, in mixtures with other canopy species, or as small groves in a matrix of brushy forest. The most common subdominant canopy species are balsam fir, yellow birch, paper birch, white spruce, and black spruce. Older stands have many fallen logs and leaning trees.

Deciduous shrubs (especially mountain maple, with smaller amounts of speckled alder and beaked hazel) and conifer seedlings and saplings (spruce and especially balsam fir) dominate the understory of the community. The ground layer contains a variety of species characteristic of mesic to wet-mesic sites; starflower (*Trientalis borealis*), wild sarsaparilla (*Aralia nudicaulis*), Clintonia (*Clintonia borealis*), oak fern (*Gymnocarpium dryopteris*), large-leaved aster (*Aster macrophyllus*), bunchberry (*Cornus canadensis*), and dwarf blackberry (*Rubus pubescens*) are common. Three-flowered bedstraw (*Galium triflorum*) and naked bishop's-cap (*Mitella nuda*) are modal species in the community. In general, the understory and ground layer of Upland White Cedar Forest are rich in species in stands on level, wet-mesic sites and less diverse on drier slopes.

There are three recognized geographic sections of Upland White Cedar Forest, the Northern Section, the Lake Superior Section, and the Southeast Section (Fig. 9). Mesic and Wet-Mesic subtypes occur in the Northern and Lake Superior sections. The distinct types are shown below:

Upland White Cedar Forest (Lake Superior)
Upland White Cedar Forest (Lake Superior) Mesic Subtype
Upland White Cedar Forest (Lake Superior) Wet-mesic Subtype
Upland White Cedar Forest (Northern)
Upland White Cedar Forest (Northern) Mesic Subtype
Upland White Cedar Forest (Northern) Wet-mesic Subtype
Upland White Cedar Forest (Southeast)

Lowland Conifer Swamp
White Cedar Swamp occurs primarily in the conifer-hardwood forest zone, with scattered stands in the deciduous forest-woodland zone. White cedars dominate the tree canopy, either forming pure, dense, even-aged stands or mixed uneven-aged stands with various

amounts of black spruces, balsam firs, white spruces, balsam poplars, or black ashes. The shrub layer is composed of speckled alder and associated species. Shrub cover ranges from sparse to dense, depending on the density of the tree canopy. There is usually a layer of mosses in the understory, although mosses tend to be sparse in densely shaded stands. There is one subtype of White Cedar Swamp, a Seepage Subtype, which occurs in groundwater seepage areas. Following the completion of studies of old-growth cedar stands, additional subtypes may be defined by nutrient levels, as some stands are very poor in nutrients and have small, very slow-growing cedar trees in comparison with other stands.

Definitions of the State of Minnesota Plant Communities are referenced at http://files.dnr.state.mn.us/ecological_services/nhnrp/nckey.pdf

The Minnesota DNR is in the process of revising the above-referenced community classification system. With the new update, field keys will be developed to aid in classifying forested native plant communities. One of the first ecological regions represented was the Northern Minnesota Drift and Lake Plain Section. (Almendinger, J. and Hanson, D 1998). An example of the field key for semi-terrestrial white cedar forest and white cedar swamp communities within the Northern Minnesota Drift and Lake Plain Section is shown:

Indicator species for keying Semi terrestrial White Cedar Forest

- *Ledum groenlandicum, Plantanthera obtusata, Coptis groenlandica, Corylus cornuta, Halenia deflexa, Gymnocarpium dryopteris, Viola renifloia*

Indicator species for keying White Cedar Swamp

- *Vaccinium oxycoccos, Listera cordata, Carex paupercula, scutellaria galericulata*

US Forest Service Ecological Sub regions

Text taken directly from *(http://www.fs.fed.us/land/pubs/ecoregions/toc.html)*

212H--Northern Great Lakes

Vegetation types are northern hardwoods dominating on moraines and stratified ice-contact hills, and northern hardwood-fir forests on similar landforms in the coldest climatic regimes of Upper Michigan. Great Lakes pine forests occurred on outwash and lacustrine sands, with jack pine forests occupying outwash and lacustrine sand plains, and white and red pine forests on more mesic areas and grading into the ice-contact hills. Conifer bogs occupied low-lying areas in Upper Michigan and near the Straits of Mackinac. The elm-ash forest dominated a part of the Saginaw Bay lowlands in the southeastern part of the Section.

212J--Southern Superior Uplands

This Section comprises the eastern two-thirds of the Superior Upland geomorphic province. Vegetation types are maple-beech-birch, aspen birch, spruce-fir forests. More recent vegetation classification is more specific. Acer-Tsuga Series and Acer-Series occur on mesic landforms; Tsuga Series occur on dry-mesic landforms; Pinus Series occur on xeric landforms; and Tsuga-Thuja Series occur on wetland landforms.

212L-Northern Superior Uplands

The Section is part of the Superior Uplands geomorphic province. Most prominent of the hills are linear ranges trending southwest to northeast along Lake Superior and parallel ranges farther north (Mesabi, Vermillion). There is a prominent escarpment along Superior's shore. Innumerable small lakes and potholes dominate the northern part of the Section. An east to west trending series of small lakes occurs in the northeastern most portion of the Section; and an east to west trending series of larger lakes follows a fault zone in the most western part of the Section. Dominant vegetation includes mixed pine with aspen-birch, white pine, red pine, jack pine, black spruce, balsam fir, and white cedar, with less common occurrences of northern hardwoods along the shore of Lake Superior.

212M-Northern Minnesota and Ontario

The Section is poorly drained, with mostly boggy ground. Anoxic accumulation of plant material is the dominant geomorphic process operating; fluvial erosion, transport and deposition occur in the northwest. Quaternary peat deposits cover the central two-thirds of the Section. Pleistocene till and lacustrine sand cover bedrock in the northwest and probably underlie most of the peat bog; lacustrine sand and silt rim the eastern and southern margins. Bedrock is composed of Archean granite, gabbro, and greenstone in the western half, with Archean quartzite and banded iron oxides underlying the eastern portion. Vegetation is (primarily) conifer bog, with lesser extent of Great Lakes spruce-fir and Great Lakes pine. Sedge fen, black spruce-sphagnum bog, and white cedar-black ash swamp dominates the Section. Some low moraines and beach ridges are dominated by jack pine or trembling aspen-paper birch forests.

212 N- Northern Minnesota Drift and Lake Plain
This Section is part of the Central Lowlands geomorphic province. Temperature regime is frigid. Moisture regimes are udic, xeric, and aquic. Uplands are dominantly medium-textured to coarse-textured, and moderately well to somewhat excessively drained. Lowlands are extensive, poorly drained, and include a significant component of organic soils. Vegetation includes a mix of conifer and hardwood forest communities. Northern hardwoods grow in the south and around larger lakes. Conifers (Great Lakes pine and Great Lakes spruce-fir) are associated with outwash plains and coarsely textured end moraines. Large areas of lowlands are dominated by potential natural communities of black spruce, tamarack, and sedge meadows, Great Lakes pine forest, Great Lakes spruce-fir forest, and conifer bog.
212O-- Lake Michigan Section – referenced with limited habitat data
212P-- Lake Huron Section – referenced with limited habitat data

U.S. National Vegetation Classification and International Classification of Ecological Communities From

Text taken directly from *Plant Communities of the Midwest: Classification in an Ecological Context* (Faber-Langendoen, D., editor. 2001)

Wooded Swamps and Floodplains

***Thuja occidentalis - Larix laricina* Seepage Forest**
The canopy is heavily dominated by *Thuja occidentalis*, sometimes to the exclusion of other trees. Other tree species that may be present are *Acer rubrum, Betula alleghaniensis*, and *Larix laricina*. The understory contains *Cornus sericea, Cystopteris bulbifera, Drosera rotundifolia, Maianthemum canadense, Mitchella repens, Mitella nuda*, and *Rubus pubescens*. The ground layer may be dominated by mosses. This community is found where water seeps from the ground. The water is moderately to highly mineralized with circumneutral pH (Wilcox et al. 1986). Soils are usually organic but may be mineral. However, the demarcation between this type and *Thuja occidentalis - (Picea mariana, Abies balsamea) /Alnus incana* Forest or other more northern white-cedar swamps is not entirely clear. Located in States**:** IL, IN, MI, MN, OH, WI. **Provinces:** ON.

***Thuja occidentalis - Picea mariana, Abies balsamea/ Alnus incana* Forest**
The canopy is often moderately dense to dense. The understory structure consists of high hummocks and deep, water-filled hollows, with fallen, moss-covered logs common. *Thuja occidentalis* is moderately to strongly dominant in the canopy, or *Picea mariana* may overtop the subdominant *Thuja occidentalis*. Other species include *Abies balsamea, Acer rubrum, Betula papyrifera, Fraxinus nigra, Larix laricina* and, more rarely, *Picea glauca* (in northern Minnesota). The shrub layer in this community is sparse to dense, in inverse proportion to the tree canopy. Species present in this stratum include *Alnus incana, Chamaedaphne calyculata, Cornus canadensis, Cornus sericea, Gaultheria hispidula, Ledum groenlandicum,*

Linnaea borealis, Rosa acicularis, Rubus pubescens, and *Vaccinium myrtilloides*. *Nemopanthus mucronatus* and *Viburnum nudum var. cassinoides* are more common eastward. The most common herbaceous species are *Carex* spp. (including *Carex disperma), Coptis trifolia, Clintonia borealis, Dryopteris carthusiana, Galium triflorum, Maianthemum canadense, Mitella nuda, Trientalis borealis*, and *Viola renifolia*. Mosses include *Hylocomium splendens, Pleurozium schreberi, Ptilium crista-castrensis, Rhytidiadelphus triquetrus, Sphagnum capillifolium, Sphagnum girgensohnii*, and *Sphagnum magellanicum*. Moss cover may be thin where the canopy is very dense. Diagnostic species include *Thuja occidentalis* as a dominant/codominant species, with a combination of acidic and more minerotrophic understory species, such as *Alnus incana* and *Cornus sericea*. Located in States: MI, MN, WI. Provinces: MB, ON.

***Thuja occidentalis* and *Fraxinus nigra* Forest**
Canopy cover is variable, sometimes fairly open. *Thuja occidentalis* and *Fraxinus nigra* dominate the canopy, but some stands may have *Fraxinus* in the upper canopy and *Thuja* in the lower canopy. *Thuja* tends to occur on the hummocks and *Fraxinus* in the hollows. *Populus tremuloides* can be a major component, but this may be caused by logging of *Thuja*. *Acer rubrum, Betula alleghaniensis*, and *Picea glauca* may also be present. Shrubs include *Acer spicatum, Cornus alternifolia, Lonicera canadensis, Ribes* spp., and *Rubus pubescens*. The herb rich layer includes *Aralia nudicaulis, Arisaema triphyllum, Clintonia borealis, Cornus canadensis, Dryopteris carthusiana, Galium triflorum, Maianthemum canadense, Tiarella cordifolia*, and *Trientalis borealis*. Stands occur on wet, saturated soils. Substrate is either wet mineral soils or well-decomposed peat, and hummocky topography is present. Located in States: MI. Provinces: ON.

***Thuja occidentalis - Larix laricina / Sphagnum* spp. Forest**
The vegetation contains a tree layer dominated by *Thuja occidentalis* often mixed with *Larix laricina*. Occasionally *Picea mariana* may overtop both of these species, as *Thuja occidentalis* is sometimes <10 m tall. The ground layer consists of high hummocks and deep, water-filled pools. The tall-shrub layer can contain *Thuja occidentalis* and *Picea mariana*. Low shrubs include *Alnus incana, Cornus canadensis, Cornus sericea, Gaultheria hispidula, Ledum groenlandicum, Linnaea borealis, Rosa acicularis, Rubus pubescens*, as well as scattered *Abies balsamea*. The herbaceous layer contains the graminoid *Carex disperma* and the forbs *Coptis trifolia, Maianthemum canadense, Maianthemum trifolium, Mitella nuda, Trientalis borealis*, and *Viola renifolia*. Mosses include *Hylocomium splendens, Pleurozium schreberi, Rhytidiadelphus triquetrus, Sphagnum capillifolium, Sphagnum girgensohnii* and *Sphagnum magellanicum.* Stands occur on shores of lakes and rivers above the flooding level, and on margins of flowage areas of peatland complexes. The substrate is saturated, well-decomposed woody peat. Located in States: MI ?,MN, WI?. Provinces: ON?.

Rich Peat Fens: Northern Rich Fens

***Thuja occidentalis* - (Myrica gale) / *Trichophorum alpinum* / *Drepanocladus* spp. Shrubland**

The vegetation contain a scrub layer between 1 and 2 m tall dominated by *Thuja occidentalis*, with occasional *Myrica gale*. The ground layer contains a rich diversity of herbs and mosses, including *Trichophorum alpinum* and *Drepanocladus* spp. Stands contain at least 40 cm or more of brown moss or sedge peat. Stands are rarely flooded, primarily saturated, and the pH is slightly alkaline to mildly acidic. Located in States: MN?. Provinces: ON.

Rocky Uplands (Glades, Rock Barrens, Outcrops and Alvars)

***Thuja occidentalis* Limestone Bedrock Woodland**

Canopy cover ranges from open to >90%, and varies from pure evergreen to mixed evergreen/deciduous. *Picea glauca* and *Thuja occidentalis* dominate the overstory in the pure evergreen phase, but *Pinus strobus* (emergent) and *Tsuga canadensis* can also be found in the mixed phase, along with deciduous species, such as *Acer saccharum, Quercus rubra*, and *Ostrya virginiana*. The shrub layer is sparse. Herbaceous cover is generally sparse in the evergreen phase, containing wide-ranging forbs, such as *Maianthemum canadense*, but is more diverse in the mixed phase. In alvar situations, type can occur on shallow soils over relatively flat, limestone bedrock. In non-alvar situations, type can occur on thin-soil cliff-rim situations, such as escarpments, or on steep, colluvial slopes.
Located in States: MI, NY. Provinces: ON.

Cliffs, Talus, Buttes and Badlands: Northern Alkaline Cliffs

***Thuja occidentalis* Cliff Woodland**

The vegetation is an open-canopied woodland. The major tree dominant is *Thuja occidentalis*. Stands occur on steep, alkaline cliffs, typically of limestone or dolostone. Moist cliffs may typically contain woody vegetation, but it is not known whether this *Thuja occidentalis* woodland description adequately represents the woody vegetation. In Wisconsin, this is a very minor type, perhaps less than 100 acres. Some cliffs in Wisconsin and further east may contain a *Thuja occidentalis – Pinus resinosa* community. In Wisconsin, there is a single occurrence of a white cedar-dominated dripping dolomite cliff community on a north-facing exposure above Bear Creek, a tributary of the lower Chippewa River in Pepin County. This is near the northern edge of the driftless area, but in "old" drift. The site is dramatically disjunctive from other white cedar populations, and was in poor condition. There are stands of white cedar along the lower St. Croix River on both the Minnesota and Wisconsin side that can perhaps be characterized as outliers of the widespread cedar cliff populations occurring just to the north. Located in States: MI, MN, WI. Provinces: ON.

***Thuja occidentalis* Carbonate Talus Woodland**
Stand structure varies from patchy and barren (20-40%) to more closed (40-70%) tree canopy. The dominant species is *Thuja occidentalis*, with typical associates including *Acer saccharum, Betula alleghaniensis, Betula papyrifera, Fraxinus americana, Ostrya virginiana, Picea glauca*, and *Tsuga canadensis*. Tall shrubs include *Acer spicatum, Cornus rugosa*, and *Sambucus racemosa*. Herbaceous species include *Asplenium trichomanes,Cystopteris bulbifera, Dryopteris marginalis, Geranium robertianum*, and *Polypodium virginianum.* Stands are found on limestone or dolostone (carbonate) talus. Located in States: MI. Provinces: ON.

Cliffs, Talus, Buttes and Badlands: Northern Acid Cliffs

Acer spicatum - Thuja occidentalis - Betula papyrifera / Taxus canadensis
At Isle Royale National Park in Michigan, the vegetation forms a closed canopy forested scrub, with about 80% canopy cover. *Acer spicatum* is dominant in the canopy, with over 50% cover; other tree species present include *Thuja occidentalis, Betula papyrifera*, and *Picea glauca*. There is about 30% cover of short shrubs; *Taxus canadensis* and *Rubus parviflorus* are the most abundant shrubs. Cover of herbs is about 30%; the most abundant herbs are *Gymnocarpium dryopteris* and *Mitella nuda*. Cover of nonvascular plants is about 20%; *Pleurozium schreberi* is a common moss. In Wisconsin, similar woody species occur, and herbs include *Cystopteris fragilis* and *Campanula rotundifolia*. At Isle Royale National Park in Michigan, stands occupy sites in the northeast part of the park on very steep talus slopes or cliffs, typically facing northwest, and thus are relatively moist. Bedrock is igneous/metamorphic and may be either granite or basalt/diabase. This type may overlap with the Basalt -Diabase Great Lakes Shore Cliff Sparse Vegetation, and the Granite - Metamorphic Great Lakes Shore Cliff Sparse Vegetation, but those types are restricted to the Great Lakes shore. Type may also overlap with White Cedar Cliff Woodland, *Thuja occidentalis* Cliff Woodland, but that type is not expected to have the boreal species present in this type. In Wisconsin, the type may occur in northeast Wisconsin (Menominee River), northwest Wisconsin (Apostle Islands), and Door Peninsula.
Located in States: MI, MN, WI? Provinces: ON?

Forests and Woodlands: Northern Mesic Conifer-(Hardwood) Forests

***Thuja occidentalis - Betula alleghaniensis, Tsuga canadensis* Forest**
This white-cedar - hemlock evergreen forest type is found in the Upper Great Lakes region of the United States and Canada. Stands occur in Michigan and Wisconsin on the Menominee Drumlins, and in Ontario on moist to fresh sites. The tree canopy contains at least 25% cover of *Thuja occidentalis*, with *Tsuga canadensis* the next leading dominant. Other associates include *Acer saccharum, Betula alleghaniensis, Fraxinus americana*, and *Pinus strobus*. The herbaceous layer may contain *Epipactis helleborine* (an exotic), *Maianthemum canadense*, and others. This type has not been well characterized and further survey work is

needed. As an upland *Thuja occidentalis* type, this type has less of a boreal composition to it. Located in States: MI, WI. Provinces: ON.

***Thuja occidentalis - Betula alleghaniensis* Forest**
The canopy of this community is dominated by *Thuja occidentalis* and a variety of hardwoods, most typically *Betula alleghaniensis, Betula papyrifera*, and *Populus tremuloides*, but occasionally *Acer rubrum, Acer saccharum* and *Fraxinus nigra*. Associated conifers include *Abies balsamea, Picea glauca*, and rarely *Tsuga canadensis*. The understory usually contains a well-developed shrub/sapling layer, including *Abies balsamea, Acer spicatum, Corylus cornuta, Diervilla lonicera, Linnaea borealis, Ribes triste, Rubus pubescens*, and *Taxus canadensis*. Herbaceous species include *Aralia nudicaulis, Aster macrophyllus, Clintonia borealis, Coptis trifolia, Cornus canadensis, Dryopteris carthusiana, Galium triflorum, Gymnocarpium dryopteris, Lycopodium* spp., *Maianthemum canadense, Mitella nuda, Onoclea sensibilis*, and *Trientalis borealis*. Diagnostic features include the mixed dominance of *Thuja occidentalis* and hardwoods, particularly *Betula alleghaniensis*, in an essentially upland site type. This community is found on poorly drained lowland soils, occasionally bordering on wet, organic soils. The soil is typically moderately acidic sandy clay with a thin litter layer. Located in States: MI?, MN, WI. Provinces: ON.

***Thuja occidentalis / Abies balsamea - Acer spicatum* Forest**
The overstory is dominated by coniferous trees, with or without a substantial deciduous component. *Thuja occidentalis* is the most abundant tree and may occur in pure stands. Usually there are other canopy species, especially *Abies balsamea, Betula papyrifera, Picea glauca, Picea mariana, Populus tremuloides*, and *Pinus strobus*. There is usually an abundant shrub/sapling layer with saplings of *Thuja occidentalis* and *Abies balsamea* along with the shrubs *Acer spicatum, Corylus cornuta, Linnaea borealis, Lonicera canadensis, Rubus pubescens*, and *Sorbus decora*. The ground layer is typically diverse on mesic to wet-mesic stands and less so on steep drier stands. Wet mesic stands can contain a hummock-and-hollow topography, with a seasonally saturated hydrology. Typical species include *Aralia nudicaulis, Aster macrophyllus, Clintonia borealis, Coptis trifolia, Cornus canadensis, Dryopteris carthusiana, Galium triflorum, Maianthemum canadense, Mitella nuda*, and *Trientalis borealis*.
Located in States: MI, MN, WI, NY, VT. Provinces: ON.

COMMUNITY ECOLOGY AND ENVIRONMENTAL CONDITIONS

Northern white-cedar is characterized as a monoecious conifer with a narrow crown, small to medium sized tree typically growing 40 to 50 feet tall and ranging in diameter from 12 – 24 inches. This species is extremely slow growing; after 50 years, it might reach
40 feet on good sites or less than 20 feet on poor sites (Johnston 1977). Shade tolerant, northern white-cedar have the potential to be long-lived and individual stands may extend beyond 500 years of age with trees documented as old as 1,397 years of age on the Niagara Escarpment in southern Ontario (Kelly 1993). Lee Frelich has documented cedar trees at least 600 years of age, and possibly 1,000 years of age on Sea Gull Lake's Three Mile Island in the Boundary Waters Canoe Area Wilderness in Minnesota (Myers 2003). Cedar stands are rarely large contiguous stands, but are more frequently isolated pockets of smaller pure stands. Cedar stands are often mixed with either deciduous or coniferous species overtopping or dominating the upper canopy. Northern white-cedar grows on both uplands and lowlands. The lowlands are typically described as organic peat substrates with alkaline soil in minerotrophic swamps (Heinselman 1970). Upland Cedar stands may occur on old farm fields, areas with a natural spring or seepage of mineral rich soils and rocky or limestone cliffs (Habeck 1958). On the Ottawa, upland cedar stands occur on Ontonagon clay types [Trull] (pers. Comm. July 2003].

Buds form in autumn and expand the following spring with pollen dispersal from late April to June. Cones reach maturity by mid-August and ripen by September. Generally cones open 7 to 10 days after ripening and seeds germinate the following spring or early summer (Johnston 1977).

Root systems tend to be shallow and lateral in formation, creating the potential for windthrow. Although initial windthrow damage can affect cedar stand viability, lower limbs on the forest floor can result in layered regeneration. Trees resulting from vegetative layering may retain curved or sweeping boles and partial windthrow may create dominant lateral branches and curved boles (Pregitzer 1990).

Pregitzer 1990 describes the presence of forest openings or gaps as a condition that historically encouraged vegetative reproduction, and resulted in seedling establishment and recruitment in large gaps. However, Pregitzer surmises that present day windthrows are more likely to release advance spruce, fir, and hardwood regeneration, due to the impacts of cedar herbivory by white tail deer. Partially uprooted and lateral branch layering may be a successful form of regeneration, although the layering would need to occur beyond the browse line of deer.

Data concerning the impact of wildfire in cedar swamps are limited. A regeneration study in northern Michigan deer yards tested the effectiveness of slash disposal to encourage regeneration. Disposal methods included broadcast burning or mechanical removal versus no treatment following clearcutting. The study revealed higher density of white cedar on the burned plots which probably resulted from a close seed source and less competition from sphagnum moss that impacts new seedlings (Verme and Johnston, 1986).

Prescribed burns by the US Forest Service in the Boundary Waters Canoe Area Wilderness area may be revealing more about the ecological impacts of fire. A recent prescribed burn on Three Mile Island on the Gunflint Ranger District in the Superior National Forest resulted in one-third of the cedar on the island perishing either through direct flame or excessive heat to the canopy and or root systems (Myers 2003). Shallow roots, thin bark and high oil content make cedar trees susceptible to fire, but the shade tolerant lower branching patterns may increase the ladder potential and spread ground fires to crown fires more quickly. Forested fens that have a grass/sedge ground cover may carry fires during seasonally dry times of the year such as the spring fire season in the Great Lakes region (Heinselman 1981). Cedar sites adjacent to pine upland species may be susceptible to fire spread. Approximately one-third of the trees that were spared during the Three Mile Island burn may have benefited by the fire-resistant locations of the cedars, including rock outcroppings adjacent to lakeshores. Cedar communities located on a high water table, peat substrate generally do not carry fires well due to the high water table. If peat fires occur, they generally occur in July – September, and with the right wind condition, can carry a crown fire (Heinselman 1981).

The remaining third of the Three Mile Island Cedar stand was protected by firefighters' efforts in controlling fire spread by using back burns and dousing trees with water to reduce radiant heat (Myers 2003).

Regeneration of cedar swamps has been documented on other controlled burn sites (Verme and Johnston 1986), and stand origin investigation has revealed charred stumps within existing cedar stands (Heinselman 1973) Although specific historical fire regimes are not as well documented in rich swamp forests (cedar component), Frelich has established a simulation model demonstrating successional pathways (Table 1).

Table 1. Rotation periods used in the simulations (Frelich 1999)

Ecosystem	Rotation period brackets		
	Stand-leveling wind (years)	Stand-killing fire (years)	Surface fire (years)
Sugar maple	1000-2000	2000-4000	
Mesic and dry-mesic white and red pine	1000-2000	150-300	40
Lowland conifer	1000-2000	150-300	
Rich swamp	1000-2000	500-1000	
Mesic birch-aspen-spruce-fir	1000-2000	100-200	
Jack pine-black spruce-oak	1000-2000	50-100	

Northern White Cedar is categorized as shade intolerant, although seedlings may be less tolerant than more mature trees and in general cedar is not as tolerant of shade as *Abies balsamea* (Johnston 1990). Kurmis et al.1986 describes northern white cedar as a climax species due to the longevity of the species and the shade tolerant nature. The scientific literature suggests seed production is less successful under dense shade (Curtis 1946), vegetative shoots have shown to be more tolerant of shade than seedlings.
Pioneer establishment of cedar in old fields, windthrow areas, forest harvest areas, fire openings, openings created by hydrologic changes and on open ledge or cliffs will occur, but cedar is also likely to succeed less tolerant, short lived species including *Populus balsamifera, Larix laricina,* and *Picea mariana* (Johnston 1990).

Fire-initiated species are defined as species that simultaneously terminates and initiates a long-lived species (Vogl 1977). In some areas of a Cedar community, fires are likely to be infrequent, but when they do occur, they are likely to be severe, especially if peat burns and destroys the humus or mineral soil layer. As indicated in Frelich's review of the Three Mile Island Burn on the Superior National Forest, the longest lived individuals probably occur on sparse ground cover, or rock substrate or with low stem densities.

Frelich discusses the successional simulation model created for the Northern Superior Uplands section of Northeastern Minnesota:
"The purpose of this report is to elucidate the landscape age structure of different forest types (or ecosystem types) in the Northern Superior Uplands Section of northeastern Minnesota under the natural disturbance regime in effect during presettlement times (1600-1900). To do this, I provide a successional pathway among several vegetation growth stages (VGS) for each forest type, and then show a reasonable range of the proportion of the landscape in each VGS given the historic disturbance regime for that forest type. VGS are combined successional and developmental stages that occur after disturbance, where successional stage refers to changes in species composition over time, and developmental stage refers to stand structure over time. For example, a post-fire birch forest may succeed to white pine and then to balsam fir. At the same time it may go from young even aged sapling or pole stands, to mature stands, to multi-aged stands. The VGS interrelates these two schemes so that we have sapling/pole birch mature birch with pine understory mature pine multi-aged pine with fir understory multi-aged fir."

Ecosystem V. Rich swamp - Vegetation growth stages and successional rules:
1. Seedling-sapling ash-birch-cedar 1-20 years after wind or fire
2. Sapling-pole ash-birch-cedar 21-50 years after wind or fire
3. Pole-mature ash-birch-cedar 51-100 years after wind or fire
4. Multi-aged ash or cedar 101 years after wind or fire

Table 2. Estimated range of variability for rich swamp forest from simulation

Vegetative Growth Stage	Age in years	% Landscape
Seedling-sapling	1-20	2.9-5.7
Sapling-pole	21-50	0.4-0.9
Pole-mature	51-100	6.8-12.2
Multi-aged ash or cedar	101	81.3-89.9

Under Frelich's model, the majority of the rich swamp forest in pre-settlement times would have been multi-aged.

RANGE OF NATURAL VARIABILITY: COMMUNITY DISTRIBUTION AND CONDITIONS

The general distribution of northern white cedar is southeastern Canada and the adjacent northern forest regions in the US. It extends south to northern Illinois and the Northwestern region of Indiana, through the Upper Peninsula of Michigan and to the New England States. Island populations exist in the Appalachian Mountains in western Pennsylvania, West Virginia, Virginia, and Tennessee. Historic references show distribution in North Carolina, although no present occurrence has been recorded (Clebsch, 1989).

When reviewing historical data, Bourdo (1956) noted an important point. He states:

> *" No matter where one investigates the nature of former forests, one will find early travelers' records and local histories inadequate because none of them viewed forests as objects of study. Early travelers quite sensibly used routes of easy travel-usually waterways or trails and their recollections reflect this bias."*

Bourdo makes the assumption that spruce-fir and cedar forests were likely avoided by early settlers due to terrain and hydrologic conditions. Uniform, dense stands with low hanging shade tolerant branches may have also restricted movement throughout these forest types. Bourdo's assessment is that:

> *"...where the spruce-fir or swamp conifer forest predominated in the past, that forest still largely predominates. Unless recently cut, it looks little different from what early settlers saw..."*

Although landforms have not changed since the Bourdo publication, see the "Potential Threats" section for a discussion of factors affecting lowland cedar forests.

A map of the Lake States showing pre-European settlement forest types was created to include Minnesota, Michigan and Wisconsin (Figure 1). Referenced from Marschner's 1930's maps, the data was representative of General Land Office notes from the Public Land Survey conducted during 1847 – 1907 in Minnesota (Wendt and Coffin 1988). The Wisconsin data were from Robert Finley maps, published in 1976 detailing the 1832-1866 General Land Office notes. Michigan's General Land Office data representing 1816-1856 was compiled and developed into a map by Comer et al. in 1995.
These pre-European settlement vegetative forest types were aligned with current FIA inventory types to allow for comparative analysis between past and present forests. Figure 1 shows the results of the GLO analysis for Wisconsin, Michigan and Minnesota. Northern White Cedar stands would be categorized as lowland conifer along with other forest types.

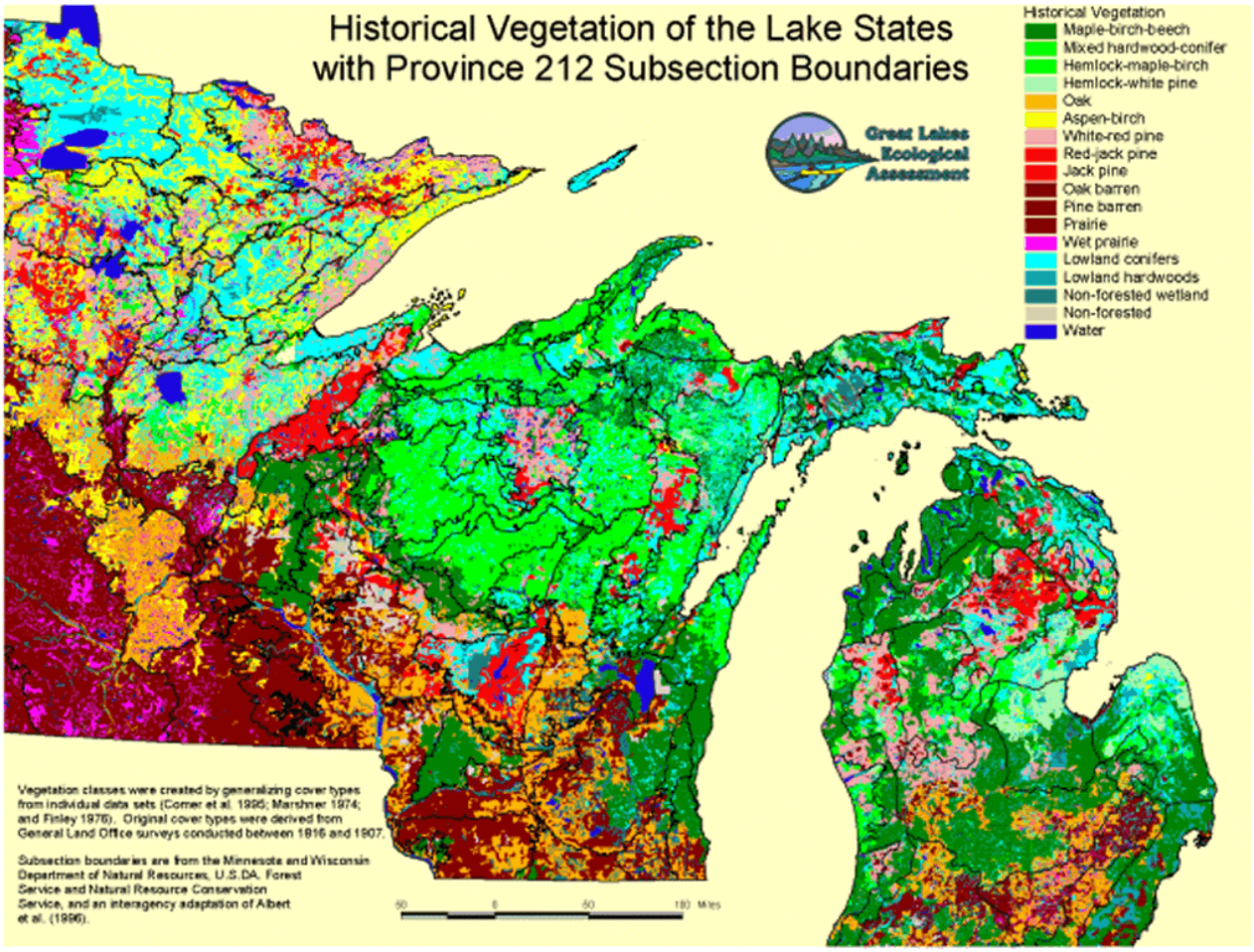


Figure 1 – Historic vegetation of the Lakes States with Province 212 Subsection Boundaries

Frelich (1995) provides estimates of pre-European settlement forests in Minnesota, Wisconsin and Michigan in comparison to current Forest Inventory and Analysis (FIA) data. Pre-settlement estimates were calculated based on public land survey maps for Wisconsin and Minnesota and a twentieth century forest cover map from Michigan (Frelich 1995).

Table 3. Comparison of Pre-European and Current Forest data (Frelich 1995).

	Pre – European Settlement Forest	Current Forest
Total hectares of forest	32.7 million hectares	19.8 million hectares
% classified as old growth	68 %	5.2 – 8.3%
Hectares of primary forest (unlogged)	n/a	369,000 hectares (40% in BWCAW) and 50 % in swamp conifer

Frelich summarizes the Pre-European Settlement forests as follows (Frelich 1995):

- About 3.6% of Lake States commercial forest are old growth, 1.7% are old-seral forest (defined as forests of relatively short-lived species)
- Currently, percentages of commercial forest area that are old forest range from 2.5% for red-white pine to 15% for northern white cedar, prior to European settlement an estimated 55% of red-white pine and northern white cedar was old growth
- Michigan's Porcupine Mountains and Sylvania Wilderness areas are the only presettlement-like upland forest landscapes, on which the species composition, spatial patterns, and disturbance dynamics have changed little, remaining in the Lake States.
- Pre-European settlement forests had much longer disturbance intervals

Van Deelen, Pregitzer, and Haufler (1996) summarize the Pre-European Settlement forests as follows:

- Catastrophic windfall "return interval" in the conifer swamps of northern lower Michigan was approximately 3000 years
- Small-scale wind disturbance such as tree-tipping was much more common, and fire was more frequent in the drier forest
- 4-5 generations of late successional trees occupied a given site in the mesic presettlement forests of northern Wisconsin before turnover by catastrophic windthrow

A recent study in the Upper Peninsula of Michigan used stem analysis to determine establishment patterns on seven mature cedar stands (Heitzman et al.1999) A summary of the results were reported as follows:

- Stands origins dated between 1870 and 1935 – probably a result of a single or multiple disturbance (literature suggests harvesting)
- Disturbances were essential for cedar recruitment into the over story
- Stands developed as single or multiple cohorts (dependent upon disturbance severity and frequency)
- Duration of the establishment period following a single disturbance ranges from 10 – 50 years
- Seedlings in multiple cohort stands establish almost continually for 100 years
- In the study area, only 3% of all stems > 2.54 cm DBH established after 1945
- Cedar germination beneath the mature canopy was abundant, but cedar seedlings taller than 30 cm were completely absent from the sites
- Successful cedar establishments and recruitment following the initial disturbance is in contrast with present day regeneration status
- Factors influencing the cedar recruitment process have apparently changed over the past century

Freidman, Reich and Frelich (2001) utilized Public Land Survey bearing tree data to characterize forest composition and spatial structure of north-eastern Minnesota. Data gathered from the General Land Office during the 1853 – 1917 survey represented over 35 thousand samples with 1-4 bearing trees per sample (land corner monumented by bearing trees) over a 3.2 hectare landscape. Nine total tree species were included (with at least 1% of the overall composition) The % representation and Basal Area data are shown in Table 4.

Table 4. Results of GLO Bearing Tree Data

Species	% Composition	% Basal Area	Mean DBH
Black Spruce	20.7	13.4	18.2 cm
Paper Birch	15.1	14.0	21.0 cm
Tamarack	15.0	11.0	19.2 cm
Aspen	10.8	7.7	18.3 cm
Balsam Fir	9.4	5.2	17.1 cm
Jack Pine	7.8	5.7	19.0 cm
White Pine	6.3	20.1	27.6 cm
Northern White Cedar	6.1	6.0	22.4 cm
Red Pine	2.7	7.3	37.0 cm
Other	6.1	-	-

This study reviewed tree composition and basal area based on Physiographic zones. These zones representing Northern Minnesota include the following (cedar percent composition and basal area is shown in parenthesis adjacent to the physiographic zone):

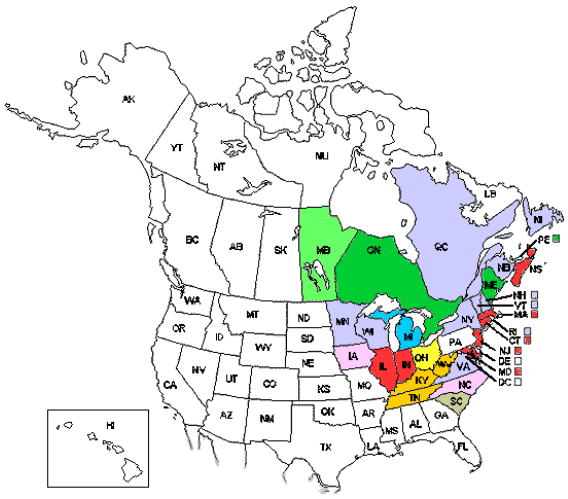
Border Lakes Region	(3.4% ; 3.9%)
North Shore Highlands	(10%; 9.5%)
Toimi Drumlin Area	(4.4%; 3.9%)
Aurora/Alborn Clay-Till Area	(4.0%; 4.3%)
Glacial Lakes Upham and Aitkin	(8.4%; 10.3)
Chisholm/Embarrass Area	(6.4%; 5.2%)
Brainerd Automba Drumlin Area	(6.9%; 5.5%)
Beltrami Arm Glacial Lake Agassiz	(7.7%; 8.8%)

In Minnesota, northern white cedar Pre-European settlement composition was highest in the North Shore Highlands, with highest density in the glacial Lakes Upham and Aitkin area. This study did not distinguish between upland versus lowland cedar.

CURRENT COMMUNITY CONDITION, DISTRIBUTION AND ABUNDANCE

The map references the State/Province Conservation Status Rank and shows the North American Distribution of *Thuja occidentalis*

Thuja occidentalis
NORTHERN WHITE CEDAR



State/Province Conservation Status Rank

	SX:	Presumed Extirpated
	SH:	Possibly Extirpated
	S1:	Critically Imperiled
	S2:	Imperiled
	S3:	Vulnerable
	S4:	Apparently Secure
	S5:	Secure
	SR:	Reported
	SZ:	Migratory Transient
	SE:	Exotic
	S?:	Unranked
		Under Review
	SU:	Unrankable

Global Heritage Status Rank: G5
Nation: United States
National Heritage Status Rank: N5 (17Dec1994)

A Global Heritage Status Rank of G5 and a National Rank of N5 has been assigned to *Thuja occidentalis*. According to the Natureserve website, the rank data is defined as:

> *"The conservation rank of an element known or assumed to exist within a jurisdiction is designated by a whole number from 1 to 5, preceded by a G(Global), N(National), or S(Subnational) as appropriate. The numbers have the following meaning:*
>
> *1 = critically imperiled*
> *2 = imperiled*
> *3 = vulnerable to extirpation or extinction*
> *4 = apparently secure*
> *5 = demonstrably widespread, abundant, and secure.*

The G5 rank indicates that *Thuja occidentalis* is widespread, abundant and secure in its global distribution. *Thuja occidentalis* has the following State/Province Conservation Status Rank taken from NatureServe Explorer (2001) as shown in Table 5.

Table 5. State and Province Rank of *Thuja occidentalis*

State or Province	Status Ranking	Definition of Status
	SX	Presumed Extirpated
	SH	Possibly Extirpated
CT, IL, IN, MD, MA, NJ Canada: NS*	S1	Critically Imperiled *Borderline (S1S2)
KY*, TN, WV	S2	Imperiled *Borderline status (S2S3)
OH	S3	Vulnerable
Canada: MB	S4	Apparently Secure
ME Canada: OT, PE	S5	Secure
MI	S?	Unranked
SC	SU	Unrankable
MN, NH, NY, RI, VT, VA, WI Canada: NB, NL, QC	SR	Reported
IA, NC	SE	Exotic

According to the US Forest Service Forest Inventory and Analysis (FIA) Mapmaker (http://www.ncrs.fs.fed.us/4801/) acreage data for Thuja occidentalis Year 2000 inventory for the Great Lakes region for both upland and lowland cedar types included:

- Minnesota - 565,756 acres of cedar out of 14,982,476 total acres of timberland
- Michigan – 1,396,884 acres of cedar out of 19,057,956 total acres of timberland
- Wisconsin - 322,147 acres of cedar out of 15,629,857 total acres of timberland

FORESTWIDE

Chippewa National Forest *Thuja occidentalis* acreage and age class data is shown in Table 6 [Ludwig (pers. comm. August 2003)]. Data was obtained from an 8/13/03 query of CDS (timber database) for forest type 14 – lowland cedar and forest type 18- lowland mixed conifer. Cedar is a component of forest type 18 but not necessarily the dominant tree species. Data shown in table 6 represents acres.

Table 6. Chippewa National Forest *Thuja occidentalis* acreage and age class data

Forest Type	Age class 0-19	Age class 20-59	Age class 60-119	Age class 120-149	Age class 150 +	Totals
14 – lowland NWC	12	153	8488	2745	1466	12864
18- lowland mixed conifer	130	1226	17584	4270	424	23634
Total Acreage by age class with cedar representation	142	1379	26072	7015	1890	36498

Superior National Forest *Thuja occidentalis* acreage and age class data is shown in Table 7 [Greenlee (pers. comm. Jul 2003)]. Data was obtained from a 7/7/03 query of CDS (Timber database) for forest types 14 – lowland cedar and forest type 18 – lowland mixed conifer. Cedar is a component of forest type 18 but not necessarily the dominant tree species. Data does not include the Boundary Waters Canoe Area Wilderness. Data shown in table 7 represents acres.

Table 7. Superior National Forest *Thuja occidentalis* acreage by age class

Forest Type	Age class 0-19	Age class 20-59	Age class 60-119	Age class 120-149	Age class 150 +	Totals
14 – lowland NWC	45	257	8028	8247	7168	23745
18- lowland mixed conifer	362	5075	30205	9436	6046	51124
Total Acreage by age class with cedar representation	407	5332	38233	17683	13214	74869

Ottawa National Forest *Thuja occidentalis* acreage and age class data is shown in Table 8 [Trull (pers. comm. September, 2003)]. Data was obtained from an 9/6/03 query of CDS (timber database) for forest type 14 – lowland cedar and forest type 18- lowland mixed conifer and forest type 19- upland NWC on dominant clay soils. Cedar is a component of forest type 18 but not necessarily the dominant tree species. Data shown in table 8 represents acres.

Table 8. Ottawa National Forest *Thuja occidentalis* acreage by age class

Forest Type	Age class 0-19	Age class 20-59	Age class 60-119	Age class 120-149	Age class 150 +	Age not Available	Totals
14 – lowland NWC	86	136	4850	876	161	310	6419
18- lowland mixed conifer	114	3755	49235	4917	3794	4994	66809
19- upland NWC	6	11	632	236	585	217	1687
Total Acreage by age class with NWC representation	206	3902	54717	6029	4540	5521	74915

Ottawa National Forest *Thuja occidentalis* data is classified as Old Growth designation defined as :

81 Maintain existing Old Growth, not managed for timber production
82 Maintain existing Old Growth, managed for timber production
83 Develop Old Growth, not managed for timber production
84 Develop Old Growth, managed for timber production

Ottawa National Forest *Thuja occidentalis* Old Growth Designation acreage is shown as Table 9. [Trull (pers. comm. March, 2003).

Table 9. Ottawa National Forest *Thuja occidentalis* Old-Growth acreage and size class data

	Size class 5	**Size class 6**	**Size class 7**	**Size class 8**	**Size class 9**
Old Growth 81	0	0	0	0	138 (type 14)
Old Growth 82	0	0	0	0	2 (type 14)
Old Growth 83	11 (type 14)	162 (type 14)	0	199 (type 14)	142 (type 14)
Old Growth 84	0	35 (type 14)	0	20 (type 14)	80 (type 14)

Chequamegon-Nicolet National Forest *Thuja occidentalis* acreage and age class data is shown in Table 10 [Parker (pers. comm. December 2002)]. Data was obtained from a 12/4/02 query of CDS (Timber database) for forest types 14 – lowland cedar and forest type 18 – lowland mixed conifer. Cedar is a component of forest type 18 but not necessarily the dominant tree species. Data shown in table 10 represents acres.

Table 10. Chequamegon-Nicolet National Forest *Thuja occidentalis* acreage by age class

Forest Type	Age class 0-19	Age class 20-59	Age class 60-119	Age class 120-149	Age class 150 +	Totals
14 – lowland NWC	126	222	11887	6395	3178	21808
18- lowland mixed conifer	473	4200	63722	12304	6389	87088
Total Acreage by age class with cedar representation	599	4422	75609	129699	9567	108896

Parker suggested that Cedar is present in type 18 (mixed swamp conifer) although it is not the dominant species in those types.

Huron Manistee National Forest *Thuja occidentalis* acreage and age class data is shown in Table 11 [Throop (pers. comm., March 2003)]. Data was obtained from a March 12, 2003 query of CDS (timber stand) and Old Growth Data base for Timber Type 14 – lowland cedar is shown as Table 11

Table 11. Huron Manistee National Forest CDS database Data acreage and size class data

Forest Type	Age class 0-19	Age class 20-59	Age class 60-119	Age class 120-149	Age class 150 +	Totals
14 – lowland NWC	0	62	9639	437	116	10254
18- lowland mixed conifer		935	13317	995	330	+ *18 acres with no age structure 15603
Total Acreage by age class with cedar representation	8	997	22956	1432	446	25857

Table 12 shows the U.S. Forest Service Forest Inventory and Analysis (FIA) Mapmaker (http://www.ncrs.fs.fed.us/4801/) acreage data for Thuja occidentalis Year 2000 inventory within the Chippewa National Forest, Chequamegon National Forest, Huron-Manistee National Forest, Ottawa National Forest, and Superior National Forest. No data was shown in a query for Nicolet National Forest. Data references forest types that contain Cedar and may indicate acreage where Cedar is not the dominant species, but a component of the stand. Large diameter is defined as Sawtimber predominantly 9.0 inches diameter root collar (D.R.C.) or greater. Medium diameter is defined as Poletimber 3.0 and 8.9 inches D.R.C.

.

Table 12. FIA data-Huron-Manistee and Ottawa National Forest Data acreage and size class data

Forest	**Total Acreage**	**Large Diameter**	**Medium Diameter**
Chequamegon*	42,737.8	42,737.8	0**
Huron-Manistee	14,138.1	6,312.6	7,825.2
Ottawa	32,292.8	29,049.0	3,243.8
Chippewa	15,505.0	11,075.0	4,430.0
Superior	69,140.6	58,208.4	10,932.1
Total	173813.90	147382.80	26431.1

*Nicolet National Forest had no data in the FIA query

**No medium size class trees appeared in the Chequamegon FIA cedar data

REGIONAL FORESTER SENSITIVE SPECIES ASSESSMENT TABLE

The following tables represent a list of species for the cedar community conservation assessment. These species represent both those that are on the Region 9 Regional Forester Sensitive Species (R9RFSS) list and those under consideration for addition to the R9RFSS list. Species in bold text have a conservation assessment that is part of this community conservation assessment. Species with 2 asterisks have conservation assessments that are being or have been completed separately. Species with 3 asterisks indicate a U.S. Fish and Wildlife Service status assessment is available.

Table 13. R9RFSS for which lowland cedar is a primary habitat.

Scientific Name	Common Name	Habitat Summary	National Forest*					
			Ch	CN	Hi	HM	Ot	Su
VASCULAR PLANT								
Amerorchis rotundifolia	Round-leaved orchis	Balsam fir-spruce-white cedar swamps not dominated by sphagnum or not have brown peat soil.	+	R	R			+
Calypso bulbosa	Fairy Slipper	Lowland coniferous forest; white pine, red pine, old aspen-birch, or cedar lowland; cool, mossy, heavily shaded cedar swamps.	R	R	R		R	R
Carex crawei	Crawe's sedge	White cedar swamps		R	+			
Cypripedium arietinum**	Ram's-head lady's slipper	Forest, bogs, acidic; wide variety of forested habitats, upland and lowland.	R	R	R	R	R	R
Listera convallarioides**	Broad-leaved Twayblade	Cedar-spruce-balsam forest - weakly acidic swamp.			+		+	R
Gymnocarpium robertianum**	Limestone oak fern	Perched root masses of cedar in swamps.	R		R			
Malaxis brachypoda**	White adder's mouth	Conifer swamps and wet depressions.	R	R	R	R		+
Polemonium occidentale v. lacustre	Western Jacob's Ladder	Cedar-black spruce wetlands		R				R
Ranunculus lapponicus	Lapland buttercup	Shallow pools with sphagnum.	x		R			x
Valeriana uliginosa	Marsh valerian	Mid-successional forested swamps.		R	+			
LICHEN								
Cetraria aurescens**		Primarily cedar swamps, and also black spruce swamps.						R
Menegazzia terebrata**	Port-hole lichen	Cedar swamps, especially old growth; base of cedar trees.			R		R	R
Usnea longissima**		Primarily cedar swamps, occasionally in upland areas adjacent to cedar swamps					R	
BRYOPHYTES								
Frullania selwyniana		Found only in glaciated areas on Thuja occidentalis bark						+

*Ch-Chippewa, CN-Chequamegon-Nicolet, Hi-Hiawatha, HM-Huron Manistee, Ot-Ottawa, Su-Superior.
E-endangered (federally listed), T-threatened (federally listed), R-R9RFSS, +-occurs but not on R9RFSS for National Forest

Table 14. R9RFSS for which lowland cedar may be a secondary habitat.

Scientific Name	Common Name	Habitat Summary	National Forest*					
			Ch	CN	Hi	HM	Ot	Su
MAMMALS								
Canis lupus - T	Gray wolf	Variety of habitats, adequate prey, low human disturbance.	T	E	E		E	T
Felis concolor v. shorgeri	Cougar	Variety of habitats, adequate prey, low human disturbance.	?					?
Lynx canadensis - T	Canada lynx	Variety of habitats, adequate prey, low human disturbance.	T	T	T		T	T
Synaptomys borealis	N. bog lemming	Spruce bogs	R					
Phenocomys intermedius	Heather vole	Forest, brushland or clearcuts with *vaccinium* spp. and rocks.						R
BIRDS								
Aegolius funereus**	Boreal owl	Secondary cavity nester. Old boreal forest (inc. aspen) next to lowland conifer feeding areas.						R
Contopus cooperi	Olive-sided flycatcher	Snags, low density conifer lowlands, riverine/riparian areas.	R					R
Dendroica castanea	Bay breasted warbler	Mature upland and lowland spruce/fir forests.	R					R
Oporornis agilis**	Connecticut warbler	Jack pine or lowland conifer with a thick ericaceous understory.	R	R	R	R	R	R
Picoides arcticus	Black-backed woodpecker	Coniferous forests with snags.	R	R	R	+	+	+
Picoides tridactylus	Three-toed woodpecker	Coniferous forests with snags.						R
Strix nebulosa	Great Grey Owl	Forested patches of upland forested nesting habitat near open lowland	R	+	+			R
AMPHIBIAN								
Hemidactylium scutatum	4-toed salamander	Sphagnum hummocks in wetlands	R	+	+	+	+	
REPTILE								
Clemmys insculpta	Wood Turtle	Upland and lowland habitats with suitable shade and insects for forage. Riparian habitats with open sandy areas for nesting.		R	+	R	+	R

*Ch-Chippewa, CN-Chequamegon-Nicolet, Hi-Hiawatha, HM-Huron Manistee, Ot-Ottawa, Su-Superior.
E-endangered (federally listed), T-threatened (federally listed), R-R9RFSS, +-occurs but not on R9RFSS for National Forest

Table 14 continued

Scientific Name	Common Name	Habitat Summary	National Forest*					
			Ch	CN	Hi	HM	Ot	Su
BUTTERFLIES								
Erebia disa mancinus	Mancinus Alpine	Shady, mature black spruce swamp.						R
Erebia discoidalis discoiddis	Red-disked Alpine	Black spruce areas, open bogs, open meadows.						R
Oeneis jutta ascerta	Jutta Arctic	Moderately forested black spruce bogs with sedges, bog forest openings.						R
VASCULAR PLANTS								
Listera auriculata**	Auricled tway-blade	Sandy floodplains and lake edges beneath alders, cool, sandy soils, occasionally under conifers including cedar			R			R
Platanthera clavellata	Small green woodland orchid	Sphagnum swamps under conifer cover & in open. Floating bogs. Also in scrapes in very sandy soil down to water level (borrow pits).	R	+	+	+	+	R
Pyrola minor	Lesser Wintergreen	Alder thickets, boreal forests, mature black spruce in lowlands, edges of jack pine-spruce-alder thicket (upland), upland white pine, edge of white cedar and black spruce (mature stands), prefers moist areas.		R	+			R
Taxus canadensis	Canada Yew	Rich mixed forest, swamps, and banks of ravines.	R	+	+		+	R
Carex gynocrates	Northern bog sedge	Primarily an open bog/fen species, but also in white cedar swamps		R				
Ranunculus gmelinii	Small yellow water crowfoot	Primarily aquatic, but can be found in pools within cedar swamps		R				
LICHENS								
Cetraria oakesiana		Spruce-fir forest; tree/stumps in cool, moist habitats.						R
Peltigera venosa	A dog lichen	Soil and moist cliffs, old tip-up mounds, partially shaded trail and road banks, bare soil, north-facing.						R
Pseudocyphellaria crocata		Rocks, trees in shady moist habitats; near lake or sufficient open water to generate fog; foggy islands.						R
Sticta fuliginosa		Humid, old growth forests, usually yellow birch.						R

*Ch-Chippewa, CN-Chequamegon-Nicolet, Hi-Hiawatha, HM-Huron Manistee, Ot-Ottawa, Su-Superior.
E-endangered (federally listed), T-threatened (federally listed), R-R9RFSS, +-occurs but not on R9RFSS for National Forest.

Table 15. Potential additions to the R9RFSS list for which lowland cedar is a primary habitat.

Scientific Name	Common Name	Habitat Summary	National Forest*					
			Ch	CN	Hi	HM	Ot	Su
LICHEN								
Ramalina thrausta**		Old cedar bogs. Very humid, cool places, frequent fog.						+
VASCULAR PLANTS								
Carex vaginata	Sheathed sedge	White cedar swamp		+				+

*Ch-Chippewa, CN-Chequamegon-Nicolet, Hi-Hiawatha, HM-Huron Manistee, Ot-Ottawa, Su-Superior.
+-occurs but not on R9RFSS for National Forest.

Table 16. Potential additions to the R9RFSS list for which lowland cedar is a secondary habitat.

Scientific Name	Common Name	Habitat Summary	National Forest*					
			Ch	CN	Hi	HM	Ot	Su
BIRD								
Peocile hudsonicus	Boreal chickadee	Mature closed canopy spruce-fir, dense pine, and lowland conifer.						+
Vermivora chrysoptera	Golden-winged warbler	Tamarack edges with alder.	+					
VASCULAR PLANTS								
Ranunculus gmelinii	Small yellow water crowfoot	Primarily aquatic, but can be found in pools within cedar swamps						+
Rubus chamaemorus	Cloudberry	Black spruce/sphagnum forest, acidic						+
NON VASCULAR								
Lobaria pulmonaria		Cedar and northern hardwoods.						+
Sphagnum quinquefarium		Conifer woodlands, swamps, seepage areas and moist cliffs and banks						+
Schistostega pennata	Luminous moss	Rock crevices with high humidity.					+	+

*Ch-Chippewa, CN-Chequamegon-Nicolet, Hi-Hiawatha, HM-Huron Manistee, Ot-Ottawa, Su-Superior.
+-occurs but not on R9RFSS for National Forest.

POPULATION BIOLOGY AND VIABILITY

Northern white-cedar can reproduce either by seed, with cones developing as young as 6 years of age, with suitable seed source for regeneration by 30 years of age and maximum production occurring after 75 years of age. Seed crops are frequent, occurring on a 2-5 year interval and can disperse up to 200 feet by wind (Johnston 1990).
Climatic conditions required for seed germination include daytime temperatures over 80 degrees Fahrenheit (Godman et al. 1976). Other requirements include a consistent moisture supply, since drought has been documented as a major source of seedling mortality (Curtis 1959).

If conditions are favorable, cedar can reproduce by layering of the lower branches. Seedlings may begin to layer lower branches as young as 5 years of age. Layering appears to be a common form of reproduction in shallow lowlands. Since seed germination may occur on logs or stumps, these trees may be more susceptible to windthrow and result in layering regeneration (Johnston 1990).

Cedar regeneration is slow to grow. Viability of cedar populations is dependent upon survival of regeneration. Seed dispersal and vegetative layering are efficient methods of reproduction, but the slow growth rate of cedar may affect the ability of regeneration to withstand threats such as browse, competition, and hydrologic changes. Data from the represented National Forest show significantly low acreage of young cedar stands.

On the Chippewa National Forest, 165 (1.28%) acres of lowland cedar type are documented under the age of 60 out of 12,864 total acres of lowland cedar (Table 6).

On the Superior National Forest 302 (1.27%) acres of lowland cedar type are documented under the age of 60 out of 23,734 total acres of lowland cedar (Table 7).

On the Ottawa National Forest 162 (2.53%) acres of lowland cedar type are documented in the 0 – 3 size class out of 6,407 total acres of lowland cedar (Table 8).

On the Chequamegon-Nicolet National Forest 348 (1.6%) acres of lowland cedar type are documented under the age of 60 out of 21,808 acres of lowland cedar (Table 10).

On the Huron-Manistee National Forest, 62 acres (.6%) acres of lowland cedar type are documented under the age of 60 out of a total cedar type of 10,254 acres (Table 11).

Viability of Cedar populations has been the subject of several research projects. Hoff (2002) references the graduate work of Minnesota Department of Natural Resources forest ecologist Meredith Cornett. As a University of Minnesota Department of Forest Resources student, Cornett assessed cedar regeneration on the North Shore of Lake Superior in Minnesota. Her findings revealed little to no cedar regeneration within .5 kilometers of the North Shore, a primary wintering grounds for whitetail deer. During this study, deer exclosures were built to compare size and survival rates of cedar in mature cedar stands as well as paper birch. Survival was reported to be greater in the

birch types in the protected samples, but in the areas without the exclosures, cover type had little impact on regeneration.

From this research project, Cornett made recommendations for cedar viability including:

- •Consider vegetative impact when managing deer populations.

- •Where deer browsing is low; consider regenerating white cedar under deciduous trees rather than in a mature white cedar stand.

- •Consider site-specific regeneration needs such as leaving large logs, and branches left behind after harvest to serve as future seedbeds for cedars

- •Protect large tracts of older forest. Large, contiguous stands may provide interior protection for species from deer browse, as deer tend to congregate on the forest edge.

Wildlife managers have an interest in maintaining cedar stands for deer management, and have been actively involved in research efforts to deter deer from browsing cedar regeneration. Exclosures, topical taste aversions such as bitters and fencing applications are some of the methods under study. Aldous's 1952 deer study demonstrated that a 15 – 20% annual browse foliage by herbivores could maintain a sufficient food supply to meet the needs of whitetail deer and still permit viable growth for regeneration. To accomplish this, wildlife managers would need to manage deer numbers specific to the biomass of a particular habitat. In high-density deer locations, regeneration less than 7 feet tall can be stunted and or suffer mortality. Trees may not be beyond the significant impacts of browsing until they reach 15 feet.

Population viability of northern white cedar is rarely impacted by insects and diseases (Fowells 1965), but invasive plants such as *Cirsium palustre* are invading cedar swamps on the Ottawa National Forest [Trull] (pers. comm., August 2002).

Heitzman, et al. (1999), discuss the shade tolerance of cedar leading to a life expectancy of 400–500 years. Cedar remains in the canopy of other species and the literature suggests cedar dominance in stands in the absence of a disturbance. Heitzman also notes that vegetative reproduction is more tolerant of environmental conditions such as drought, shade and competition than seedlings.

POTENTIAL THREATS

The primary threats to the northern white cedar community include herbivory, environmental conditions, drought and fire impact, and land use changes. Predominantly wet soils and relatively shallow root systems can be a threat to cedar by making trees more susceptible to windthrow. Burns and Honkala (1990) identify wind throw threat to be most significant on exposed ledges, in stands opened by cutting, in large trees with basal defect, and in swamps adjacent to ledges.

Heitzman et al. (1997) describes Michigan's soil and climate as being favorable for cedar as shown by the significantly higher abundance of trees in the state and Minnesota to be less favorable since the state is at the northern white cedar's western range.

FIA data can be analyzed by land ownership. Table 19 shows the acreage of Northern White Cedar across federal, state, county and private Land in the last 3 FIA inventory cycles for Minnesota, Michigan and Wisconsin. In Michigan, the FIA database reveals a trend of decline in cedar acreage on federal land, an increase on state, county and private lands. Wisconsin's data shows a similar decline on federal land, but private, county and municipal cedar ownership has declined as well. State land appears to have a 40,000-acre increase from the 1996 to the 2000 sampling period. These data may be reflective of inventory format changes or land acquisitions. There is no specific reference or reason for this dramatic increase. Minnesota's data show relatively stable acreage on Federal land, with an increase in Cedar acreage on State land. County and Municipality land had a peak of 111,900 acres in 1993 with nearly half the acreage reported in 2000. Cedar on private lands has declined as well.

Table 19: Land Ownership in acres of Northern White Cedar in FIA Sampling Cycles

Michigan	**Sampling Year/Acreage**	**Sampling Year/Acreage**	**Sampling Year/Acreage**
Federal Land	1980/157,796	1993/145,000	2000/118,860 (USFWS-8, 284)
State Lands	1980/332,547	1993/362,900	2000/389,592
County/Municipal	1980/10,804	1993/16,600	2000/21,711 (other local – 9,683)
Private Lands	1980/792,416	1993/824,900	2000/848,755
Wisconsin	**Sampling Year/Acreage**	**Sampling Year/Acreage**	**Sampling Year/Acreage**
Federal Land	1983/65,600	1996/53,575	2000/42,738
State Lands	1983/18,900	1996/6,050	2000/46,970
County/Municipal	1983/46,200	1996/61,000	2000/54,563
Private Lands	1983/240,000	1996/198,627	2000/177,877
Minnesota	**Sampling Year/Acreage**	**Sampling Year/Acreage**	**Sampling Year/Acreage**
Federal Land	1977/86,900 (BLM/other Fed 7,700)	1990/93,100 (BLM/other Fed 10,200)	2001/83,820 (other fed 8,691)
State Lands	1977/204,000	1990/288,100	2001/303,961
County/Municipal	1977/80,400	1990/111,900	2001/60,889
Private Lands	1977/167,000	1990/178,300	2001/108,394

Declines in cedar communities may be related to the lack of recruitment in cedar stands, generally caused by white tail deer herbivory. Cornett (2000) discusses the impact of large-scale clearcutting at the turn of the century in the Great Lakes region as precipitating a dramatic decline to early successional plant communities with abundant browse. 1938 deer densities are referenced as within a range of 4 to 16 deer per square kilometer. While fluctuations may occur, deer populations are still maintained at this density through the Upper Great Lakes region. An area of concern is the density of winter deeryards. In areas of the Lake Superior Highlands in Minnesota, the Jonvik

winter deer densities can reach 45 deer per square kilometer with most of this concentration within cedar stands (Cornett et al. 2000).

Rooney et al. (2002) conducted a study on seedling establishment and sapling recruitment in the Upper Great Lakes Region. This study analyzed 77 stands of multiple ownerships, site conditions and deer densities for a period of 6 years (1990-1996). The study demonstrated that initial seedling establishment increases in areas with greater seed input and in higher light levels, but recruitment to saplings > 30 cm tall depends upon deer browsing. In his conclusions Rooney writes:

> *"Prognosis for cedar swamps is poor... it was clear to us that without human intervention, cedar swamps is "living dead". Canopy trees will persist for decades or centuries but have little chance of passing on their genes to the next generation because of deer-induced sapling mortality."*

Fowells (1965) includes a reference to several herbivory threats. Porcupine can cause mature stem or branch girdling that can cause mortality or reduce productivity. Red-back voles browsing on seedling terminal or lateral branches also affect cedar survival. Red squirrels impact seed supply by clipping cone-bearing branchlets and also by eating the cone buds. In some areas of the cedar range, Fowells notes snowshoe hare browsing as more significant than white tail deer, but no specific locations were identified. Moose browsing may occur in some areas of the cedar range, such as Isle Royale, but cedar is not a preferred food of moose (Miller 1992).

Aldous (1952) conducted a study of deer clipping in the lake states region that indicated that northern white cedar under 7 feet tall can produce well and continue to grow when less than 15 – 20 % of the foliage is removed. Heavier clipping retards growth and eventually kills small trees. He goes on to state that larger trees can be browsed heavily below the 7 foot level without injury. On average, deer require 4.5 lbs of browse a day, equivalent to all available browse below 7 feet on a 3 inch diameter tree (Fowell 1965).

Davis et al. (1998) conducted a study of site preparation treatments and browse protection, noting the effects of deer and rodent browsing in the Brule Bog near Solon Springs, Wisconsin. Results supported the need for harvesting techniques to integrate cedar's requirement for open growing conditions and protection from browse.

A 1944–1945 winter rabbit browse tally at the University of Wisconsin Arboretum observed significant browse on vegetation. During two winters of similar temperatures and rabbit densities, rabbit browsing was much heavier during the winter with higher snow levels. Several hundred white cedars with averaging eight feet were untouched, as were five hundred white spruce. In other browse studies, spruce and cedar were subject to browse at much higher rates. The main point of discussion from this study is differential palatability of winter foods (McCabe 1947).

Environmental conditions including snow and ice damage can create physical stem damage or a permanent lean to the bole. Winter drying can affect cedar as well as summer drought conditions (Curtis 1946). Kutscha conducted a 5-year study on cedar

transplants treated with tap water and varying levels of sodium chloride through foliage applications and soil applications. The study showed less impact to the transplants treated through the soil than the foliage, although both had an impact on productivity and mortality of lower branches. Soil applications had indirect effects including impaired root aeration, water deficiency and nutrient analysis. The study found cedar to be more tolerant of salt applications than white spruce. The publication referenced Cedar as a preference for roadside plantings over spruce.

Cedar are described as having limited impact by insects and diseases, but black carpenter ants (*Camponotus pennsylvanicus*) and red carpenter ants (*C. ferrugineus* -primarily in Minnesota) are considered the most serious insect threat. They frequently attack the decaying heartwood of live trees, weakening boles and making them susceptible to windthrow. Heart rotting fungus may occur as well as stringy butt rot (*Poria subacida*) and *Polyporus balsameus or P. schewinitzii*, fungi that cause a brown cubical rot more common on drier sites.

Restricted soil aeration due to high water levels can be a threat to cedar by reducing growth and or causing mortality. Stoeckeler (1967) discusses several causes including beaver dams, road crossings, agricultural practices, or pipelines. Drought conditions can also cause mortality particularly on seedlings that have a moss understory susceptible to summer drying.

Cedar is naturally a thin-barked tree with high oil content and shallow roots, making it susceptible to fire. In areas of the upper Great Lakes, wildland fires naturally occur on a fire regime, but frequency of fires is dependent upon habitat type. Cedars are not as susceptible to large crown fires, but a running ground fire may be sufficient to damage the shallow root systems. Yet, cedars may be found to live in excess of 400 years. (Heinselman 1973). Large trees may survive fires if ground cover is sparse, but the more likely reason that cedars avoid fire mortality is due to their location of rocky and swampy habitats where fire tends to die out or rarely occurs.

Iverson and Prasad (2002) discuss the potential redistribution of tree species habitat under five climate change scenarios in the eastern United States. Their study used the DISTRIB regression tree analysis model. Using current forest distribution data, they modeled habitats based on 5 climate change scenarios. Seventy-six species were selected for review, but the most significantly impacted during model simulations include: *Populus tremuloides, Populus grandidentata, Acer saccharum, Betula papyrifera* and *Thuja occidentalis*. The model data supported the conclusion that all five of the aforementioned species could have their suitable habitat extirpated from the United States. *Thuja occidentalis* was the only species where habitat was shown to move north into Canada in all 5 scenarios.

Tribal elders interviewed by Danielson (2002) identified several threats to cedar types including:

- Clearcutting of cedar stands and cutting adjacent to cedar swamps,
- Lack of respect for cedar when utilizing or harvesting,
- Urban development,
- Disease,
- Lack of regeneration,
- Acid rain and pollution,
- Changes in waterways and drainage.

SUMMARY OF LAND OWNERSHIP AND EXISTING HABITAT PROTECTION

FIA database queries can be utilized to compare land ownership and corresponding abundance of northern white cedar.

In Michigan during the year 2000 inventory, private landholders were estimated to hold 848,755 acres of the total 1,396,884 acres. State agencies were the next highest landholders with 389,592 acres followed by the federal ownership of 118,860.

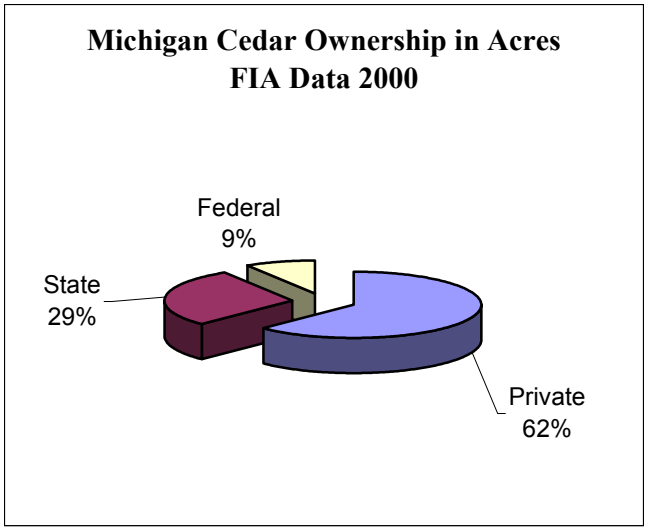


Figure 2: Michigan Acreage Data (table 19)

In Wisconsin during the year 2000 inventory, private landholders were estimated to hold 177,877 acres of the total 322,147 acres. County and municipal agencies were the next highest landholders with 54,563 acres followed by the state and federal ownership of with 46,970 and 42,738 respectively.

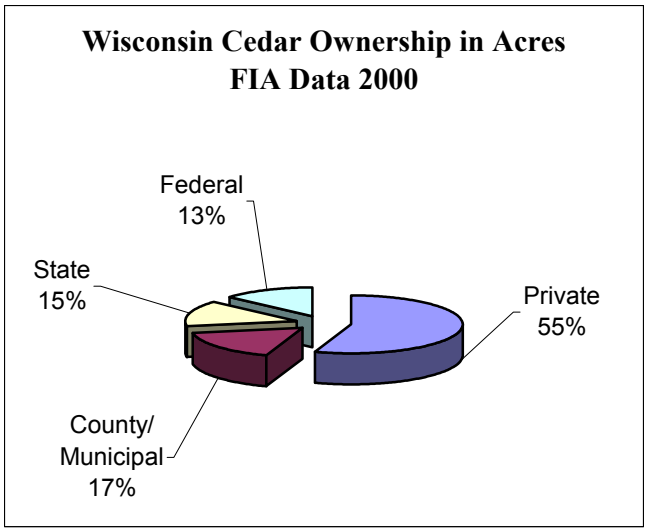


Figure 3: Wisconsin Acreage Data (table 19)

In Minnesota during the year 2000 inventory, the data referenced the state agencies as the largest landholder with 303,961 acres, followed by private landholders with 108,394 acres of the total 565,756 acres. National forests and other federal agencies accounted for 92,511 acres with county and municipal agencies the smallest landholder with 60,899 acres.

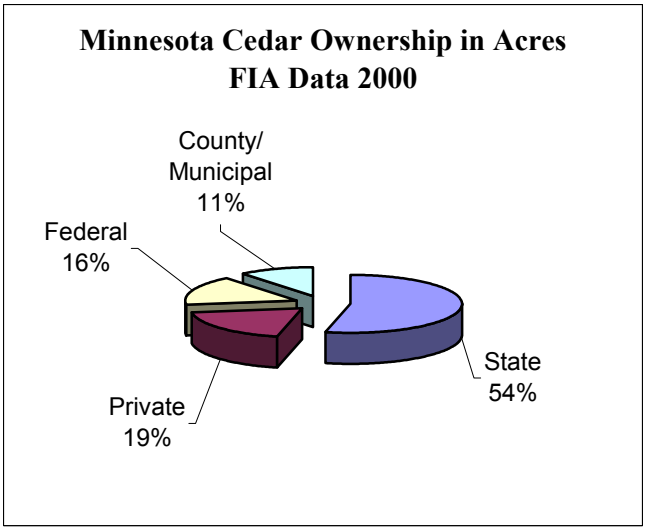


Figure 4: Minnesota Acreage Data (table 19).

According to Throop, the Huron–Manistee National Forest in Michigan is a forest that was almost totally in a non- forested condition, deforested in the early 20th century. Many of the stands today are in the 70-80 year old class due to logging, fires, and agriculture that followed the logging in the 1930's. Given that only 62 acres of cedar on the forest are less than 60 years old (Table 11), cedar has not actively been managed since the 1930's stand originating fires. The cedar type makes up less than 1% of the total forest acreage. Data suggest most of the cedar acreage on the Huron Manistee National Forest occurs in old-growth designation as most of the acres are along major river corridors and may be designated as Recreational or Scenic Rivers. Cedar types are not harvested unless some major mortality event occurs outside of the old growth designation. [Throop (pers. comm., March 2003].

Current management of *Thuja occidentalis* on the Ottawa National Forest would fall under the lowland conifer type, which does provide for some silvicultural methods of harvest and regeneration. However, it is very, very, rare to have treatments prescribed on these wetland sites. The Forest Plan calls for case by case basis for treatments. In general most of the Ottawa's cedar swamps were so heavily cutover in the late 1800's and early 1900's for mining timbers that they are still recovering. The impact of this historic harvesting combined with restricted seasons for equipment operations, and riparian protection explain the limited management efforts in lowland cedar types on the Ottawa National Forest. [Trull/James Meunier (pers. comm., December 2002].

In Michigan experimental harvesting of cedar stands to study silvicultural techniques is allowed on state lands, but no large scale harvesting. Private lands in Michigan are subject to the management philosophy of each individual landowner and counties in Michigan allow harvest of cedar [Schools (pers. comm., February 2003].

Current management of *Thuja occidentalis* in Minnesota calls for no harvesting on Federal land on the Chippewa or Superior National Forests. State Land in Minnesota has a component of cedar preserved in Scientific and Natural Areas, although no actual inventory of SNA cedar types exist [Wilson (pers. comm., December 2002]. State land designated for timber harvest in Minnesota generally has a limited harvest policy on cedar [Klevorn (pers. comm., February 2003], but a recent sale within Grand Portage State Forest brought the issue of Northern White Cedar protection and forest policy to the headlines. Six acres of old-growth Cedar was cut against state forest policy and two adjacent sales were called into question by the Sierra Club (Myers 2003). Private lands in Minnesota are subject to the management philosophy of each individual landowner. Minnesota counties do allow harvests, but are a small component of total timber sales [Thompson (pers. comm., November 2002].

The Chequamegon-Nicolet National Forest is not harvesting cedar at present, although it has been done in the past. Draft standards and guidelines in the draft Forest Plan specifically reference no-harvest management as well as specific silvicultural guidelines. An example is the recommendation for lowland conifers: lowland hardwoods, and hemlock will only be harvested to benefit or maintain habitat for species of viability concern. The Forest Silviculturist and Forest Ecologist would evaluate the effects of a

proposed treatment but either the District Ranger or the Forest Supervisor would grant authorization [Parker (pers. comm., December 2002].

The Wisconsin DNR doesn't have an official policy banning cedar harvests, but harvesting rarely occurs [Peterson] (pers. comm., April 2003). Counties and private landowners may schedule harvest, but the Wisconsin DNR believes harvesting of cedar is discouraged on other government lands and by private consulting foresters.

Danielson references forest management policies on Tribal lands. Historically, Bureau of Indian Affairs policy dictated Cedar harvests, possibly causing the decline of larger trees. Recent management actions by local tribes are likely to be more restrictive in harvesting cedar (Danielson 2002).

SUMMARY OF EXISTING MANAGEMENT ACTIVITIES

In reviewing the current age distribution of cedar, trends suggest that if current management of Northern White Cedar does not change stands in reserve will age without recruitment to replace the natural mortality. Additional management problems were presented by Miller et al. (1990) as follows:

- Silvicultural problems include:
  - A poor seed source or lack of regeneration
  - Seeds that fall do not germinate due to moisture or pH problems
  - Seedlings become established but desiccate or drown due to changes in water table
  - Too much competition on the site prevents early seedling development
- Wildlife problems include:
  - Newly established seedlings may be eaten by hare or deer
  - Animal populations may fluctuate during the 20 years the cedar is vulnerable to browsing
  - Improperly coordinated feeding and cutting practices in adjacent areas can cause deer to concentrate on regenerating stands

The wood products value of northern white cedar consists of small scale applications for sauna logs, fence posts, paneling and boats due to the rot resistance of cedar. When forest harvest occurs, it is generally restricted to private or county lands with a small localized market. As cedar stands decline, the financial pressure on private markets may impact the harvesting rate. Management activities include market assessment and stand assessment to ensure maximum resource use with regard for regeneration. A management concern relates to the collapse of the cedar market and its impact on small localized mills (Miller et al. 1990).

Native management of cedar has traditionally supported many uses. A more thorough list of applications can be referenced in Danielson (2002). The most common uses include:

- Tea
- Bedding or floor covering
- Smudge/Incense
- Insect repellent
- Cleansing hair/household
- Cash crop/wreaths decorations
- Ricing sticks/Push poles/Net poles
- Canoe or boats
- Drums
- Toboggans/Snowshoe frames
- Flutes/whistles

Northern white cedar stands are vital winter habitat for white-tail deer and snowshoe hare because they provide browse and thermal cover. Management issues relate to excessive browsing that impacts regeneration. Wildlife populations may fluctuate in density over time and in some management plans, control measures may be implemented to relieve vegetative stress, but the slow growing nature of cedar makes it difficulty to modify

wildlife populations sufficiently to reduce the risks of over browsing. States generally control game species, not the national forests; the national forests can only manipulate habitat [Trull (pers. comm., August 2003)]. Other wildlife species utilize cedar stands (Dawson 1979) and may be a specific focus of management plans. These include:

- Pileated woodpeckers feed on carpenter ants
- White-throated sparrows
- Golden-crowned kinglets
- Yellow-bellied flycatchers
- Ovenbirds
- Northern parulas
- Winter wrens
- Swainson's thrushes
- Blackburnian warblers (and numerous warblers)
- Golden-crowned kinglets

Burns and Honkala (1990) discuss a management philosophy for deer yards that includes large even-aged stands of 40 – 160 acres, annually harvested in small blocks. Each block would be broadcast burned to maximize regeneration. If extremely high deer densities occurred, the entire patch would be completely cleared in 10 years to minimize over browsing. If low density deer herds exist, small strips or blocks would be cut on a 30-year interval.

Burns and Honkala (1990) advocate harvest blocks as small clearcuts or narrow strips. Management of competition is best achieved through clearcuts, but the overstory shade of a shelter cut can protect regeneration during dry or hot spells.

Van Deelen et al. (1996) reviews a management case study of Michigan deer yards that found management plans to be based on inaccurate assumptions. These inaccurate assumptions include:

- Deer abandon deeryards and don't browse new growth
- Winter deer confine themselves to thick cover so seedlings in clearcuts are not vulnerable
- Winters severe enough to restrict deer are frequent to allow cedars to grow

Van Deelen dispels these inaccurate assumptions and sees the deer yard management issues as having bigger impacts. He states:

> *"Lack of recruitment indicates a broader inability to conserve late successional communities with current deer densities."*

Alverson et al. (1988) expands the concept of late successional management to include a management concept called Diversity Management Areas. Diversity Management Areas were proposed in a 1986 statement of record in appeal of the U.S. Forest Service's adoption of the Chequamegon's Land and Resource Management Plan (Task Force 1986). A management proposal suggested 200 to 400 square kilometer reserves of contiguous habitat within the National Forests (the literature references the Chequamegon). Designs would need to be consistent with deer migration patterns. A management recommendation may include use of exclosures and specific deer reduction

through permitted harvest. The Diversity Management concept is only conceptual and is not currently practiced.

Several management recommendations exist concerning slash disposal on harvest sites. Davis et al. (1998) discuss slash as a barrier to seed germination due to slow decomposition and rot resistance in cedar. Verme (1986) established management recommendations after results from a research study testing the effectiveness of three silvicultural treatments. From 1973-1984 the Petrel Grade deeryard in Shingleton, Michigan was harvested. These techniques were evaluated:

1. Broadcast burning to remove slash
2. Full tree skidding and delimbing at the landing
3. Delimbing slash left as felled,

Data suggested that broadcast burning killed advanced regeneration, but influenced higher regeneration 5 years later (regeneration density averaged 33.3 stems per miliacre) and 10 years after the harvests (stem density increased to 40.2 stems per miliacre). Comparatively, on the mechanical treatments regeneration after 5 years on the full tree skid averaged 11.5 miliacre whereas the slash plots averaged 22.2 stems per miliacre. There was no change in the stem densities of the mechanical plots from the 5 year to the 10 years survey.

Miller et al. (1999) presentation at the Northern White-Cedar Workshop in Michigan identified stand assessment and management options that may improve cedar resources. Their management suggestions include:

- Improving means of describing site suitability or potential for management
- Site index considered poor on most cedars, avoid following blanket prescriptions based on site index alone, treat stands on a case by case basis
  (Michigan FIA data shows 52% of cedar have a site index lower than 30)
- Improve assessment of the following before a management plan is written:
  - Review indicator species
  - Soil and mechanical properties
  - Ground water conditions
  - Pre-harvest stand treatments – remove undesirables and encourage advanced regeneration
- If harvesting is allowed, conduct clearcuts with small strips or blocks
  - Consider slash management including:
    - Burning
    - Mechanical scarification
    - Microsite modification
    - Drainage affecting pH or fertility
    - Competition control
    - Wildlife population control
    - Wildlife behavioral modification (Providing an alternate, more desirable food source at the stand; treating the cedar foliage with repellents that discourage browsing; or by breeding and planting cedar that contain natural repellents.)
    - Wildlife exclosures

Fire management serves to remove competition and will remove moss layers that may increase drought conditions in summer seasons. Prescribed fire is a recommended management tool unless advanced regeneration already exists on site or if organic soil conditions are depleted of moisture. Fire can reduce slash that has been shown to restrict regeneration, and is recommended as a management tool with the following prescription: (Rooney et al. 1992)

If the management objective is to remove slash only

- Fires should be limited to 3-10 days after a rainfall (of at least .1 inches)
- A maximum air temp of 60-90 degrees F
- A maximum wind speed of 5-15 mph

If the management objective is to remove slash and prepare a seed bed

- The fire must be hotter
- At least 7 days since a rainfall of more than .1 inch
- Less than 45% humidity
- Air temp. greater than or equal to 80 degrees
- Wind, 5-15 mph

Prescribed Fire Management can also be used to eliminate northern white cedar in fens. Low intensity fires rarely increasing beyond 70 BTU's have been documented to reduce cedar vegetation for at least 3 growing seasons.

PAST AND CURRENT CONSERVATION ACTIVITIES

The Michigan Working Group is a policy-developing group comprised of the Michigan DNR, the Nature Conservancy, Huron-Manistee National Forest, and Michigan Natural Features Inventory personnel. The group develops design criteria for old growth and biodiversity restoration of forested ecosystems in Michigan. According to the "*Old Growth And Biodiversity Stewardship Fact Sheet For Michigan*" The US Forest Service estimates there are between 60,000 and 70,000 acres of true, native "old growth" within Michigan's 19.3 million acres of forested land. The Biodiversity Stewardship fact sheet had no reference to forest type or the designation process for stands, but the age structure of most cedar located on National Forest land may warrant consideration as "old growth" (Table 6-10) . The FIA database has a data variable entitled Reserve Status class. A query of the Michigan 2001 cycle 6 FIA database revealed no northern white cedar acreage in reserved status.

Of the other cooperating agencies, most of the designated acreage is located in the Upper Peninsula including Porcupine Mountain State Park, McCormick and Sylvania Wilderness areas of the Ottawa National Forest, and the privately owned Huron Mountain Club (Michigan DNR).
The Michigan Department of Transportation has been actively involved in Northern White Cedar restoration projects through the use of Wetland Mitigation Bank and compensatory wetlands.

The Minnesota Department of Natural Resource non-game wildlife staff participate in forest planning with the Division of Forestry to assist in maintaining ecologically sound

northern forests managed for diversity of age and species, but specifically designed to target old growth stands. The Minnesota DNR defines old growth as a stand of trees over 120 years of age and has worked on the old-growth forests issue since the 1980s. Issues include defining and identifying the importance and the survival of old growth forests, and can be referenced at: http://www.dnr.state.mn.us/forests/oldgrowth/policy.html
As of October 2002, a network of 38,000 acres of old-growth forest have been designated on MN DNR administered lands with approximately 4000 acres of old-growth northern white cedar (DNR Old-growth committee 2002).

Important dates in the development and implementation of DNR's old-growth policy include the following:

- **1983** - Old-growth forest issue emerges and DNR begins policy discussions – how much and where to protect old growth – using the Forestry/Wildlife Coordination Guidelines.
- **1988** - DNR forms task force to develop Old-Growth Forests Guidelines.
- **1990** - DNR Commissioner approves Old-Growth Forests Guideline following public review and in response to an out-of-court settlement.
- **1994** - DNR Old-Growth Committee establishes a Stakeholders Roundtable of forest industry and environmental interests agree on targets for protecting remaining highest quality old-growth forests on state lands; Guideline is revised.
- **1998** - Old-Growth Guideline is implemented with systematic inventory, evaluation, and designation using an old-growth database; DNR Commissioner's Office and OMB Science-Policy Unit staff provide standards and oversight.
- **2003** - Old-growth forest designation of highest quality stands completed.

The Wisconsin DNR has specialized projects related to old growth preservation. One group is called the Community Restoration and Old Growth Assessment Team (CROG) This team developed and applied a process to identify, rank and map natural plant communities based on a set of ecological criteria to the Brule River State Forest.

A Challenge Cost-Share Agreement between the Superior National Forest and the Natural Heritage program of the Minnesota DNR funded a 1992 research project. Four associations were described on this project including:

- Northern hardwood-conifer forest
- Mesic upland white cedar forest
- Wet-mesic upland white cedar forest
- White cedar swamp

Rusterholz (1992) identified the following tentative general criteria for old growth cedar stands :

1. White Cedar should comprise a plurality of the total basal area of the stand or a plurality of total number of trees in a stand

2. The stand should be at least 120 years old
3. The stand should show relatively little evidence of human disturbance. The degree of past logging that is acceptable is a subjective judgment. Uncut stands are of high ecological value, and stands in which cut stumps outnumber mature trees are less valuable as natural areas. Stand in which old, cut stumps are infrequent could be considered significant old growth if other criteria are met.
4. Mean DBH of cedars should be at least 21 cm or 8.7 inches. This is smaller than the MN DNR guidelines...but use of smaller DBH is important in slow-growing swamps.
5. Total Tree Basal area should be at least 35 m^2/ha.
6. Total Snag Basal area should be at least 4m^2/ha
7. Volume of downed logs should be at least 15m^3/ha

RESEARCH AND MONITORING

There are a number of important research and monitoring topics pertaining to the conservation of cedar communities. These include:

- Relationship between herbivory and cedar recruitment
- Prevention of herbivory
- Ongoing FIA monitoring of abundance and status of cedar stands in Lake States

Recent examples of such research include Cornett's studies in northeast Minnesota. Cornett conducted two studies pertaining to northern white cedar in Minnesota. The first study compared the importance of seedbed and canopy type in the restoration of upland *Thuja* forest in northeastern Minnesota (Cornett et al. 2001). The second study reviewed the effects of browsing on recruitment of cedar on seven sites in and outside of deer exclosures. To evaluate seedbed and canopy type, restoration experiments and field surveys were conducted on three study sites in the Lake Superior Highlands of Minnesota. Colonization and establishment phases of regeneration, differentiating safe-site components, seed and seedbed availability were reviewed. Data showed greatest seed and seedbed availability under *Thuja* cover with a critical role played by decaying conifer logs. The lowest mortality of seedlings occurred under *Betula papyrifera* overstories. Cornett's recommendations include the conservation of the natural process for seedbed preparation and placing a priority on retaining longer segments of downed logs after management activities.

Cornett studied 7 sites to understand the effects of browsing on seedling recruitment inside and outside of constructed deer exclosures (Cornett et al. 2000). The results of this study offered recommendations for the conservation of *Thuja occidentalis*. If low browsing pressure exists, concentrate *Thuja* regeneration efforts in micro environments with higher light. If high browsing pressure exists, invest efforts in protection from browse for a time frame of 30-50 years until seedlings reach a height class of > 2.1 meters.

Scott and Murphy seemed to support the Cornett's recommendation for downed log segments and higher light intensity. In their 1987 study of *Thuja occidentalis* in an old-

growth dune forest on South Manitou Island in Michigan , Murphy and Scott noted 81% of Thuja stems between 2.5 cm and 15 cm associated with a log substrate. There was no significant correlation between state of log decay and the density of seedlings, indicating survival is not dependent upon state of log decomposition. There was a correlation between seedlings >25 cm tall and forest openings. 78% of cedar stems >2.5 cm occurred on decomposing logs near a single windthrow gap.

Chimner and Hart (1996) studied a regenerating cedar fen near Escanaba, Michigan to study the factors affecting regeneration success and failure. Their data suggested a positive correlation between stem density and percentage of hummocks for unsaturated soil conditions in fen peatlands. There was more cedar on micro sites with drier conditions while more shrubs such as alder and hardwood species were found on wetter sites with fewer hummocks.

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