13022

Laurentian-Acadian Northern Hardwoods Forest - Hemlock

BpS Model/Description Version: Aug. 2020

**Reviewed by:** Ron Deckert and Greg Nowacki, plus staff from Chequamegon-Nicholet National Forest.

Vegetation Type

Forest and Woodland

Map Zones

41, 50, 51

Model Splits or Lumps

This Biophysical Setting (BpS) is split into multiple models. Laurentian-Acadian Northern Hardwoods Forest (BpS 1302) was split into three models: 511302-1-Laurentian Acadian Northern Hardwoods Forest, 511302-2-Laurentian-Acadian Northern Hardwoods Forest - Hemlock, and 511302-3-Northern Sugar Maple-Basswood Forest.

Due to mapping challenges and further review, 13021 was lumped into this BpS, 13022 during the 2017 BpS review

Geographic Range

This system occurs throughout the Northern Lower and especially the western Upper Peninsulas of Michigan and northern Wisconsin and Minnesota. In map zone (MZ) 51, this system would have occurred in 212 Hf, Hi, He, Hd, Ha, Jo, Jb, Sn, Sb, Sq, and Sc.

Biophysical Site Description

Commonly occurs on coarse-textured ground and end moraines lying predominantly north of the tension zone. Also occurs on thin glacial till over bedrock and medium-textured moraines and locally on kettle-kame topography (Cohen 2000). Dominant soil texture is sandy loam. May have silt cap.

Vegetation Description

Structurally, these uneven-aged forests were characterized by large volumes of coarse, woody debris lying beneath multi-storied canopies of different-aged cohorts, with supercanopies composed of trees centuries old (Tyrell and Crow 1994). The dominant tree species are among the most moisture- and nutrient-demanding species in the eastern United States (Woods 2000; Whitney 1986). Hemlock diminished in the southern and western parts of this BpS. Some areas would have been dominated by hemlock, yellow birch, and eastern white cedar. Beech restricted to easternmost part of MZ.

Composition of the ground flora and understory varies along a moisture-nutrient gradient and typically consists of high densities of shade-tolerant tree species and mesophilic herbaceous species including blue cohosh, yellow violet, sweet cicely, various ferns, and ginseng. In hemlock-dominated stands, ground layer diversity is low due to the nutrient-poor and acidic mor humus as well as the low understory light intensity caused by the perpetually dense hemlock canopy (Curtis 1959).

Sugar maple, hemlock, yellow birch, balsam fir, cedar in swales, spruce, and beech were the dominant late-successional species recorded along section lines by GLO surveyors in Michigan. Conifer-dominated mesic northern forests usually have hemlock and yellow birch as the primary canopy components. Often present in these stands are white cedar and large, but widely spaced white pine, relics of an earlier successional stage generated by forest fire and/or windthrow (Nichols 1935). Large openings likely occurred on <1% of the landscape.

BpS Dominant and Indicator Species

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

Disturbance Description

Catastrophic windthrow is an important yet infrequent component of the disturbance regime of the northern mesic forests. Because of the long rotation period of large-scale disturbance in this community type, several generations of trees can pass between catastrophes. The principal mechanisms for large-scale windthrow are tornadoes and downbursts from thunderstorms. These wind-driven ecosystems historically changed slowly over centuries due to fine-scale blowdowns, relatively rare broad-scale catastrophic storms, and even rarer fire events (Cleland et al. 2004; Woods 2000; Canham and Loucks 1984; Frelich and Lorimer 1991; Grimm 1984; Runkle 1982). Fine-scale or gap-dynamic windthrow events were modeled as Optional1, with ~5-20% of canopy trees dying per decade and creating gaps of tens to a few hundred square meters (Woods 2004). Frelich et al. (1993) proposed that unless followed by catastrophic fire, catastrophic windthrow would cause little change in species composition because of the prevalence of advanced regeneration of shade-tolerant species. Blowdowns affected conifers more than hardwoods and older trees more than younger trees (Foster and Boose 1992; Webb 1984). The coarse woody debris from blowdowns served as an important feature affecting the regeneration of hemlock, by serving as nurse logs. These forests seldom burned (Grimm 1984; Stearns 1949) and exhibited a repeating and shifting steady state of fine-scaled mosaics of species whose overall proportions remained essentially constant (Borman and Likens 1979).

Fire Regime Description: Because this forest type was composed of fire-sensitive species, fires only occurred within it following catastrophic wind events or during periods of extreme drought. This fire resistance is due to high rates of organic matter decomposition and low rates of fuel accumulation, closed and multistoried canopy effects on microclimate, succulent ground-flora and herbaceous layers, high soil-moisture storage capacity, and the dispersed canopies of volatile coniferous foliage within a fire-resistant deciduous hardwood matrix. The principal cause of fuel formation leading to fire in northern hardwood ecosystems is broad-scale, storm-driven windthrow of catastrophic proportions (Canham and Loucks 1984; Dunn et al. 1983; Runkle 1982). Canham and Loucks (1984) estimated the return interval for catastrophic storms to be ~1200yrs in northern Wisconsin. Their comparisons of the pre-settlement disturbance regime with contemporary climatological records suggest that catastrophic thunderstorms were the principal mechanism for large-scale windthrow, followed by tornadoes that accounted for one-third of blowdown recorded by surveyors. Not only were these storms nearly stand-replacing events in themselves, but after the slash resulting from them cured, the probability of fire increased exponentially. However, fires within undisturbed, intact systems that did start or that moved into these stands from adjacent areas tended to smolder in the duff layer and move very slowly, eventually going out and causing little damage to the overstory (Frelich and Lorimer 1991; Stearns 1949).

Within the 5.8 million acres of northern hardwood ecosystems in the Upper Peninsula of Michigan, there were 146,028ac of blown-down forests and 54,903ac of burned areas based on analyses of General Land Office survey notes recorded between 1840-1855 (Cleland et al. 2004a; Maclean and Cleland 2003). Assuming a 15yr recognition window, the historical fire rotation was 1,568yrs. If surveyors recognized a blowdown 20yrs after the event, catastrophic wind rotations would have been 786yrs, with a 30yr recognition window estimate of 1179yrs. Because of the fire resistance of undisturbed mesic deciduous forests, these estimates suggest that ~40% of the blown-down areas within this forest type in the Upper Peninsula subsequently burned.

Fire Regime Group V is applicable to this system. Severe wind events were assumed to reset mature stands on a ~1,100yr rotation in Michigan’s Upper Peninsula in the following VDDT models. Most replacement fire occurs in slash created by these wind events. Forty percent of the blowdown areas burn and revert to an open land or an early-seral aspen-birch stage that lasts 60yrs. Replacement fires without associated wind events are very rare.

From 2017 review:

Historically, most foresters/ecologists/researchers always assumed that small-scale, autogenic (within-stand) disturbances drove the prevailing “gap phase” dynamics of these systems. And to some degree they were right. But that was before the emergence of dendroecology and the identification of canopy disturbance events via tree-ring release. Fairly recently, Dr. Craig Lorimer and his graduate students have done a superb job documenting the importance of intermediate, partial-canopy disturbance (wind) events in the development and maintenance of northern hardwood forests. Instead of being “rare” events (sensu Woods 2004), moderate-severity wind storm events appear to be relatively common in this forest type (Hanson and Lorimer 2007). Hanson and Lorimer (2007; p. 1326) state: “Most remnant old-growth stands of the northeastern United States have experienced several episodes of moderate damage from wind, fire, insect outbreaks, and other disturbances (Hough and Forbes 1943; Oliver and Stephens 1977; Foster 1988a; Abrams and Orwig 1996; Orwig et al. 2001; Ziegler 2002; Fraver and White 2005). In northern hardwood forest of upper Michigan, disturbances removing 30-60% of the forest canopy had estimated rotation periods of 300-390 years, or about once during the expected lifespan of an individual cohort. Irregular, multi-cohort forests consequently dominated about 80% of the landscape (Frelich 1986; Frelich and Lorimer 1991a,b). Moderate-severity wind events have unique impacts on forest composition and structure that differ from small gap-phase dynamics (i.e., things come in pulses) (Woods 2004; Hanson and Lorimer 2007). As such, classic models of forest development/succession do a poor job capturing the more complex and unpredictable trajectories representative of periodic moderate-severity events. Most stands are probably multi-cohort in age structure rather than purely uneven-aged (Oliver and Larson 1996), with moderate-severity wind events causing partial retrogression of stand structure that differs substantially from complete stand replacement or continuous small gap-phase dynamics (Hanson and Lorimer 2007). Moreover, the maintenance of yellow birch (*Betula alleghaniensis*) in these systems might be predicated on moderate-severity wind events. Please refer to Halpin and Lorimer (2016) for how they incorporated moderate-severity wind events into their modelled trajectories.

New research on the pine component: In regard to pine as an associate in these systems or as the dominant conifer in pine-northern hardwoods, there is increasing evidence that fire was an important driver. Fahay (another Lorimer grad student) has recently produced a number of good works documenting pine dynamics within northern hardwood systems (Fahay et al. 2012; Fahay and Lorimer 2013, 2014a, 2014b).

General consensus is that fire may have occurred more than we originally thought. The model was adjusted accordingly. Additionally, the model was adjusted to capture the thinking that wind would occur on roughly 2-5% of the landscape annually.

Fire Frequency

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

None

Adjacency or Identification Concerns

Large areas of red pine and white pine occur on sandy, drier soils adjacent to this type. Embedded within this Northern Hardwood-Hemlock forest are lowland complexes. Similar BpSs are mesic maple-beech-hemlock forest and maple-basswood. The maple-basswood forest type is usually associated with more nutrient-rich and moisture-rich sites.

BpSs adjacent to this system include 1310 (North-Central Interior Dry-Mesic Oak Forest and Woodland), 1311 (North-Central Interior Dry Oak Forest and Woodland), 1344 (Boreal Jack Pine-Black Spruce Forest), and 1345 (Boreal White Spruce forest and Woodland).

This system can be easily confused with 1314 (North-Central Interior Maple Basswood Forest) and 1362 (Laurentian-Acadian Northern Pine-[Oak] Forest).

Issues or Problems

Exotics and invasives such as earthworms, garlic mustard, European buckthorn, and honey suckle occur presently but would not have affected this system historically. Encroachment in the form of conversion, urban sprawl, and management practices (forestry and fire suppression) are effects that would not have impacted this system historically but occur in the present day.

As a result of the forest management practices in the late 1800s, the majority of today's forests are second growth. In terms of structure and composition, this system is much simpler in present day, lacking shrub species such as Canada yew, and the successional stages tend to be younger, resulting in a second-growth forest. The presence of exotics and invasives in the present-day forest should also be noted.

It is possible that the replanting efforts by the Civilian Conservation Core (CCC) in the 1930s have converted some of this system to red pine monoculture.

This type has been in decline due to heavy winter browse by deer, single tree selection, which in some areas has greatly simplified this type, and reduction in microtopography from management style -- there are fewer trees blowing down, resulting in fewer tip-up mounds and nurse logs.

Native Uncharacteristic Conditions

Maple monocultures. See Issues and Problems above.

Comments

Modified from Rapid Asessment (RA) Model R6NHHEgl created by Dave Cleland (dcleland@fs.fed.us), Jim Merzenich (jmerzenich@fs.fed.us), and Linda Parker (lparker@fs.fed.us).

Kuchler typed the Wisconsin portion as Northern Hardwoods but the Upper Peninsula portion as Northern Hardwood-Fir. We based this description on the FRCC Northern Hardwood-Fir description document. At the Great Lakes RA workshop, it was agreed to rename as Northern Hardwood-Hemlock Forest (Great Lakes). Suggested reviewers: Eric Epstein (WDNR Natural Heritage Ecologist), Randy Hoffman (WDNR Natural Areas program), Eunice Padley (WDNR Div of Forestry), Mike Kost (Mich NFI), and John Almendinger (MN DNR).

Succession Classes

**Mapping Rules**

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 1 Early Development 1 - All Structures

Indicator Species

Description

Class A contains early-seral stands characterized by aspen and paper birch.

It occurs due to the combination of blowdown followed by fire. Aspen and paper birch start dying off as they are attacked by disease and they cannot reproduce in the shade. Species in Class B are in the understory such as maples (later), white pine/yellow birch (early). Paper birch will last longer than aspen.

A blowdown here simply resets the age, with aspens and birches resprouting. Other species may include red maple, white pine, and black cherry.

*Maximum Tree Size Class*  
Seedling <4.5ft

Class B 4 Early Development 2 - All Structures

Indicator Species

Description

Class B contains regenerating stands dominated by mid-tolerant northern hardwood species. Windthrow of mature stands (without subsequent fire) generally results in this class.

Yellow birch seeds need old nurse logs as they cannot germinate in maple litter. White pine needs mineral soil, so it will not germinate in later stages unless there is a tip-up mounds.

*Maximum Tree Size Class*  
Sapling >4.5ft; <5" DBH

Class C 14 Mid Development 1 - Closed

Indicator Species

Description

Class C contains mid-aged mixed hardwood-conifer stands.

*Maximum Tree Size Class*  
Large 21-33" DBH

Class D 77 Late Development 1 - Closed

Indicator Species

Description

This class represents old late-seral forests and the end point of succession. Sugar maple, hemlock, and yellow birch are co-dominants. A white pine component is common, especially in the supercanopy.

White pines would occur in the later stages only on tip-ups. With blowdowns, the small maples can suffer terminal leader death from freezing since they do not have the canopy to protect them. Maples can grow in the shadows of maples.

*Maximum Tree Size Class*  
Very Large >33" DBH

Class E 4 Mid Development 2 - Closed

Indicator Species

Description

Class E represents transition from fire response, early successional stands.

*Maximum Tree Size Class*  
Medium 9-21"DBH

Model Parameters

Deterministic Transitions

Probabilistic Transitions

References

Bormann, F.H. and Likens, G.E., 1979. Catastrophic disturbance and the steady state in northern hardwood forests. American Scientist. 67: 660-669.

Canham, C.D. and Loucks, O.L., 1984. Catastrophic windthrow in the presettlement forests of Wisconsin. Ecology 65: 803-809.

Cleland, D.T., S.C. Saunders, T.R. Crow, D.I. Dickmann, A.L. Maclean, J.K. Jordan, R.L. Watson, and A.M. Sloan, 2004. Characterizing historical and modern fire regimes in the Lake States: a landscape ecosystem approach. Landscape Ecology 19: 311–325.

Cohen, J.G. 2000. Natural community abstract for mesic northern forest. Natural Features Inventory, Lansing, MI. 8 pp.

Curtis, J.T. 1959. Vegetation of Wisconsin: An Ordination of Plant Communities. University of Wisconsin Press, Madison, WI. 657 pp.

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.

Dunn, Christopher P., Guntenspergen, Glenn R. and Dorney, John R. 1983. Catastrophic wind disturbance in and old-growth hemlock-hardwood forest, Wisconsin. Canadian Journal of Botany. 61:211-217. - 5 -NHFI (December 2004).doc

Fahey, R.T. and Lorimer, C.G., 2013. Restoring a midtolerant pine species as a component of late-successional forests: Results of gap-based planting trials. Forest Ecology and Management, 292, pp.139-149.

Fahey, R.T. and Lorimer, C.G., 2014a. Persistence of pine species in late‐successional forests: evidence from habitat‐related variation in stand age structure. Journal of vegetation science, 25(2), pp.584-600.

Fahey, R.T. and Lorimer, C.G., 2014b. Habitat associations and 150 years of compositional change in white pine-hemlock-hardwood forests based on resurvey of public land survey corners. Journal of the Torrey Botanical Society, 141(4), pp.277-293.

Fahey, R.T., Lorimer, C.G. and Mladenoff, D.J., 2012. Habitat heterogeneity and life-history traits influence presettlement distributions of early-successional tree species in a late-successional, hemlock-hardwood landscape. Landscape ecology, 27(7), pp.999-1013.

Foster, David R. and Boose, Emery R., 1992. Patterns of forest damage resulting from catastrophic wind in central New England, USA. Journal of Ecology. 80: 79-98.

Frelich, L.E. and Lorimer C.G. 1991. Natural disturbance regimes in hemlock hardwood forests of the Upper Great Lakes Region. Ecological Monographs 61(2): 159-162.

Frelich, L.E., R.R. Calcote, M.B. Davis and J. Pastor. 1993. Patch formation and maintenance in an old-growth hemlock-hardwood forest. Ecology 74: 513-527.

Grimm, E.C. 1984. Fire and other factors controlling the Big Woods vegetation of Minnesota in the mid-Nineteenth century. Ecological Monographs 54: 291-311.

Halpin, C.R. and Lorimer, C.G., 2016. Trajectories and resilience of stand structure in response to variable disturbance severities in northern hardwoods. Forest Ecology and Management, 365, pp.69-82.

Hanson, J.J. and Lorimer, C.G., 2007. Forest structure and light regimes following moderate wind storms: Implications for multi‐cohort management. Ecological applications, 17(5), pp.1325-1340.

Maclean, Ann L. and David T. Cleland, 2003. Determining the spatial extent of historical fires with geostatistics in northern Lower Michigan. In: Fire, fuel treatments, and ecological restoration. Conference proceedings; 2002 April 16-18. Omi, Philip N.; Joyce, Linda A., tech. eds. Fort Collins, CO. Proc. RMRS-P-29. Fort Collins, CO: Department of Agriculture, Forest Service, Rocky Mountain Research Station. Pages 289-300.

Muzika, R.M., Guyette, R.P., Stambaugh, M.C. and Marschall, J.M., 2015. Fire, drought, and humans in a heterogeneous Lake Superior landscape. Journal of sustainable forestry, 34(1-2), pp.49-70.

Nichols, G.E. 1935. The hemlock-white pine-northern hardwood region of Eastern North America. Ecology 16: 403-422.

Oliver, C.D. and Larson, B.C., 1996. Forest stand dynamics: updated edition. John Wiley and sons.

Runkle, James Reade, 1982. Patterns of disturbance in some old growth mesic forests of eastern North America. Ecology. 63(5): 1533-1546.

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.

Stearns, F.W. 1949. Ninety years change in a northern hardwood forest in Wisconsin. Ecology 30:350-358.

Tyrell, L.E. and T.R. Crow. 1994. Structural characteristics of old-growth hemlock-hardwood forests in relation to age. Ecology 75: 370-386.

USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2002, December). Fire Effects Information.

Webb, S.L. 1989. Contrasting windstorm consequences in two forests, Itasca State Park, Minnesota. Ecology. 70(4): 1167-1180.

White, P.S. and Pickett, S.T.A., 1985. Natural disturbance and patch dynamics: An introduction. In The Ecology of Natural Disturbance and Patch Dynamics, pp. 3-13. Edited by S.T.A. Pickett and P.S. White. Academic Press: New York, NY.

Whitney, G.G. 1986. Relation of Michigan's presettlement pine forests to substrate and disturbance history. Ecology 67(6): 1548-1559.

Woods, K.D. 2000. Long-term change and spatial pattern in a late-successional hemlock-northern hardwood forest. Journal of Ecology 88: 267-282.

Woods, K.D., 2004. Intermediate disturbance in a late‐successional hemlock‐northern hardwood forest. Journal of Ecology, 92(3), pp.464-476.