13660

Laurentian-Acadian Pine-Hemlock-Hardwood Forest

BpS Model/Description Version: Aug. 2020

|  |  |  |  |
| --- | --- | --- | --- |
| **Modelers** |  | **Reviewers** |  |
| Dave Cleland | dcleland@fs.fed.us | Brendan Ward | bward@fs.fed.us |
| Randy Swaty | rswaty@tnc.org | None | None |
| None | None | None | None |

Vegetation Type

Forest and Woodland

Map Zone

50

Geographic Range

In map zone (MZ) 50, this system would have historically been present in sections 212X, 212T, 212J, 212Y, with occasional relict patches in 222Lc and 222Ld.

This type estimated to cover approximately 2 million acres ca.1800 in Michigan, with heavy concentrations in the Saginaw Valley and Thumb regions in the Lower Peninsula and extending northward through the Upper Peninsula. Beech-sugar maple-hemlock forests, which dominated nearly 17% of the state surface in the 1800s, were mostly found on large expanses of rolling moraines in the northern Lower Peninsula and eastern Upper Peninsula. This species mix was also found on the clay lake plain along Saginaw Bay.

Biophysical Site Description

Hemlock and white pine have wide ecological amplitudes, occurring with wetland conifers in poorly drained landforms and with mesophilic northern hardwoods in marginal upland landforms. White pine and hemlock become dominant within mixed forests in upland ice-contact and glacial lakebed landforms of intermediate soil fertility. These landscape ecosystems typically have low proportions of sugar maple and associated mesophilic deciduous species due to limited soil nutrient availability or moisture-holding capacity. Species adapted to frequent disturbance (e.g., jack pine, aspen) occur in low proportions.

Extreme podzolization can occur in relatively pure hemlock stands due to highly acidic hemlock needles (Curtis 1959). In MZ50, the distribution would be correlated with SSURGO map units with high percentages of Spodosols, especially Entic and Alfic Haplorthods, and occasionally on Oxyaquic Haplorthods.

Vegetation Description

In the mid-1800s, there were 2.2 million acres of white pine-hemlock ecosystems within the 10.6 million acres of forestlands in northern lower Michigan (Province 212; Cleland et al. 2004; ongoing R-9/SRS/MTU study). Based on analysis of GLO line tree observations, white pine-hemlock communities were dominated by “pine” recorded to the genus level, followed by hemlock, white pine, red pine, and beech. It is likely much of the undifferentiated pine was white pine, given the large diameters of this class (mean of 19.3in). Pine and hemlock comprised 62% of GLO line trees, mesophilic sugar maple 3%, and early successional oak, white birch, and aspen 10%.

In the mid-1800s, there were 3.2 million acres of white pine-hemlock-birch ecosystems within the 17.8 million acres of forest lands in northern Wisconsin (Cleland et al. 2004a; ongoing R-9/SRS/MTU study). These landscape ecosystems were dominated by three communities identified by Schulte et al. (2002) as hemlock, hemlock-white pine, and hemlock-yellow birch. Pine and hemlock comprised 33% of GLO line trees, mesophilic sugar maple and yellow birch ~17%, and early successional oak, white birch, and aspen ~20%. The white pine-hemlock forests of Wisconsin were more diverse than those of northern lower Michigan, with higher proportions of both early and late successional deciduous species. This may be due to the prevalence of wetlands and lakes within Wisconsin, which provided sheltered landscape positions favoring sugar maple, and poorly drained soils favoring yellow and white birch and quaking aspen. Much of the white pine-hemlock Biophysical Setting (BpS) was in an old-growth state, and relatively low densities of tall, large-diameter trees dominated the landscape. Old-growth white pine-hemlock stands were often partially multi-aged (Holla and Knowles 1988) or uneven-aged due to continuous recruitment caused by local disturbances (Quinby 1991). Rogers (1978) reported only 8% of the hemlock stands sampled from Wisconsin to Nova Scotia were even-aged, indicating that very few of the hemlock stands were initiated after a catastrophic event such as a wildfire. In a study of old-growth white pine in Canada (Guyette and Dey 1995), canopy dominance and tree size suggested an even-aged structure, whereas actual ages of dominant trees ranged from 267-486yrs. White pine >400yrs made up 20% of the dominant trees, 52% were 300-400yrs old, and 28% were 250-300yrs old. White pine persisted as the dominant species over a seven-century period in an old-growth white pine forest of Canada, indicating that white pine was self-replacing (Quinby 1991).

BpS Dominant and Indicator Species

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** |
| PIST | *Pinus strobus* | Eastern white pine |
| TSCA | *Tsuga canadensis* | Eastern hemlock |
| BEAL2 | *Betula alleghaniensis* | Yellow birch |

Species names are from the NRCS PLANTS database. Check species codes at http://plants.usda.gov.

Disturbance Description

The hemlock-white pine forests of northern lower Michigan and Wisconsin were disturbed by large-scale stand-replacing crown fires within rotations of 400-500yrs (Cleland et al. 2004a) and by wind events of comparable rotations. During the centuries between catastrophic disturbances, low-intensity small surface fires, windthrown trees, and the death of large individual trees through biological or other agents interacted to regulate stand-scale gap dynamics.

The complex structure and age-class distribution of this ecosystem are due to these two distinct disturbance regimes. Broad-scale crown fires occurred very infrequently, selecting for pyrophilic species capable of reproducing in full-light conditions following stand-replacing disturbance. Fine-scale single or group tree mortality and blowdown occurred continuously and selected for shade-tolerant and mid-shade-tolerant species.

Once white pine has matured and attained larger diameters and crown height, widely spaced dominants are highly resistant to intense surface or maintenance fires (Beverly and Martell 2003). Hemlock is injured or killed by surface fires due to its shallow root system, thin bark, and low branches (Carey 1993), and all species suffer high rates of mortality following crown fires. The successional dynamics of this ecosystem after mixed or severe crown fires may involve establishment of aspen, paper birch, red pine, or white pine immediately following the disturbance, with subsequent succession to white and red pine and red oak, followed by late successional gap-phase invasion of hemlock and yellow birch beneath white pine during long fire-free periods (Davis et al. 1992).

Successional trajectories were historically regulated by disturbance regime, as well as by landscape-level patterns in communities and environment and localized edaphic conditions. Landscape-level patterns of lakes, wetlands, deciduous species, openlands, and other fuel discontinuities determined fire-exposed versus fire-protected landscape positions (Dovciak et al. 2003). Within landforms, localized conditions of soil texture and drainage, and resulting gradients of available nutrients and moisture, impeded invasion by nutrient-demanding shade-tolerant hardwoods (Rogers 1978).

Preferential recruitment of hemlock beneath white pine and development of mor-like soil organic horizons within hemlock stands that inhibited hardwood invasion (Davis et al. 1994) are examples of biologically mediated successional dynamics. All these natural processes and factors have had a strong selective effect on the age, structure, and composition of these forests.

Fire Frequency

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Severity** | **Avg FI** | **Percent of All Fires** | **Min FI** | **Max FI** |
| Replacement | 484 | 32 |  |  |
| Moderate (Mixed) | 1019 | 15 |  |  |
| Low (Surface) | 291 | 53 |  |  |
| All Fires | 154 | 100 |  |  |

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is the central tendency modeled. Percent of all fires is the percent of all fires modeled in that severity class. Minimum and Maximum FIs show the relative range of fire intervals as estimated by model contributors, if known.

Scale Description

Landscape must be adequate in size to contain natural variation in vegetation and disturbance regime. Replacement fires at 400-500yrs may be in the 1,000s of acres. Surface and mixed fires could be <10ac.

Adjacency or Identification Concerns

This system is distinguished from other similar systems by a strong pine component and the potential to succeed to hemlock-dominated stands; this would have been possible under the natural disturbance regime and given natural densities of seed sources. Historical harvesting and subsequent repeated fires in the late 1800s and early 1900s have allowed some expansion of BpS 1302 (Laurentian-Acadian Northern Hardwood Forest) and BpS 1362-2 (Laurentian-Acadian Northern Pine-Oak Forest) onto sites formerly occupied by this type, particularly due to dramatic decreases in available hemlock seed sources. Expansion and comingling of 1302 would generally be restricted to more loamy and nutrient rich soils. Comingling with 1362-2 would occur primarily near sites with historically more frequent fire. Lack of hemlock seed sources and hemlock recruitment on the landscape would effectively convert this to 1362-2 during the later successional stages. Historical data sources will be required to correctly depict the historic distribution of this type.

Issues or Problems

Much of this type was heavily altered during landscape-scale historical harvesting in the late 1800s and early 1900s (Mladenoff & Pastor 1993), primarily resulting in a drastic reduction of hemlock seed sources on the landscape. Current recruitment of hemlock may be limited not only by this reduced distribution of seed sources but also from significant rates of browsing by white-tailed deer (Carey 1993).

Native Uncharacteristic Conditions

Comments

Succession Classes

**Mapping Rules**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Upper Layer Lifeform** | **Height (m)** | **Canopy Cover (%)** | | | | | | | | | |
| **0-10** | **11-20** | **21-30** | **31-40** | **41 - 50** | **51-60** | **61-70** | **71-80** | **81-90** | **91-100** |
| Herb | 0-0.5 | A | A | A | A | A | A | A | A | A | A |
| Herb | 0.5-1.0 | A | A | A | A | A | A | A | A | A | A |
| Herb | >1.0 | A | A | A | A | A | A | A | A | A | A |
| Shrub | 0-0.5 | A | A | A | A | A | A | A | A | A | A |
| Shrub | 0.5-1.0 | A | A | A | A | A | A | A | A | A | A |
| Shrub | 1.0-3.0 | A | A | A | A | A | A | A | A | A | A |
| Shrub | >3.0 | A | A | A | A | A | A | A | A | A | A |
| Tree | 0-5 | A | A | A | A | A | A | A | A | A | A |
| Tree | 5-10 | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix | B mix |
| Tree | 5-10 | C con | C con | C con | C con | C con | C con | C con | C con | C con | C con |
| Tree | 5-10 | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf | B brdlf |
| Tree | 10-25 | D | D | D | D | D | D | D | D | D | D |
| Tree | 25-50 | D | D | D | D | D | D | D | D | D | D |
| Tree | >50 | D | D | D | D | D | D | D | D | D | D |

Succession class letters A-E are described in the Succession Class Description section. Some classes use a leafform distinction where a qualifier is added to the class letter: Brdl (broadleaf), Con (conifer), or Mix (mixed conifer and broadleaf). UN refers to uncharacteristic native or a combination of height and cover that would not be expected under the reference condition. NP refers to not possible or a combination of height and cover which is not physiologically possible for the species in the BpS.

**Description**

Class A 2 Early Development 1 - All Structures

Upper Layer Lifeform: Tree

Upper-layer lifeform is not the dominant lifeform. Shrubs can be dominant lifeform, 50-100% cover.

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| BEPA | Betula papyrifera | Paper birch | Upper |
| POTR5 | Populus tremuloides | Quaking aspen | Upper |

Description

Openings.

Class B 16 Early Development 2 - Closed

Upper Layer Lifeform: Tree

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| QURU | Quercus rubra | Northern red oak | Upper |
| BEPA | Betula papyrifera | Paper birch | Upper |
| POTR5 | Populus tremuloides | Quaking aspen | Upper |
| ACRU | Acer rubrum | Red maple | Upper |

Description

Post-replacement regeneration with early seral species.

Balsam fir could occasionally become established during this class but would have been primarily limited to the understory and midstory strata.

Class C 39 Mid Development 1 - Closed

Upper Layer Lifeform: Tree

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIST | Pinus strobus | Eastern white pine | Upper |
| PIRE | Pinus resinosa | Red pine | Upper |

Description

Stands consist of red pine and young white pine, generally, and the box is aged 81-300yrs.

Class D 43 Late Development 1 - Closed

Upper Layer Lifeform: Tree

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIST | Pinus strobus | Eastern white pine | Upper |
| TSCA | Tsuga canadensis | Eastern hemlock | Upper |

Description

Stands consist of mature and old-growth white pine. Over time, and in fire’s absence, associated large hemlock may develop.

Model Parameters

Deterministic Transitions

|  |  |  |  |
| --- | --- | --- | --- |
| **From Class** | **Begins at (yr)** | **Succeeds to** | **After (years)** |
| Early1:ALL | 0 | Early2:CLS | 10 |
| Early2:CLS | 11 | Mid1:CLS | 80 |
| Mid1:CLS | 81 | Late1:CLS | 300 |
| Late1:CLS | 301 | Late1:CLS | 999 |

Probabilistic Transitions

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Disturbance Type** | **Disturbance occurs In** | **Moves vegetation to** | **Disturbance Probability** | **Return Interval (yrs)** | **Reset Age to New Class Start Age After Disturbance?** | **Years Since Last Disturbance** |
| Replacement Fire | Early1:ALL | Early1:ALL | 0.005 | 200 | Yes | 0 |
| Wind or Weather or Stress | Early2:CLS | Early1:ALL | 0.001 | 1000 | Yes | 0 |
| Replacement Fire | Early2:CLS | Early1:ALL | 0.002 | 500 | Yes | 0 |
| Surface Fire | Early2:CLS | Early2:CLS | 0.005 | 200 | No | 0 |
| Wind or Weather or Stress | Mid1:CLS | Early1:ALL | 0.001 | 1000 | Yes | 0 |
| Replacement Fire | Mid1:CLS | Early1:ALL | 0.002 | 500 | Yes | 0 |
| Mixed Fire | Mid1:CLS | Mid1:CLS | 0.0025 | 400 | No | 0 |
| Surface Fire | Mid1:CLS | Mid1:CLS | 0.004 | 250 | No | 0 |
| Wind or Weather or Stress | Late1:CLS | Mid1:CLS | 0.001 | 1000 | Yes | 0 |
| Replacement Fire | Late1:CLS | Early1:ALL | 0.002 | 500 | Yes | 0 |
| Surface Fire | Late1:CLS | Late1:CLS | 0.0025 | 400 | No | 0 |

References

Carey, J.H. 1993. Tsuga canadensis. In: Fire Effects Information System, [Online]. USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2007, July 2].

Cleland, D.T., T.R. Crow, S.C. Saunders, D.I. Dickmann, A.L. Maclean, J.K. Jordan, R.L. Watson, A.M. Sloan and K.D. Brosofske, 2004. Characterizing historical and modern fire regimes in Michigan (USA): a landscape ecosystem approach. Landscape Ecology 19:311-325.

Cleland, D.T., S.C. Saunders, K.D. Brosofske, A.L. Maclean, J.K. Jordan, R.L. Watson, A.M. Sloan, T.M. Scupien, T.R. Crow and D.I. Dickmann, 2004a. Ongoing project to determine historical and modern wind and fire regimes, fire risk, and historical landscape and community composition and structure in the Lake States and R-9 National Forests.

Curtis, J.T. 1959. The Vegetation of Wisconsin. University of Wisconsin Press, Madison, WI.

Davis, M.B., Sugita, S., Calcote, R.R., Ferrari, J.B. and Frelich, L.E., 1994. Historical development of alternate communities in a hemlock hardwood forest in northern Michigan, U.S.A. In Large Scale Ecology and Conservation Biology: The 35th Symposium of the British Ecological Society with the Society for Conservation Biology, pp. 19-39. Edited by P.J. Edwards, R.M. May and N.R. Webb. University of Southampton. Blackwell Scientific Publications: Boston, MA.

Davis, B., Sugita, S, Calcote, R. and Frelich, L.E. 1992. Effects of invasion by Tsuga canadensis on a North American forest ecosystem. In: Teller, A., Mathy, P. and Jeffers, J.N.R. Responses of forest ecosystems to environmental changes. Elsevier Applied Science, London and New York. P. 34-44.

Doviak, M., Reich, P.B. and Frelich, L.E., 2003. Seed rain, safe sites, competing vegetation, and soil resources spatially structure white pine regeneration and recruitment. Can. J. For. Res. 33: 1892–1904.

Beverly, J.L. and D.L. Martell, 2003. Modeling Pinus strobus mortality following prescribed fire in Quetico Provincial Park, northwestern Ontario. Can. J. For. Res./Rev. Can. Rech. For. 33(4): 740-751.

Guyette, R.P. and D.C. Dey, 1995. Age, size and regeneration of old growth white pine atDividing Lake Nature Reserve, Algonquin Park, Ontario. Ontario Ministry of Natural

Resources, Ontario Forest Research Institute, Sault Ste. Marie, Forest Research Report No. 131, 11p.

Holla, T.A. and Knowles, P. 1988. Age structure analysis of a virgin white pine, Pinus strobus,population. Canadian Field-Naturalist. 102(2): 221-226.

Mladenoff, D.J. and J. Pastor. 1993. Sustainable forest ecosystems in the northern hardwood and conifer forest region: concepts and management. Pages 145-179 in: Defining sustainable forestry, Aplet, G.H., N. Johnson, J.T. Olson and V.A. Sample (eds.). Island Press, Washington, D.C.

Quinby, P.A. 1991. Self-replacement in old-growth white pine forests of Temagami, Ontario. For. Ecol. Manage. 41: 95–109.

Rogers, R.S. 1978. Forests dominated by hemlock (Tsuga canadensis): distribution as related to site and post-settlement history. Canadian Journal of Botany 56: 834-854.

Schulte, L.A., D.J. Mladenoff and E.V. Nordheum, 2002. Quantitative classification of a historic northern Wisconsin (U.S.A.) landscape: mapping forests at regional scales. Can. J. For. Res. 32: 1616–1638.