15260

Laurentian-Acadian Swamp Systems

BpS Model/Description Version: Aug. 2020

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| --- | --- | --- | --- |
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Vegetation Type

Woody Wetland

Map Zones

64, 65, 66

Model Splits or Lumps

This biophysical setting (BpS) is split into multiple models. The most acidic systems have been split out of this model and lumped into the model for BpS 1477.

Geographic Range

This group of systems occurs throughout the upper Midwest and northeastern United States, and adjacent Canadian provinces, including Michigan, Minnesota, Wisconsin, Ontario, Manitoba, Quebec, New York, New Hampshire, Vermont, Maine, Connecticut, northern Illinois, Indiana, Ohio, small patches in Massachusetts, New Brunswick, and Nova Scotia (Faber-Langendoen 2001; Lundgren 2000; NatureServe 2007). These systems do not occur in Pennsylvania, New Jersey, or Rhode Island.

Biophysical Site Description

These systems include coniferous to mixed swamps and seepage slope forests in the temperate-boreal transition zone of the eastern half of the United States and adjacent Canada, mostly at elevations <2,000ft. These communities occupy shallow basins and adjacent wet slopes, as well as slopes alongside but above stream channels. The latter expression -- the seepage slope forest --often occurs as a series of discontinuous patches within the upland forest matrix. Across New England, these systems occur in small to large patches, from several acres to hundreds of acres, and up to 1,000ac in Maine and Canada. Among the larger examples are the cedar swamps in the Lake Champlain basin (Map Zone 65), with single occurrences of >1,000ac, similar in scale to the counterparts of this system group in the Great Lakes region.

Soils are saturated for all or most of the growing season and, in some cases, are irregularly flooded for short durations. Prolonged flooding causes a shift to other systems because the tree species of these swamps are not tolerant of high water levels. The substrate is typically mineral soil with an organic fraction or shallow, well-decomposed peat (muck) over mineral soils. Deeper peat may occur in some circumneutral basins (i.e., some white-cedar swamps). Hummocks and water-filled hollows characterize the basin and floodplain swamps, whereas the hillside seepage swamps typically include mossy openings, springs, and rivulets. The majority of swamps in this system group are circumneutral to alkaline, with pH ranging from 5.5-7.6. These systems include some acidic swamps (pH, 4-5), but do not include forested bogs of Acidic Peatland Systems (e.g., black spruce peat swamps). Enrichment can be derived from direct contact with calcareous bedrock or from nutrient-rich groundwater inflow. Analysis of the distribution of basin wetlands in the northern Appalachians ecoregion (including much of MZs 64 and 66) showed that these systems occur on a range of geologic formations -- from calcareous bedrock, coarse or fine sediments or marl, to granitic bedrock (Anderson et al. 2005).

Vegetation Description

These systems cover the range from conifer-dominated swamps, dominated by northern white-cedar (*Thuja occidentalis*) or a mix of conifer, to mixed conifer-hardwood swamps lacking *Thuja* altogether, but do not include forested bogs of Acidic Peatland Systems. Some examples are dominated by hardwoods such as red maple (*Acer rubrum*) and black ash (*Fraxinus nigra*). American larch (*Larix laricina*) may dominate some swamps within this systems group.

Two primary expressions are characteristic, based on substrate pH, hydrology, and minerotrophy. In circumneutral to alkaline settings or where seepage waters provide a greater supply of nutrients, *Thuja occidentalis* is characteristic and often dominant. It may be mixed with balsam fir (*Abies balsamea*), spruce (*Picea rubens*, *P. mariana*, *P. glauca*), red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), tamarack/larch (*Larix laricina*), and black ash (*Fraxinus nigra*). Characteristic tall shrubs are wild raisin (*Viburnum cassinoides*), redosier dogwood (*Cornus sericea*), Canadian honeysuckle (*Lonicera canadensis*), mountain maple (*Acer spicatum*), mountain holly (*Nemopanthus mucronatus*), and speckled alder (*Alnus* *incana* ssp. *rugosa*). Other shrubs and herb-like dwarfed creeping shrubs are often present and include creeping spicy-wintergreen (*Gaultheria hispidula*), American twinflower (*Linnaea borealis* ssp. *americana*), bristly swamp currant (*Ribes lacustre*), and American yew (*Taxus canadensis*). Alderleaf buckthorn (*Rhamnus alnifolia*) and velvetleaf blueberry (*Vaccinium myrtilloides*) are occasional. Herbaceous flora are often extensive, and small, open fenny areas may occur within the wetland. Herbs include species such as cinnamon fern (*Osmunda cinnamomea*), miterwort (*Mitella diphylla*), bunchberry (*Chamaepericlymenum canadense*), dwarf raspberry (*Rubus pubescens*), threeleaf goldthread (*Coptis trifolia*), foamflower (*Tiarella cordifolia*), tussock sedge (*Carex stricta*), and three-seeded sedge (*C. trisperma*). Circumneutral to alkaline sites are characterized by local to regional rarities such as ram’s head lady’s slipper (*Cypripedium arietinum*), yellow lady’s slipper (*C. calceolus* var. *parviflorum*), showy lady’s slipper (*C. reginae*), Loesel’s wide-lipped orchid (*Liparis* *loeselii*), northern sweet coltsfoot (*Petasites* *frigidus* var. *palmatus*), and spreading globeflower (*Trollius laxus*). Bryophytes carpet the ground and may include *Hylocomium splendens* (moss), *Amblystegium riparium* (moss), *Rhytidiadelphus triquetrus* (moss), *Rhytidiadelphus subpinnatus* (moss), *Thuidium delicatulum* (moss), *Bazzania trilobata* (liverwort), *Rhizomnium punctatum* (moss), *R. appalachianum* (moss), *Sphagnum girgensohnii* (peat moss), *Sphagnum subtile* (peat moss), and *Sphagnum russowii* (peat moss).

In acidic and more nutrient-poor settings, the canopy may be characterized by red spruce (*Picea rubens*), with lesser amounts of balsam fir (*Abies* *balsamea*) and occasionally some black spruce (*Picea* *mariana*), red maple (*Acer* *rubrum*), and birch (*Betula* spp.). Shrubs include mountain holly (*Ilex* *mucronata*), common winterberry (*Ilex* *verticillata*), withe-rod (*Viburnum* *nudum* var. *cassinoides*), speckled alder (*Alnus* *incana* ssp. *rugosa*), sheep laurel (*Kalmia* *angustifolia*), and creeping spicy wintergreen (*Gaultheria* *hispidula*). Herbaceous species include three-seeded sedge (*Carex trisperma*), cinnamon fern (*Osmunda cinnamomea*), threeleaf goldthread (*Coptis* *trifolia*), yellow bluebead-lily (*Clintonia* *borealis*), bunchberry (*Chamaepericlymenum* *canadense*), dewdrop (*Rubus* *dalibarda*), and northern wood sorrel (*Oxalis* *montana*). *Sphagnum* moss forms a carpet in hollows and on the sides of hummocks. Species commonly encountered include *Sphagnum papillosum*, *S. magellanicum*, and *S. fallax*. Other mosses are occasional, particularly on hummocks and tree bases.

In both expressions, red maple (*Acer* *rubrum*), black gum (*Nyssa* *sylvatica*), and hemlock (*Tsuga* *canadensis*) become more important canopy species, moving from the temperate-boreal transition zone to more temperate areas.

BpS Dominant and Indicator Species

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** |
| THOC2 | *Thuja occidentalis* | Northern white-cedar |
| ABBA | *Abies balsamea* | Balsam fir |
| PIMA | *Picea mariana* | Black spruce |
| BEAL2 | *Betula alleghaniensis* | Yellow birch |
| PIST | *Pinus strobus* | Eastern white pine |
| FRNI | *Fraxinus nigra* | Black ash |
| ACRU | *Acer rubrum* | Red maple |
| TSCA | *Tsuga canadensis* | Eastern hemlock |

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

Disturbance Description

Fire regime group V characterizes this group of systems. Conifer- and hardwood-conifer-dominated lowland forests occur as isolated to extensive patches in landscapes dominated by both fire-prone and fire-resistant upland matrix systems (such as northern hardwoods or mixed conifer-northern hardwood forest), and the fire regime is generally driven by the return interval of these upland vegetation types. Fire may occur after drought cycles and may be severe, but sites are typically very wet and fire is infrequent. As summarized by Carey (1993), northern white-cedar is usually killed by surface fire. It is highly susceptible to fire because of its thin bark, shallow roots, and high oil content. In the understory of a pine, aspen, or birch forest, northern white-cedar acts as a fuel ladder, carrying fire into the overstory. Vogl (1977) (referring to upland and wetland *Thuja* forests) classifies northern white-cedar as a fire-initiated species in which fire simultaneously terminates and initiates a long-lived species.

Fire frequency of these systems depends largely on the upland forest matrix. Within the northern hardwood matrix that dominates MZs 63-65, fire is not a major ecological driver. The fire plan for Lake Umbagog National Wildlife Refuge (US FWS) is a good example of a model for the Laurentian-Acadian Conifer-Hardwood Swamp System. From Vollick and Drew (2006): Bonnicksen (2000) estimated that light surface fires crept through the forest about once in 600yrs, and severe fire burned it once in 3,000yrs. However, these authors suggest that “even light surface fires can kill beech and maple trees.” (Fires that killed >25% of the canopy trees would not be considered surface fires by LANDFIRE.) Cogbill (2001) estimated that the pre-settlement mean fire return intervals (MFRIs) for forests in this region were on the order of “several millennia,” based on witness tree reports from colonial land surveys. In contrast, the spruce-fir forests in northern New England burned on a slightly more frequent 200- to 400-yr cycle, and some areas escaped a major fire for as long as 800yrs (Bonnicksen 2000). In MZs 63-65, these systems occur mostly within a matrix of northern hardwood forest, although in some areas they may adjoin more fire-prone systems. An MFRI of 1,700yrs for replacement fire was used in this model for MZs 63-65.

The Great Lakes versions of this model stated that “non-replacement mixed-severity fires can occur randomly in any class and are associated with lightning strikes or small fires in the surrounding vegetation. Frequency will be about twice that of replacement-stand fires, which were estimated to occur in Minnesota on a 920-yr interval (MN DNR 2003).” These fires were not modeled for the Great Lakes. Similar fires likely occurred in these systems in the Northeast, but their impact on the successional dynamics of this type would have been very minor. As a result, they were not included in this Northeast model either.

Windthrow disturbances occur as a result of shallow rooting, affecting single trees and small to large patches of trees. Insect and disease outbreaks primarily affect mature or over-mature dominant trees in both closed and open canopies, impacting black spruce, red spruce, tamarack, and balsam fir in particular. Also, changes in hydrology, such as flooding or draining due to the construction or abandonment of beaver dams, are another important natural disturbance in these systems and typically change the entire unit into a wetland with an open succession pathway. Catastrophic windthrow may have occurred on a 400- to >1,000-yr rotation, with a median of 700yrs. Light windthrow (small patches) occurred on a rotation of 40-380yrs, with a median of 85yrs. Boose et al. (2001) calculated a mean return interval of >380yrs for large-scale storms (high wind events) across northern New England that would cause blowdowns of large forest patches. Thus, chances of a given site being affected are infrequent, and disturbance intervals estimated for Minnesota may be appropriate for systems in New England and proximity. Catastrophic windthrow was included in the model at a 700-yr return interval for age classes with pole-size or larger trees. Light windthrow was not included in this model because it is expected to create only small patch openings that would not impact the successional dynamics of these systems as a whole.

NOTE from 2017 BPS review: In the current model, all fires are “replacement” and this is questionable. During the review, Randy Swaty did a brief (not comprehensive) literature review and, although there are numerous papers citing overall FRIs in the Northeast, even some with ecosystem-specific numbers, Swaty did not find BpS, fire type, and succession class-specific information needed to parameterize the model further. Note previous comment stating that surface fire would not have impacted succession class dynamics.

Future Research Need: fire type (surface, mixed, replacement) and succession class-specific annual fire probabilities (or FRIs)

Fire Frequency

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Severity** | **Avg FI** | **Percent of All Fires** | **Min FI** | **Max FI** |
| Replacement | 1013 | 100 |  |  |
| Moderate (Mixed) |  |  |  |  |
| Low (Surface) |  |  |  |  |
| All Fires | 1013 | 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

This landscape unit can typically range from hundreds of acres to <5ac, although scattered large patches of thousands of acres occur in MZ64 in the Lake Champlain basin and may occur in northern Maine and possibly Canada. In the southern portion of the Great Lakes region and east to New England, occurrences are generally small (<100ac) and widely distributed. These wetlands are often generally homogeneous in vegetation composition, but can vary considerably in overstory coverage, even within the same wetland. Larger areas may also contain scattered better drained islands with mineral soils and hardwoods.

Adjacency or Identification Concerns

This concept includes “cedar swamps” and associated hardwood-conifer-dominated lowland forests on alkaline substrates.

Issues or Problems

Ecosystem modeling in lower New England, as part TNC’s ecoregional plan, predicted a larger extent for these systems than was suggested by records in the state heritage program inventories (Lundgren, 2007, pers. comm.).

Native Uncharacteristic Conditions

Unclear whether beaver abundance deviates from natural condition.

Comments

Buckthorn invasion, northern white-cedar logging pressure, increase in summer drought leading to increased fire, and increase in organic matter decomposition; northern type at southern limit of range in New England, so may see retreat of type to the north.

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 | UN | UN | UN | UN | UN | UN | UN | UN | UN | UN |
| Herb | 0.5-1.0 | UN | UN | UN | UN | UN | UN | UN | UN | UN | UN |
| Herb | >1.0 | UN | UN | UN | UN | UN | UN | UN | UN | UN | UN |
| Shrub | 0-0.5 | A | A | A | A | UN | UN | UN | UN | UN | UN |
| Shrub | 0.5-1.0 | A | A | A | A | UN | UN | UN | UN | UN | UN |
| Shrub | 1.0-3.0 | A | A | A | A | UN | UN | UN | UN | UN | UN |
| Shrub | >3.0 | A | A | A | A | UN | UN | UN | UN | UN | UN |
| Tree | 0-5 | UN | UN | B | B | B | B | B | C | C | C |
| Tree | 5-10 | UN | UN | B | B | B | B | B | C | C | C |
| Tree | 10-25 | UN | UN | UN | UN | UN | UN | UN | C | C | C |
| Tree | 25-50 | UN | UN | UN | UN | UN | UN | UN | D | D | D |
| Tree | >50 | UN | UN | UN | UN | UN | UN | UN | 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 14 Early Development 1 - All Structures

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| LALA | Larix laricina | Tamarack | Upper |
| ALIN2 | Alnus incana | Speckled alder | Mid-Upper |
| ILVE | Ilex verticillata | Common winterberry | Mid-Upper |
| VACO | Vaccinium corymbosum | Highbush blueberry | Middle |
| PIMA | Picea mariana | Black spruce | Mid/Upper |
| THOC2 | Thuja occidentalis | Northern white-cedar | Upper |
| ABBA | Abies balsamea | Balsam fir | Upper |
| PIRU | Picea rubens | Red spruce | Upper |

Description

Early successional stand following flooding or stand-replacing fire (rare). Shrubs increase dominance over time, although open grass- and sedge-dominated wet meadow may be dominant for the first 10yrs+, particularly in areas in which existing shrubs were flood-killed. Open to dense thicket dominated by speckled alder and winterberry, potentially associated with willow, nannyberry, and mountain holly. Early successional trees establish (particularly tamarack and black ash) in the absence of additional disturbance; northern white-cedar and/or white pine may establish from seed after catastrophic fire.

This stage results from major disturbance, including stand-replacement fire, flooding, or windthrow. Replacement fire was estimated to occur every ~1,000yrs across the extent of these systems. This likely varied across the region and depended on the nature of the upland matrix in any given area (fire dependent vs. fire intolerant). Replacement fire maintains the systems in Class A (an early shrub and less likely an herb-dominated successional stage). Flooding caused by beaver or other natural hydrologic alteration, modeled as wind/weather/stress, is estimated to occur every 300+yrs, although this number may be much higher, and maintains the systems in Class A. Insect outbreaks were not modeled due to the fact that most of these systems are dominated by northern white-cedar, which is not generally impacted by this disturbance type. Alder-dominated thickets are sometimes relatively stable and long-lived, but the concept used for this model is of a site that, due to edaphic factors, favors the development of forested wetland in the absence of major disturbances.

In reality, a variety of early-successional communities can result from major disturbance of conifer or conifer-hardwood-dominated alkaline lowland forest. Class A is meant to capture a “typical” disturbance-followed-by-succession scenario.

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

Class B 11 Early Development 2 - Closed

Upper Layer Lifeform: Tree

Upper Layer Lifeform Is Not the Dominant Lifeform

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| THOC2 | Thuja occidentalis | Arborvitae | Upper |
| PIMA | Picea mariana | Black spruce | Upper |
| LALA | Larix laricina | Tamarack | Upper |
| ACRU | Acer rubrum | Red maple | Mid-Upper |
| ILMU | Ilex mucronata | Mountain holly | Mid |
| ALINR | Alnus incana ssp. rugosa | Speckled alder | Mid |
| ABBA | Abies balsamea | Balsam fir | Upper |
| PIRU | Picea rubens | Red spruce | Upper |

Description

Scattered tree canopy develops from hardwood and conifer seedlings that establish under shrubs and trees present in Class A. Typical species include black ash, tamarack, northern white-cedar, and balsam fir, with some paper birch and quaking aspen. General appearance is of a shrub-dominated system with an open tree canopy, grading into forested wetland at the end of this period.

This stage transitions to Class C in the absence of major disturbances. Insect outbreaks were not modeled because most of these systems are dominated by northern white-cedar, which is not generally impacted by this disturbance type.

Class C 21 Mid Development 1 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| THOC2 | Thuja occidentalis | Northern white-cedar | Upper |
| PIMA | Picea mariana | Black spruce | Upper |
| LALA | Larix laricina | Tamarack | Upper |
| ACRU | Acer rubrum | Red maple | Mid-Upper |
| ABBA | Abies balsamea | Balsam fir | Upper |
| PIRU | Picea rubens | Red spruce | Upper |

Description

Mid-age stands dominated by cedar, with some black spruce, balsam fir, and tamarack. May include red maple. Some shrub layer; >70% canopy closure. Scattered successional species (e.g., quaking aspen, paper birch) present in the canopy, but declining as stands age.

This stage matures to Class D in the absence of major disturbances. Replacement fire was estimated to occur every ~1,000yrs across the extent of these systems. This likely varied across the region and depended on the nature of the upland matrix in any given area (fire dependent vs. fire intolerant). Insect outbreaks were not modeled because most of these systems are dominated by northern white-cedar, which is not generally impacted by this disturbance type.

*Maximum Tree Size Class*  
Pole, 5-9" DBH; mature trees, >9"DBH

Class D 54 Late Development 1 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| THOC2 | Thuja occidentalis | Northern white-cedar | Upper |
| PIRU | Picea rubens | Red spruce | Upper |
| FRNI | Fraxinus nigra | Black ash | Upper |
| ABBA | Abies balsamea | Balsam fir | Mid-Upper |

Description

Mature, multi-seral stands typically dominated by northern white-cedar, with black spruce and balsam fir usually important. Other canopy species may include tamarack (but this is typically in open microsites and peripherally), white pine, hemlock, and a variety of hardwoods, with the latter in low numbers except where favored due to hydrology (streambanks, frequently flooded areas) or substrate (thin organic or mineral soils). Canopy cover generally >75% but may be lower, particularly in areas associated with active groundwater discharge or peat deposition (these grade into open rich fen).

Canopy height typically ca. 20-25m; super-canopy white pines >25m may be present. On deep peats, average DBH of old-growth canopy cedars may be <53cm (21in), but older stands may contain canopy trees up to 60-100cm DBH (24-40in).

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

Model Parameters

Deterministic Transitions

|  |  |  |  |
| --- | --- | --- | --- |
| **From Class** | **Begins at (yr)** | **Succeeds to** | **After (years)** |
| Early1:ALL | 0 | Early2:CLS | 29 |
| Early2:CLS | 30 | Mid1:CLS | 55 |
| Mid1:CLS | 56 | Late1:CLS | 115 |
| Late1:CLS | 116 | 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 | 0.001 | 1000 | Yes | 0 |
| Wind or Weather or Stress | Early1:ALL | Early1:ALL | 0.003 | 333 | No | 0 |
| Replacement Fire | Early2:CLS | Early1:ALL | 0.001 | 1000 | Yes | 0 |
| Wind or Weather or Stress | Early2:CLS | Early1:ALL | 0.0045 | 222 | Yes | 0 |
| Replacement Fire | Mid1:CLS | Early1:ALL | 0.001 | 1000 | Yes | 0 |
| Wind or Weather or Stress | Mid1:CLS | Early1:ALL | 0.0045 | 222 | Yes | 0 |
| Replacement Fire | Late1:CLS | Early1:ALL | 0.001 | 1000 | Yes | 0 |
| Wind or Weather or Stress | Late1:CLS | Early1:ALL | 0.0045 | 222 | Yes | 0 |

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