

13700

Appalachian (Hemlock-)Northern Hardwood Forest

BpS Model/Description Version: Aug. 2020

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Vegetation Type

Forest and Woodland

Map Zones

60, 63, 64, 65, 66

Geographic Range

Generally, ranges from Pennsylvania west to Lake Erie and south to northern Georgia, eastern Kentucky, southeastern Ohio, western North Carolina, northwestern South Carolina, eastern Tennessee, southwestern West Virginia, western Virginia, the Appalachian Mountains, and the Cumberland Plateau. May also be on the upper Piedmont.

Canada hemlock (*Tsuga canadensis*) extends from Maine and Nova Scotia south to northern Alabama and Georgia. Includes physiographic provinces 212b, 212c, 212d, 212e, 212f, 212g, 221a, 221b, 221d (may also include others).

Biophysical Site Description

This mixed forest occurs predominantly on mesic sites over a broad range of topographic conditions with elevations generally ranging from 1,000-3,000ft. Sites remain moist in all but the most severe drought conditions. The Biophysical Setting (BpS) shifts from occupying a broad elevation range in the northern extent of the map zone (MZ) (Pennsylvania) to a narrower range (higher elevation) in the southern extent of the MZ (West Virginia).

In the northern portion of its range, it occurs primarily at higher elevations and on slope positions that favor cool, moist conditions. Soils are usually acidic and can contain a variety of parent material and drainage conditions.

At lower elevations and in the southern portion of its range, it occurs more frequently in sheltered coves and valleys. Sites are acid, generally on moist but moderately well-drained to well-drained loamy or silty soils, either colluvial or alluvial. Soils are often rocky and usually deep (>40in), even if only in pockets between boulders. In riparian areas, it is usually along high gradient (1-2%) streams. Also found on lower slopes with west and south aspect, lower to mid slope on east and north aspects, and in narrow cliff bound valleys; it may occur to the base of cliffs on all slopes.

Vegetation Description

In the northern part of the range, dominant overstory species include eastern hemlock (*Tsuga canadensis*), American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), and yellow

birch (*Betula allegheniensis*). While this community as a whole occurs across a wide range of topographic conditions, the species mix can vary considerably. Hemlock will dominate the overstory on cool/moist sites at higher elevations and in shaded coves, valley bottoms, and riparian areas. Moist bottomlands and footslopes may also contain a larger component of yellow birch, white ash (*Fraxinus americana*), and sycamore (*Platanus occidentalis*) (Whitney 1990). Locally, on slopes, sugar maple becomes more abundant, resulting in a beech-hemlock-sugar maple complex (Braun 2001). Other common associates include red maple (*Acer rubrum*), black cherry (*Prunus serotina*), black birch (*Betula nigra*), basswood (*Tilia americana*), and cucumber magnolia (*Magnolia acuminata*). The understory and mid-story are usually well developed and include hobblebush (*Viburnum alnifolium*), mapleleaf viburnum (*Viburnum acerifolium*), witch hazel (*Hamamelis virginiana*), serviceberry (*Amelanchier alnifolia*), pin cherry (*Prunus pensylvanica*), large-leaved holly (*Ilex monticola*), and alternative-leaved dogwood (*Cornus alternifolia*). Common herbaceous species include wild lily of the valley (*Maianthemum canadense*), sensitive fern (*Onoclea sensibilis*), shining clubmoss (*Lycopodium lucidulum*), *Dryopteris spinulosa* (*Dryopteris spinulosa*), mountain woodsorrel (*Oxalis montana*), and partridgeberry (*Mitchella repens*) (Lutz 1930; Braun 2001).

In the southern part of the range, dominant vegetation is generally in two to three layers. The canopy in well-developed late seral conditions is composed of eastern hemlock (*Tsuga canadensis*) (most common) and/or white pine (*Pinus strobus*) mixed with various hardwoods, including tulip poplar (*Liriodendron tulipifera*), American beech (*Fagus grandifolia*), black and white oaks (*Quercus velutina*, *Q. alba*), black birch (*Betula lenta*), and bigleaf and umbrella magnolias (*Magnolia macrophylla*, *M. tripetala*). In the southern Appalachians, Fraser magnolia (*M. fraseri*) and silverbell (*Halesia carolina*) may also be found. There may be gaps with a younger cohort of the same set of species. A dense, low- to high-shrub layer of great laurel (*Rhododendron maxima*) and sometimes mountain laurel (*Kalmia latifolia*) is often present. Yellowroot (*Xanthorhiza simplissima*) may occur immediately adjacent to streams in sandy/silty alluvial deposits in gaps. Few if any herbs are found, and bryophyte and hepatophyte cover is generally restricted to downed wood, tree/shrub boles, and rocks/boulders.

BpS Dominant and Indicator Species

Symbol	Scientific Name	Common Name
FAGR	<i>Fagus grandifolia</i>	American beech
TSCA	<i>Tsuga canadensis</i>	Eastern hemlock
ACSA3	<i>Acer saccharum</i>	Sugar maple
BEAL2	<i>Betula alleghaniensis</i>	Yellow birch
TIAM	<i>Tilia americana</i>	American basswood
LITU	<i>Liriodendron tulipifera</i>	Tuliptree
PIST	<i>Pinus strobus</i>	Eastern white pine
QUVE	<i>Quercus velutina</i>	Black oak

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

Disturbance Description

Non-Fire Disturbance: This system is dominated by long-lived, mesic species that form multilayered, uneven-aged forests over time. Canopy dynamics are dominated by single and multiple disturbances, encouraging gap phase regeneration (Abrams and Orwig 1996). Larger disturbances include windthrow, insect attack, and ice storms. Although stand-replacing wind

events are rare, small to medium blowdown events are more common and occur at greater frequency on the plateau and exposed side slopes (Ruffner and Abrams 2003). Localized insect and disease outbreaks can create small to medium canopy gaps.

Running the VDDT model resulted in 0.9% disturbance (fire and/or wind, weather, stress) annually, consistent with disturbance rates documented by Runkle (1981, 1985) and others. Wind, weather, stress alone resulted in 0.7% disturbance annually.

Fire Regime Description: Historically, this system was probably only subject to occasional fires. Fires that did occur may have been catastrophic and may have led to even-aged stands of pine and hemlock (NatureServe 2007).

Due to the predominance of cool, moist site conditions, surface and replacement fires are extremely rare, occurring at 700-1,000yr intervals. Most protected sites are essentially fire-free. The principal cause of fuel formation leading to fire in northern hardwood ecosystems is broad-scale, storm-driven windthrow of catastrophic proportions (Hough 1963, Runkle 1982).

Fire Frequency

Severity	Avg FI	Percent of All Fires	Min FI	Max FI
Replacement	1005	53		
Moderate (Mixed)	1118	47		
Low (Surface)				
All Fires	529	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

NatureServe (2007) notes that this BpS is a matrix in the northern portion of its range to large patch on the southern end of its range in Virginia and West Virginia, and some examples may be as large as 1,000ac but smaller in the southern part of the range.

Both small- and large-scale disturbances characterize the natural disturbance regime of this region, with wind, insects/diseases, and ice storms as primary disturbance agents. These forests are characterized by small-scale disturbance, with a high degree of vertical structure and fine-grained patch size (Spies 2004). This disturbance regime strongly favors tolerant species but allows opportunists to persist in low densities (Runkle 1982). On high plateaus and exposed slopes, small-scale wind disturbances are a common agent driving gap dynamics (Ruffner and Abrams 2003). However, medium-scale intensity disturbances also characterize the region (Runkle 1982; Ruffner, unpublished). A significant glazing or ice storm event can be expected every 50yrs or so (Hough, 1963). Depending on the severity of ice loading, damage may range from minimal to severe crown damage.

Gap sizes range from 28 square meters to 2,000 square meters, with a mean of 200 square meters. Canopy turnover rates of 0.5-2% per year with a return interval of 50-200yrs characterize old-growth beech and hemlock stands (Runkle 1981, 1985). Repeat disturbances affecting the same location may be common. More recent estimates of the return interval based on actual tree ring analysis suggest that 10-20% of the canopy may be disturbed every decade depending on the topographic position of the stand (Ruffner, unpublished).

Along streams in the southern part of the range, stands range from 2-3ac to >200ac in some areas, much smaller than typical stand sizes in the northern tier.

Adjacency or Identification Concerns

Using the International Ecological Classification Standard, this system corresponds to the Appalachian (Hemlock)-Northern Hardwood Forest (CES202.593) (NatureServe 2007).

However, the concept of this system was revised in April 2007 to remove areas south and west of Virginia and West Virginia from its range. The Region 8 National Forests and other Federal lands, as well as ecoregions and MZs related to this area, were also removed (NatureServe 2007).

Northward this system is replaced by Laurentian-Acadian Pine-Hemlock-Hardwood Forest (CES201.563 -- BpS 1366) and Laurentian-Acadian Northern Hardwoods Forest (CES201.564 -- BpS 1302), but the limits of both are not yet clear in western New York (Allegheny Plateau) and central New England. USFS ecological province lines provide an apparently appropriate delimiter, with areas in Provinces 212 and M212 (as well as the Great Lakes part of 221 in New York and Ohio) falling into the Laurentian-Acadian systems and areas in Provinces 221 and M221 falling into this Appalachian system (NatureServe 2007).

As written, this model includes the moist, acid, lower-elevation landscape position variant of NatureServe's 202.373 (Southern and Central Appalachian Cove Forest). R8HEWP -- Hemlock -- White Pine -- Hardwood differs from R7NHHE -- Northern Hardwood Hemlock in fire and disturbance regimes and in structure but shares key composition elements and successional pathways.

The four "Northern Hardwood" models in the Rapid Assessment (RA) (R6NHMB, R7NHHE, R7NHNE, and R7NHSP) occur across both the Northeast and Great Lakes model zones and have several similarities, including: high moisture/nutrient gradients; historical inclusion of more conifer; frequent dominance by sugar maple; and windthrow as the main disturbance agent with fires occurring every ~1,000-2,000yrs. There are also several differences, including: the limited extent of beech west of eastern Wisconsin and the central Upper Peninsula of Michigan; and the variation in the amount of hemlock.

Non-Fire Disturbances

Wind/Weather/Stress

Adjacency or Identification Concerns

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delimiter, with areas in Provinces 212 and M212 (as well as the Great Lakes part of 221 in New York and Ohio) falling into the Laurentian-Acadian systems and areas in Provinces 221 and M221 falling into this Appalachian system (NatureServe 2007).

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Issues or Problems

This community has been significantly altered through exotic insect and diseases, including the beech scale disease complex, which has been causing widespread mortality of American beech for the last 20yrs, and more recently the hemlock woolly adelgid, which kills hemlock in all age and size classes. It is also threatened by global warming, as hemlock is typically found in cooler microclimates. These factors will reduce the range and extent of the vegetation type.

This system is currently being devastated in large parts of its range by the hemlock woolly adelgid (*Adelges tsugae*). This sucking insect is continuing to cause close to 100% mortality as it spreads from the north into the southern United States. The insect will most likely cause canopy hemlocks to be replaced by other canopy trees (NatureServe 2007).

Native Uncharacteristic Conditions

Past logging in many areas has altered this system by creating a predominantly even-aged structure, which contains a much higher proportion of shade-intolerant species. In many areas, this change in species composition is further aggravated by decades of overbrowsing by deer (Runkle 1982; Abrams and Orwig 1996), which has significantly reduced the hemlock component and reduced species and structural diversity in many areas.

Sugar maple decline is another current forest health concern that is attributed to a combination of factors including insect defoliations, drought, and site factors related to soil nutrient status (impacted by acid deposition) (Horsley et al., 2002). Second-growth stands are characterized by an underrepresentation of significant habitat elements such as large diameter trees, canopy gaps, gap saplings, "tip-up" mounds, coarse woody debris, and a limited range of seral stages (Litvaitis, 2003; Lorimer and Frelich 1994).

Other forest health concerns in the region include changing soil nutrient status due to acid deposition and concerns about potential increases in ozone from industrial byproducts.

Comments

Succession Classes	
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Mapping Rules

[illegible]

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	9	Early Development 1 - All Structures
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Indicator Species

Symbol	Scientific Name	Common Name	Canopy Position
ACRU	<i>Acer rubrum</i>	Red maple	Mid-Upper
LITU	<i>Liriodendron tulipifera</i>	Tuliptree	Upper
FAGR	<i>Fagus grandifolia</i>	American beech	Mid-Upper
TSCA	<i>Tsuga canadensis</i>	Eastern hemlock	Low-Mid

Description

Early age classes include forests <50yrs of age. Initially young stands have an even-aged structure and may include birches, tulip poplar, beech, basswood, white ash, hemlock, red maple, and black cherry. In the southern parts of the range, white pine, magnolia, and a few oaks may also be present. As the stand matures, intermediate and intolerant species move into the canopy with beech and hemlock existing in the understory and midstory. Tree size ranges from seedling through poles. Closed canopy conditions exist throughout most of this class, and with the exception of the early stand initiation phase, there is little development of herbaceous or shrubby vegetation.

Maximum Tree Size Class

Pole 5-9" DBH

Class B	14	Mid Development 1 - Closed
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Indicator Species

Symbol	Scientific Name	Common Name	Canopy Position
TSCA	Tsuga canadensis	Eastern hemlock	All
FAGR	Fagus grandifolia	American beech	All
ACSA3	Acer saccharum	Sugar maple	All
ACRU	Acer rubrum	Red maple	Lower

Description

Closed canopy conditions exist throughout the life of this class. Beech and hemlock move into the middle to upper portions of the canopy, with white pine in the southern reaches, and the overstory will include a mixture of intermediate and intolerant species such as yellow birch, tulip poplar, red and sugar maple, basswood, ash, magnolias, black cherry, and a few oaks (black, white). Both even- and uneven-aged stand structure conditions may exist, and forests in this class will start to develop a well-established shrub and herbaceous layer; mountain and/or great laurel can be present in dense patches.

Maximum Tree Size Class

Large 21-33" DBH

Class C	9	Mid Development 1 - Open
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Indicator Species

Symbol	Scientific Name	Common Name	Canopy Position
LITU	Liriodendron tulipifera	Tuliptree	All
BEAL2	Betula alleghaniensis	Yellow birch	All
FAGR	Fagus grandifolia	American beech	All
TSCA	Tsuga canadensis	Eastern hemlock	Upper

Description

This class is characterized by more open canopy conditions resulting from partial blowdown, ice glaze events, localized insect and disease outbreaks, or mixed-severity fire. Greater than 20% overstory mortality occurs during these events, which creates open canopy conditions and stimulates development of the understory and midstory. Associate intermediate and intolerant species such as red maple, black birch, ash, red and/or sugar maple, black cherry, basswood, and magnolias will become established in greater abundance. Great and/or mountain laurel may be present in dense patches. Canopy gaps close laterally, and this class succeeds to D within 2-3 decades. Fuel model 10 may occur where windthrow has created large quantities of slash.

Maximum Tree Size Class

Large 21-33" DBH

Class D**68****Late Development 1 - Closed**Indicator Species

Symbol	Scientific Name	Common Name	Canopy Position
TSCA	Tsuga canadensis	Eastern hemlock	All
FAGR	Fagus grandifolia	American beech	All
ACSA3	Acer saccharum	Sugar maple	All
LITU	Liriodendron tulipifera	Tuliptree	Upper

Description

Class D is characterized by an uneven-aged, closed-canopy structure with beech, hemlock, and sugar maple occurring in all size classes. The overstory is characterized by large-diameter beech, hemlock, sugar maple, and tulip poplar, with white pine in the southern parts. In hemlock-dominated stands, the shrub layer consists almost exclusively of shade-tolerant shrub species, with a less well-developed herbaceous layer; in hardwood-hemlock mixes, a well-developed shrub and rich herbaceous layer is often present. Great and/or mountain laurel may still be present in mixed stands. Oldest trees are 200-350yrs old and sometimes >400yrs old.

Maximum Tree Size Class

Very Large >33" DBH

Model Parameters**Deterministic Transitions**

From Class	Begins at (yr)	Succeeds to	After (years)
Early1:ALL	0	Mid1:CLS	49
Mid1:OPN	50	Mid1:OPN	199
Mid1:CLS	50	Late1:CLS	199
Late1:CLS	200	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
Wind or Weather or Stress	Early1:ALL	Early1:ALL	0.001	1000	No	0
Replacement Fire	Early1:ALL	Early1:ALL	0.001	1000	Yes	0
Alternative Succession	Mid1:OPN	Late1:CLS	1	1	Yes	100
Mixed Fire	Mid1:OPN	Mid1:OPN	0.001	1000	No	0

Wind or Weather or Stress	Mid1:OPN	Early1:ALL	0.001	1000	Yes	0
Replacement Fire	Mid1:OPN	Early1:ALL	0.001	1000	Yes	0
Wind or Weather or Stress	Mid1:OPN	Mid1:OPN	0.0071	141	No	0
Mixed Fire	Mid1:CLS	Mid1:OPN	0.001	1000	Yes	0
Wind or Weather or Stress	Mid1:CLS	Early1:ALL	0.001	1000	Yes	0
Replacement Fire	Mid1:CLS	Early1:ALL	0.001	1000	Yes	0
Wind or Weather or Stress	Mid1:CLS	Mid1:OPN	0.0071	141	Yes	0
Mixed Fire	Late1:CLS	Mid1:OPN	0.001	1000	Yes	0
Wind or Weather or Stress	Late1:CLS	Early1:ALL	0.001	1000	Yes	0
Replacement Fire	Late1:CLS	Early1:ALL	0.001	1000	Yes	0
Wind or Weather or Stress	Late1:CLS	Mid1:OPN	0.0071	141	Yes	0

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