13020

Laurentian-Acadian Northern Hardwoods Forest

BpS Model/Description Version: Aug. 2020

**Reviewed by:** William Nichols and Brad Simpkins

Vegetation Type

Forest and Woodland

Map Zones

65, 66

Geographic Range

This system occurs in northern New England and northern New York west across the upper Great Lakes to northern Minnesota and adjacent portions of Canada, occasionally southward (NatureServe 2007). In New England and New York, this system is positioned latitudinally and elevationally between two other matrix forest systems, the Acadian-Appalachian Montane Spruce-Fir Forest and Laurentian-Acadian Pine-Hemlock-Hardwood Forest. In this region, the Laurentian-Acadian Northern Hardwoods Forest occurs in the mountains and high hills between 1,400-2,500 ft. elevation and occasionally down to ~1000ft elevation in cool, mesic settings (Sperduto 2011; Sperduto and Nichols 2011). In map zone (MZ) 66, this type occurs at much lower elevations.

Biophysical Site Description

Northern hardwood forests are only uncommon where clay and sand prevail as parent materials and in other places where soils are specialized. Such places include alluvial soils along streams and rivers, glaciofluvial deposits of sand or gravel terraces, rocky or bedrock-controlled soils, and wet soils in depressions. Soil pH will range from 5.0-5.6 (http://www.maine.gov/dacf/mnap/features/communities/beechbirchmap.htm). Typical sites are buffered from seasonal drought by fine-textured, moisture-retaining soils or dense subsoil layers. Essential nutrients are mineralized from decaying organic matter at twice the rate of that in fire-dependent forest or wet forest communities.

Vegetation Description

This system is a mixture of mesophyllic hardwood species and is typified by *Acer saccharum*, *Fagus grandifolia*, *Betula allegheniensis*, *Acer rubrum*, and *Ulmus americana*. Near the upslope ecotone to the Acadian-Appalachian Montane Spruce-Fir Forest in the northeast, *Picea* *rubens* and *Abies* *balsamea* increase in importance and *Acer* *saccharum* and *Fagus* *grandifolia* drop out; near the downslope ecotone to the Laurentian-Acadian Pine-Hemlock-Hardwood Forest, *Tsuga* *canadensis*, *Quercus* *rubra*, and *Pinus* *strobus* increase in cover and *Acer* *saccharum* and *Betula* *alleghaniensis* decrease in importance (Sperduto 2011; Sperduto and Nichols 2011). *Populus tremuloides*, *Populus grandidentata*, and *Betula papyrifera* are early seral species in this system. *Acer rubrum* and *Abies balsamea* occasional and/or more abundant species found in mid-seral stands, especially on less productive soils. In more enriched soil, white ash (*Fraxinus* *americana*) and basswood (*Tilia* *americana*) may occur. Occasional *Pinus strobus* individuals were present in early and mid-seral stands that were in proximity to seed sources, but their presence in contemporary forests likely indicates 1) a site that would have formerly been occupied more strongly by pine under the natural disturbance regime or 2) a close proximity to the Laurentian-Acadian Pine-Hemlock-Hardwood Forest ecotone. *Tsuga canadensis* was an occasional late-seral species on poorer soils.

Structurally, these uneven-aged forests were characterized by large volumes of coarse, structurally complex woody debris arranged both vertically and horizontally beneath multi-storied canopies of different-aged cohorts, with super canopies 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 USA, and their distribution is confined to glacial landforms underlain by fertile soils (Woods 2000; Whitney 1986). In New Hampshire, fertile and more enriched soils within this system type are restricted to rich and semi-rich forests that comprised a minor component of the system mosaic (Sperduto 2011; Sperduto and Nichols 2011). Composition of the ground flora and understory varies along moisture, nutrient, elevation, and latitude gradients and typically consists of high densities of shade-tolerant tree species and mesophilic herbaceous species. The shrub layer includes *Taxus canadensis*, *Corylus cornuta*, *Viburnum* *lantanoides*, *Acer pensylvanica*,and *Amelanchier* species. In the northeast, common herbs and shrubs include *Clintonia* *borealis*, *Huperzia* *lucidula*, *Dryopteris campyloptera*, *Oxalis montana*, *Oclemena* *acuminata*, *Streptopus* *lanceolatus*, *Coptis* *trifolia*, *Chamaepericlymenum* *canadense*, *Acer spicatum*, *Viburnum lantanoides*, and *Lonicera* *canadensis*. Species that are frequent or in higher abundance in semi-rich pockets include *Sambucus* *racemosa*, *Tiarella* *cordifolia*, *Solidago* *flexicaulis*, and *Polystichum braunii* (Sperduto and Nichols 2011). On more calcarius sites, this Biophysical Setting (BpS) may include blue cohosh, yellow violet, sweet cicely, various ferns, and ginseng.

Crosswalks to New Hampshire’s northern hardwood-conifer forest system(http://www.nhdfl.org/about-forests-and-lands/bureaus/natural-heritage-bureau/photo-index/SystemPhotos/nhwconiferforest.aspx).

BpS Dominant and Indicator Species

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

1In the northeast, occurred near ecotone to the Laurentian-Acadian Pine-Hemlock-Hardwood Forest.

2In the northeast, this shade-intolerant species mostly occurred in successional vegetation or in forest openings.

13In the northeast, mostly restricted to minerotrophic swamps and floodplain forests.

Disturbance Description

In the northeast, hurricanes and other major storms were the primary large-scale disturbance agents. They occurred infrequently and affected most of the trees over large areas. Historically, hurricanes affected forests in southern and central parts of New England more than Laurentian-Acadian Northern Hardwoods Forests to the north. Ice storms caused local to moderate-scale damage; downbursts, nor’easters, and tornadoes caused significant local damage (Sperduto and Kimball 2011; Sperduto and Nichols 2011). Small-scale disturbances were more common. Chronic wind stress was severe at high elevations, causing individual trees to periodically fall. Fungi and insects were also responsible for tree mortality and increased susceptibility to windthrow. Occasional pathogen outbreaks also caused larger-scale impacts.

Fire Regime Description: In these forests, fires of natural origin were only important 1) locally and more frequently on ridges with fire-tolerant species (Sperduto and Kimball 2011) and 2) infrequently on a larger scale following catastrophic wind events or during periods of extreme drought (this matrix forest was characterized by late-successional, fire-sensitive tree species). Other than on ridges, this fire resistance is due to high rates of organic matter decomposition and low rates of fuel accumulation, closed and multi-storied 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). 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. Also see the seminal work of White and Seymour (2002).

Insects and disease are present but in a very minor way, most likely affecting individual trees versus at a stand level. Insect outbreaks could occur on a broad scale but typically did not result in large-scale mortality or successional changes. As an example, root and stem rot cause individual tree mortality primarily in late development. These types of disturbances would likely contribute to higher fuel loads and structural complexity of stands.

Additional disturbance notes from 2017 BpS review (Greg Nowacki, William Patterson):

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 300-390yrs -- 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, which 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 modeled trajectories.

New research on the pine component: Regarding 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, b).

Swaty updated the model as best as possible based on Nowacki’s notes and other citations. It is unclear exactly how to set wind/weather/stress and fire parameters based on these notes, personal communications, and citations as they typically apply across the entire BpS (not by succession class) and/or, as in the case with Halpin and Lorimer (2016), the states do not line up with the succession classes in this BpS.

These disturbances are often coupled. For example, fire is rare (~1000yr return interval) as an isolated event, but every hurricane, wind storm, ice storm, or insect/disease outbreak increases fuel loads and the likelihood of fire. All it takes is *drought* -- not considered here. Droughts like that of 1947 occur multiple times per century. If you get drought coinciding with increased fuel loads due to other disturbances, all it takes is the “right” weather -- then you get a fire.

Future work should include:

* A more in-depth incorporation of the work of Fahey, Halpin, and Lorimer;
* More detailed incorporation of hurricanes into the model. Currently lumped in to wind/ weather/stress. Suggest adding separate “Other1” with hurricane probabilities for specific areas.

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

In the northeast, this was a large matrix forest system.

Adjacency or Identification Concerns

In the northeast, adjacent to Acadian-Appalachian Montane Spruce-Fir Forest at higher elevation/latitude and Laurentian-Acadian Pine-Hemlock-Hardwood Forest at lower elevation/latitude.

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 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. Exotics and invasives such as earthworms, garlic mustard, European buckthorn, and honey suckle occur occasionally, particularly in the southern part of the region (MZ65).

Issues or Problems

There are floristic differences in this type from south to north. However, the disturbance regimes are similar enough across MZs that they are grouped together here. Smaller patch fires occur occasionally on ridgetops (50yr return?) and may have encroached downslope in dry years; it is difficult to extrapolate this small patch regime to the broader fire regime across this entire forest type. Historic and current fire suppression makes it difficult to determine the natural patch size of these fires.

Several species are threatened currently including beech (Beech bark disease), hemlock (hemlock wooly adelgid), and sugar maple (Asian longhorn beetle). All of this is facilitated or mitigated to a greater or lesser extent by changing climate.

Native Uncharacteristic Conditions

The prevalence of red maple in stands may reflect past forest management (red maple more likely to regenerate in some harvested stands on some sites). Some silvicultural systems can significantly alter the structure and composition of hardwood stands (e.g., clearcut, overstory removal).

Comments

In some areas, beech bark disease has altered the composition and structure of northern hardwood stands, reducing the abundance of beech in the overstory.

In addition to beech bark disease, emerald ash borer and hemlock wooly adelgid are important exotic pests that can have profound impacts.

Scientists predict climate-pest interactions that may be more widespread than climate-caused migration of northern hardwood species.

Fragmentation is a bigger problem in MZ65 than MZ66 but is present in both. This increases edge and has other impacts.

Also see:

* Charlie Cogbill reference on pre-settlement surveys of these map zones.
* Bill Leak research note NE-336.

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 4 Early Development 1 - All Structures

Indicator Species

Description

Class A contains early-seral stands characterized by aspen and paper birch 0-39yrs of age. It occurs due to the combination of blowdown followed by fire; 40% of blowdown areas burn and revert to this class.

Early successional tree species in the northeast include: white pine (*Pinus* *strobus*), balsam fir (*Abies* *balsamea*), black cherry (*Prunus* *serotina*), pin cherry (*Prunus* *pensylvanica*), gray birch (*Betula* *populifolia*), heart-leaved paper birch (*Betula* *cordifolia*), and big-toothed aspen (*Populus* *grandidentata*).

Fire can produce a flush of hemlocks if there is a seed source nearby.

*Maximum Tree Size Class*  
Pole 5-9" DBH

Class B 5 Early Development 2 - All Structures

Indicator Species

Description

Specific composition depends on site and soils. Black birch can be dense in larger openings in parts of MZ65, rare in MZ 66.

Red oak, hemlock, and white ash are all occasional in northern hardwoods in classes B thru E but are site-dependent.

*Maximum Tree Size Class*  
Pole 5-9" DBH

Class C 18 Mid Development 1 - Closed

Upper Layer Lifeform: Tree

Upper Layer Canopy Cover: 81 - 100%

Upper Layer Canopy Height: Tree 10.1m - Tree 25m

Indicator Species

Description

Class C contains mid-aged stands dominated by sugar maple, beech, and yellow birch.

Red oak, hemlock, and white ash are all occasional in northern hardwoods in classes B thru E but are site-dependent.

Maximum height can exceed 25m but will not reach 50m.

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

Class D 66 Late Development 1 - Closed

Indicator Species

Description

Class D represents old late-seral forests and the end point of succession. These stands are >150yrs old. Sugar maple, with beech, yellow birch, white ash, and hemlock occasional. Hemlock can be dominant in the riparian areas (that are not mapped as another type). Red oak can be occasional on southern exposure and ridgetops.

Red oak, hemlock, and white ash are all occasional in northern hardwoods in classes B thru E but are site-dependent.

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

Class E 7 Mid Development 2 - Closed

Indicator Species

Description

Class E represents transition from fire response, early successional stands (aspen-birch) to mid-successional northern hardwood stands.

Red oak, hemlock, and white ash are all occasional in northern hardwoods in classes B thru E but are site-dependent.

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

Model Parameters

Deterministic Transitions

Probabilistic Transitions

References

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

Braun, E.L. 1950. Deciduous Forests of Eastern North America. Blackburn Press. 596 pp.

Canham, C.D. and O.L. Loucks. 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.

Cleland, D.T., S.C. Saunders, K.M. 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. North Central Research Station of the USDA Forest Service.

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

Dunn, Christopher P., Glenn R. Guntenspergen and John R. Dorney. 1983. Catastrophic wind disturbance in an old-growth hemlock-hardwood forest, Wisconsin. Canadian bJournal of Botany 61: 211-217.

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 Emery R. Boose. 1992. Patterns of forest damage resulting from

catastrophic wind in central New England, USA. Journal of Ecology 80: 79-98.

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

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.

http://www.maine.gov/dacf/mnap/features/communities/beechbirchmap.htm).

Lorimer, C.G. and Frelich, L.E., 1994. Natural disturbance regimes in old-growth northern hardwoods: implications for restoration efforts. Journal of Forestry, 92(1), pp.33-38.

Maclean, A.L. and D.T. Cleland. 2003. Determining the spatial extent of historical fires with geostatistics in northern Lower Michigan. In: Omi, P.N. and L.A. Joyce, tech. eds. Fire, fuel treatments, and ecological restoration conference proceedings, April 16-18 2002. Fort Collins, CO. Proc. RMRS-P-29. Fort Collins, CO. USDA Forest Service, Rocky Mountain Research Station. 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.

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

NatureServe. 2007. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Arlington, VA. Data current as of 10 February 2007.

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

Sperduto, D. D. 2011. Natural Community Systems of New Hampshire, 2nd

ed. New Hampshire Natural Heritage Bureau, Concord, NH.

Sperduto, D. D. and B. Kimball. 2011. The Nature of New Hampshire: Natural Communities of the Granite State. University Press of New England, Durham, NH.

Sperduto, D. D. and W. F. Nichols. 2011. Natural Communities of New Hampshire,

2nd ed. New Hampshire Natural Heritage Bureau, Concord, NH.

Stearns, F.W. 1949. Ninety years of 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.

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

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

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.

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

Seymour, R.S. and White, A.S., 2002. Natural disturbance regimes in northeastern North America—evaluating silvicultural systems using natural scales and frequencies. Forest Ecology and Management, 155(1), pp.357-367.