

13440

## Boreal Jack Pine-Black Spruce Forest

BpS Model/Description Version: Aug. 2020

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| Modelers     |                  | Reviewers    |                              |
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| None         | None             | None         | None                         |

### Vegetation Type

Forest and Woodland

### Map Zones

66

### Model Splits or Lumps

This biophysical setting is lumped with 1464 (CES201.561)

### Geographic Range

This system is found from eastern Alberta to eastern Canada, southward into Minnesota and the Great Lakes region and very locally into northwestern Maine (NatureServe 2007).

In map zone (MZ)66, this system is found in subsection M212Aa (Aroostook Hills and Lowlands). (Royte, personal observation)

### Biophysical Site Description

Mesic to somewhat xeric sites over a broad range of topographic conditions. including valley flats and low gentle hills. Soils generally have a thick organic epipedon over a thin spodosol draped over a network of roots supported by rocks and boulders. This type also occurs on thin folists (organic soils over boulders). Despite sometime circumneutral bedrock, soils are often acidic and species diversity is low. The forest floor in this landscape is dense with often ubiquitous ground-coverings of feather mosses and liverworts where soils vary from <1in (2cm) to >1ft (30cm) in thickness.

### Vegetation Description

In the United States, characteristic species are black spruce, red spruce, balsam fir (*Abies balsamea*), isolated red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*) and along the coast and large rivers white spruce (*Picea glauca*). Common, early-seral associates are paper birch (*Betula papyrifera*) and aspen (*Populus tremuloides* and *P. grandidentata*) and occasionally pin cherry (*Prunus pensylvanica*). Balsam poplar (*Populus balsamea*) is common in disturbed areas along riparian corridors. White spruce (*P. glauca*) is uncommon in general, except along major stream riparian zones. In the more extensive Canadian range this forest type is often dominated by black spruce with jack pine (*Pinus banksiana*); in wetter areas white spruce can be also be dominant. The forest dominants and fire cycles in these Canadian forests are dictated by broad-scale climatic and edaphic changes (Parisian 2004). These forests are in more localized landscapes in the U.S., confined by landscape position and climatic variables.

This forest often grades into hillier terrain dominated by northern hardwood forests of sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), striped maple (*A. pensylvanicum*), and mountain maple (*A. spicatum*). Occasionally, Eastern white pine (*Pinus strobus*) are found occasionally towering over the older growth that is scattered throughout this landscape, although they are not common. Early successional black cherry (*Prunus serotina*) and elderberry (*Sambucus pubescens*) appear in more disturbed sites; on wet sites the black spruce opens up to speckled alder (*Alnus incana* ssp. *rubra*). Open exposed soils often become dominated by sweet fern (*Comptonia peregrine*, an atmospheric Nitrogen-fixer), several raspberry and blackberry species (*Rubus alleghaniensis*, *ideaus*, *fragellans*, *hispidus*). Two common ferns with reputed allelopathic properties are the bracken (*Pteridium aquilinum*) and the hay-scented (*Dennstaedtia punctilobula*). Red spruce (called umbrella spruce), can persist in a shady understory for 100yrs and then quickly fill a gap when an opportunity arises. It can then grow into the canopy over a short period. White and black spruce do not do this. While black spruce grows slowly in the understory and can outlive fir, it remains dwarfed if it is suppressed too long, even with canopy release. Balsam fir is an early competitor and grows faster than young red spruce; however, it dies at ca. 90yrs or earlier, and the residual red or black spruce will persist to dominate the stand. Ironically, because fir is more susceptible to spruce budworm damage than all but late-stage spruce, several outbreaks of budworm can convert a mixed spruce-fir stand to almost pure spruce. Minor spruce budworm outbreaks are of considerable importance, particularly in classes B and D where fir is at its peak of attractiveness to the budworm. One or two cycles of budworm over a 50-150yr period slowly decreases the dominance or co-dominance of fir and increases in waves the strong dominance of red and, in some areas, black spruce (Fraver 2007).

This forest is punctuated with 100-500ac patches of late successional stands of black spruce occasionally interspersed with red spruce (*P. rubens*) and balsam fir (*Abies balsamea*) growing more densely in canopy gaps and along edges. This sits within a matrix of younger stands heavier to balsam fir. There are distinct patches of nearly pure early successional birch and aspen forests, especially on the low hill tops and barren edges where disturbance has been more severe or more frequent.

BpS 1464, Acadian Near-Boreal Spruce Barrens, is a closely related system that often grades into BpS 1344 in map zone 66; it is included in this model. This system is found on sandplains and coarse outwash that often have undulating topography. Substrate microtopography can result in wetland pockets interspersed with upland areas. *Picea mariana* tends to be the dominant tree. *Picea rubens* and red/black spruce hybrids are also common in the southern part of the range. Dwarf heath shrubs are extensive and diagnostic. Lichens, especially reindeer lichens, are often abundant in the ground layer. Vegetation physiognomy can vary within sites and can range from nearly closed forest to sparse trees over a dense dwarf heath understory. (NatureServe 2007)

#### **BpS Dominant and Indicator Species**

| <b>Symbol</b> | <b>Scientific Name</b>     | <b>Common Name</b> |
|---------------|----------------------------|--------------------|
| PIMA          | <i>Picea mariana</i>       | Black spruce       |
| ABBA          | <i>Abies balsamea</i>      | Balsam fir         |
| BEPA          | <i>Betula papyrifera</i>   | Paper birch        |
| POTR5         | <i>Populus tremuloides</i> | Quaking aspen      |

|       |                              |                |
|-------|------------------------------|----------------|
| POGR4 | <i>Populus grandidentata</i> | Bigtooth aspen |
| PIRU  | <i>Picea rubens</i>          | Red spruce     |
| ACRU  | <i>Acer rubrum</i>           | Red maple      |

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

### Disturbance Description

This type displays a much more frequent fire interval (145yr) in the northwest corner of Maine than in the surrounding northern hardwood forest types (Royte and Cogbill 2003). The vegetation pattern and stand dynamics are similar to southwest Quebec where intense thunderstorms start small fires more frequently (Bergeron 2000 and Chandler 1983). In general, the less common fire disturbances are still severe and can affect moderate patch sizes (10-100ac), at 150-300yr+ intervals. Fire that occurs in the spring or later in the growing season under drought conditions favors a pathway to early successional aspen-birch, delaying spruce-fir regeneration (see Class C). This pathway extends to ~120yrs before the paper birch finally senesces and a dense fir-spruce canopy emerges. Less intense fire or other stand-replacing disturbance may produce dense fir-spruce regeneration with few hardwoods (see class B). In either successional pathway, spruce budworm outbreaks are likely to move the stand from fir-dominated to spruce-dominated over a period of 50-150yrs. Wind events, insect attack, and ice storms on a small patch-to-stand scale are more important than fire, and they may predispose the forest to fire especially when coupled with drought. Wind disturbance often results in an abundance of mountain ash (*Sorbus decora* and *S. canadensis*) and elderberry (*Sambucus pubescens* and *S. canadensis*).

Spruce budworm outbreaks today are on a 40-60yr cycle; the historic cycle is thought to be much longer. Before the late 1800s, outbreaks appear to have been of smaller size and intensity, and with a greater interval between outbreaks. There clearly are synergies between budworm cycles, with fir die-off and stand-replacing wind followed by fire.

Spruce beetle attacks trees >18in DBH. Over-mature or stressed spruce is susceptible to witch's broom, Armillaria; in severe outbreaks the stand can collapse. Susceptibility to fire is estimated to be highest 5-8yrs after tree mortality after which flammability gradually decreases as fuel decomposes and new understory develops. Sustained crown fire runs covering several hundred acres can occur, with severe damage at the ground surface, depending on time of year (see model descriptions by Dibble 2006). Drought spring conditions produce the most severe effects, whereas late summer or fall burns may temper effects due to presence of live fuel moisture. In the relatively stable late-closed class, moderate disturbances from wind, spruce budworm, spruce bark beetle, Armillaria, and ice storm can have impacts that range from small gaps to stand-replacing.

On deep and coarse glacial outwash where fire return intervals can be quicker and more intense, it may take much longer to get back to the spruce forest type. Intense fires (circa 1940s) on extensive deposits of sand and gravel outwash along the St. John River consumed most of the organic soils and spruce, resulting in open heath-lichen barrens with stunted and widely-spaced spruce (Royte 2003). In areas with excessively well-drained soils or thin organic matter on cobble, fires can burn much hotter, consuming both forest and soil biomass, and leaving thin layers of residual soil, potentially the root bases of heath plants such as huckleberry (*Gaylussacia baccata*), sour-top blueberry (*Vaccinium myrtilloides*), and rhodora

(*Rhododendron canadensis*). The hottest fires can produce open areas of cobble that are slow to recover. In this case, many thousands of years may be required for soil development to occur and forests to develop enough biomass for a return fire.

Insects may slowly convert stands from low-level outbreaks, or impact larger areas of even-aged fir stands. However, these large homogeneous areas would have been much less common on the presettlement landscape than they are today (see “Uncharacteristic native conditions”).

Wind is a frequent disturbance along the wetland and riverine edges of forests, with larger downburst impacts more randomly creating 300ft (100m)-wide swaths up to 50ac (20ha) in size.

Ice damage along the major rivers is a frequent but localized disturbance, where spring breakup flooding can level swaths of floodplain or near-floodplain forests for up to several hundred feet (75-100m) into the surrounding forest.

Ice storm damage can be moderately severe in hardwood canopies, especially older aspen and birch forests, but that damage is likely to be localized on those stands and mostly with canopy recovery

### Fire Frequency

| Severity         | Avg FI | Percent of All Fires | Min FI | Max FI |
|------------------|--------|----------------------|--------|--------|
| Replacement      | 213    | 100                  | 50     | 200    |
| Moderate (Mixed) |        |                      |        |        |
| Low (Surface)    |        |                      |        |        |
| All Fires        | 213    | 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

Patches of old, nearly pure black spruce stands and the patches of early successional birch and aspen are consistently moderate-sized, 20-100ac (8-40ha), similar to the patch or grain size of this landscape of low hills, wetlands, and valley flats. As proposed by Turner and Romme (1994), the edaphic features and geography of the landscape appear to determine the grain or patch size of the landscape just as they influence the disturbances that determine the patch seral condition and species composition.

### Adjacency or Identification Concerns

The type occurs within a zone that is less influenced by temperature-moderating effects of the Atlantic Ocean than areas at lower elevations to the east. The type covers species transition zones, and ranges from the Acadian spruce-fir forest to northern hardwood to boreal hardwood-conifer forest.

### Issues or Problems

The historic distribution of this type in nearby Quebec and New Brunswick is not known, although it is well-documented in southwest and central Quebec. There are black spruce-dominated flats as localized landscape features in valley bottoms and broad basins throughout the range of black spruce. The areas with frequent fires are less well-documented in the United States.

Height and cover classes for each Class are unrealistic, due to the constraints of the LANDFIRE modeling process. Canopy heights and cover classes for class C would overlap in both classes B and D, with the major distinction between these classes being species composition. Additionally, class A would likely reach 7-8m in height by age 29, while classes C and D would likely reach 30m in height, causing overlap with class E.

### Native Uncharacteristic Conditions

Spruce budworm outbreaks today are thought to be on a much shorter cycle (40-60yrs) than would have occurred under presettlement conditions. Before the late 1800s, outbreaks appear to have been of smaller size and intensity, and with a greater interval between outbreaks. Twentieth century harvesting created many large openings that, along with later century stand treatments, favored extensive coniferous and, in this case, fir-dominated stands (Fraver 2007). This created abnormally large and mono-typic stands of nearly even-aged fir dominating large parts of the landscape, creating a palette for run-away budworm epidemics whose impacts were much more intensive and wide-ranging than we assume would occur under prior condition.

### 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      | 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      | UN               | UN    | UN    | UN    | UN    | UN    | UN    | UN    | UN    | UN     |
| Shrub                | 0.5-1.0    | UN               | UN    | UN    | UN    | UN    | UN    | UN    | UN    | UN    | UN     |
| Shrub                | 1.0-3.0    | UN               | UN    | UN    | UN    | UN    | UN    | UN    | UN    | UN    | UN     |
| Shrub                | >3.0       | UN               | UN    | UN    | UN    | UN    | UN    | UN    | UN    | UN    | UN     |
| Tree                 | 0-5        | UN               | UN    | UN    | UN    | A     | A     | A     | A     | A     | A      |
| Tree                 | 5-10       | UN               | UN    | UN    | UN    | UN    | C     | C     | C     | B     | B      |
| Tree                 | 10-25      | UN               | UN    | UN    | UN    | UN    | C     | C     | C     | D     | D      |
| Tree                 | 25-50      | UN               | UN    | UN    | UN    | UN    | E     | E     | E     | E     | E      |
| Tree                 | >50        | UN               | UN    | UN    | UN    | UN    | E     | E     | E     | E     | E      |

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

|                |           |                                             |
|----------------|-----------|---------------------------------------------|
| <b>Class A</b> | <b>15</b> | <b>Early Development 1 - All Structures</b> |
|----------------|-----------|---------------------------------------------|

### Indicator Species

| Symbol | Scientific Name            | Common Name   | Canopy Position |
|--------|----------------------------|---------------|-----------------|
| ABBA   | <i>Abies balsamea</i>      | Balsam fir    | Mid-Upper       |
| PIMA   | <i>Picea mariana</i>       | Black spruce  | Mid-Upper       |
| BEPA   | <i>Betula papyrifera</i>   | Paper birch   | Mid-Upper       |
| POTR5  | <i>Populus tremuloides</i> | Quaking aspen | Mid-Upper       |

#### Description

The community type occupies an opening that follows a stand-replacement fire, microburst, or other major disturbance. Intense fire is likely to result in regeneration dominated by birch and aspen. This type of young stand is characterized by dense paper birch, occasionally yellow birch (*B. alleghaniensis*), and aspen (quaking and/or big-tooth) seedlings. Understory has spruce (red/black, but especially black) and predominantly balsam fir. There are occasional densely vegetated patches of raspberry (*Rubus ideaus*), sweet fern (*Comptonia peregrina*), bracken fern (*Pteridium aquilinum*), or hay-scented fern (*Dennstedtia punctilobula*).

Alternatively, less-intense fire or stand-replacing wind events such as severe hurricane damage or microbursts are likely to produce regeneration dominated by fir and black spruce, with only occasional aspen and birch. About 60% of regenerating stands are likely to be dominated by fir and spruce.

#### Maximum Tree Size Class

Pole 5-9" DBH

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|                |           |                                   |
|----------------|-----------|-----------------------------------|
| <b>Class B</b> | <b>19</b> | <b>Mid Development 1 - Closed</b> |
|----------------|-----------|-----------------------------------|

#### Indicator Species

| Symbol | Scientific Name          | Common Name  | Canopy Position |
|--------|--------------------------|--------------|-----------------|
| ABBA   | <i>Abies balsamea</i>    | Balsam fir   | Mid-Upper       |
| BEPA   | <i>Betula papyrifera</i> | Paper birch  | Mid-Upper       |
| PIMA   | <i>Picea mariana</i>     | Black spruce | Low-Mid         |

#### Description

This class comes from the fir-spruce type of class A without disturbance. These are intermediate stands typically dominated by fir, with a minor component of birch in the overstory and mostly spruce, with some fir, in the understory. This class may also be produced by moderate wind, snow or ice damage in class D or E, or by insect damage that selectively kills the firs in class D. In this case, the canopy may be more spruce-dominated.

#### Maximum Tree Size Class

Medium 9-21"DBH

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|                |           |                                   |
|----------------|-----------|-----------------------------------|
| <b>Class C</b> | <b>18</b> | <b>Mid Development 2 - Closed</b> |
|----------------|-----------|-----------------------------------|

#### Indicator Species

| Symbol | Scientific Name     | Common Name   | Canopy Position |
|--------|---------------------|---------------|-----------------|
| BEPA   | Betula papyrifera   | Paper birch   | Mid-Upper       |
| POTR5  | Populus tremuloides | Quaking aspen | Mid-Upper       |
| ABBA   | Abies balsamea      | Balsam fir    | Low-Mid         |
| PIMA   | Picea mariana       | Black spruce  | Low-Mid         |

#### Description

This class may come from the variation of class A that is dominated by aspen and birch. This is modeled as an alternate successional pathway and is expected to occur less frequently than the primary pathway to class B. This class may also be produced through a budworm outbreak in class B that eliminates most of the dominant fir, leaving an open birch canopy over spruce in the understory. This class is characterized by a closed to somewhat open canopy of mature birch and aspen, with an understory dominated by spruce and fir. Toward the end of this age range, the aspen will have died out, and the birch senescences, leaving an open birch canopy with a dense spruce-(fir) subcanopy.

#### Maximum Tree Size Class

Medium 9-21"DBH

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|                |           |                                    |
|----------------|-----------|------------------------------------|
| <b>Class D</b> | <b>18</b> | <b>Late Development 1 - Closed</b> |
|----------------|-----------|------------------------------------|

#### Indicator Species

| Symbol | Scientific Name   | Common Name  | Canopy Position |
|--------|-------------------|--------------|-----------------|
| ABBA   | Abies balsamea    | Balsam fir   | All             |
| PIMA   | Picea mariana     | Black spruce | All             |
| BEPA   | Betula papyrifera | Paper birch  | Upper           |

#### Description

This is the primary pathway from B. The canopy is typically dominated by mature fir, with some spruce and occasional senescing birches. The understory is usually dominated by spruce, with some fir.

Disturbance types: The height, age and species composition of the canopy make this class vulnerable to severe wind events. More than 50% of balsam fir trees over 70yrs old in this landscape have heart or butt rot, making them especially susceptible to wind, snow, and ice damage. A stand-replacing wind event is expected to impact about 20% of the landscape every 100yrs in this class (500yr return interval). Wind damage, snow loading, and ice storm damage of moderate severity that damages the canopy, transitions the system to class B, and occurs every 500yrs, on average.

#### Maximum Tree Size Class

Large 21-33"DBH

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|                |           |                                    |
|----------------|-----------|------------------------------------|
| <b>Class E</b> | <b>30</b> | <b>Late Development 2 - Closed</b> |
|----------------|-----------|------------------------------------|

### Indicator Species

| Symbol | Scientific Name | Common Name  | Canopy Position |
|--------|-----------------|--------------|-----------------|
| PIMA   | Picea mariana   | Black spruce | All             |
| ABBA   | Abies balsamea  | Balsam fir   | Low-Mid         |

### Description

This class represents a closed stand of mature spruce. These stands can persist as near monotypic spruce stands for 250-300yrs (Royte, personal observation). Moderate disturbances from wind, spruce budworm, spruce bark beetle, Armillaria, and ice storm impact on this community but not to stand-replacing severity.

### Maximum Tree Size Class

Large 21-33"DBH

## **Model Parameters**

### **Deterministic Transitions**

| From Class | Begins at (yr) | Succeeds to | After (years) |
|------------|----------------|-------------|---------------|
| Early1:ALL | 0              | Mid1:CLS    | 29            |
| Mid1:CLS   | 30             | Late1:CLS   | 69            |
| Mid2:CLS   | 30             | Late2:CLS   | 119           |
| Late1:CLS  | 70             | Late2:CLS   | 119           |
| Late2:CLS  | 120            | Late2: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                            |
| Alternative Succession    | Early1:ALL            | Mid2:CLS            | 0.015                   | 67                    | Yes                                                 | 0                            |
| Wind or Weather or Stress | Mid1:CLS              | Early1:ALL          | 0.001                   | 1000                  | Yes                                                 | 0                            |
| Insects or Disease        | Mid1:CLS              | Mid2:CLS            | 0.002                   | 500                   | Yes                                                 | 0                            |
| Wind or Weather or Stress | Mid1:CLS              | Mid1:CLS            | 0.004                   | 250                   | No                                                  | 0                            |
| Replacement Fire          | Mid1:CLS              | Early1:ALL          | 0.006                   | 167                   | Yes                                                 | 0                            |
| Wind or Weather or Stress | Mid2:CLS              | Early1:ALL          | 0.002                   | 500                   | Yes                                                 | 0                            |
| Insects or Disease        | Mid2:CLS              | Mid2:CLS            | 0.003                   | 333                   | No                                                  | 0                            |

|                           |           |            |       |     |     |   |
|---------------------------|-----------|------------|-------|-----|-----|---|
| Replacement Fire          | Mid2:CLS  | Early1:ALL | 0.003 | 333 | Yes | 0 |
| Wind or Weather or Stress | Late1:CLS | Mid1:CLS   | 0.002 | 500 | Yes | 0 |
| Wind or Weather or Stress | Late1:CLS | Early1:ALL | 0.002 | 500 | Yes | 0 |
| Insects or Disease        | Late1:CLS | Mid1:CLS   | 0.003 | 333 | Yes | 0 |
| Replacement Fire          | Late1:CLS | Early1:ALL | 0.006 | 167 | Yes | 0 |
| Wind or Weather or Stress | Late2:CLS | Early1:ALL | 0.002 | 500 | Yes | 0 |
| Wind or Weather or Stress | Late2:CLS | Mid1:CLS   | 0.003 | 333 | Yes | 0 |
| Wind or Weather or Stress | Late2:CLS | Late1:CLS  | 0.003 | 333 | Yes | 0 |
| Replacement Fire          | Late2:CLS | Early1:ALL | 0.006 | 167 | Yes | 0 |

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