10480

Northwestern Great Plains Highland White Spruce Woodland

BpS Model/Description Version: Aug. 2020

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| --- | --- | --- | --- |
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**Reviewer:** Shannon Murphy

Vegetation Type

Forest and Woodland

Map Zone

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Geographic Range

This uncommon forest type occurs primarily in the central and northern Black Hills of South Dakota and Wyoming and occasionally in the subalpine forests of the Bighorn Mountains of northcentral Wyoming and southcentral Montana (Meyer 2005, NatureServe 2013). This ecosystem represents a small fraction of the total forested area of this region (Hoffman and Alexander1987; NatureServe 2013).

Biophysical Site Description

This group is found in the Central Granitic Core and Upper Limestone Plateau at the highest elevations above 5,700 feet (Marriott et al. 2000). This forest type grows above and is surrounded by Biophysical Setting (BpS) 11791 (Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna-Low-elevation Woodland), often as small to large patches within the ponderosa pine matrix (NatureServe 2013). These highland areas generally have a cooler and wetter climate than the surrounding ponderosa pine savannas and woodlands and mixed-grass prairie found at lower elevations. This type occurs on gentle to steep slopes and on variable aspects. At lower elevations, these communities are restricted to north-facing slopes or mesic areas where snow is retained for longer periods (NatureServe 2013). This forest type grows on deep to shallow soils generally underlain by limestone, granite, slate, or schist rock. The Black Hills montane grassland community intersperses with this forest community (Marriott et al. 2000; McIntosh 1931; NatureServe 2013) and may influence burn patterns (NatureServe 2013).

Vegetation Description

Ponderosa pine or white spruce dominate these communities (Hoffman and Alexander 1987; Marriott et al. 2000). Ponderosa pine is seral to white spruce in this ecosystem (Hoffman and Alexander1987). Paper birch and aspen can be found in these communities, particularly on cool, moist sites throughout the northern half of the Black Hills, often as an early successional species after a fire (Pase 1958). Common shrubs include common juniper, common snowberry, creeping barberry, grouse whortleberry, kinnikinnick, and twinflower. Forbs like northern bedstraw and Virginia strawberry grow commonly along with roughleaf ricegrass (Marriott et al. 2000).

BpS Dominant and Indicator Species

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** |
| PIPO | *Pinus ponderosa* | Ponderosa pine |
| PIGL | *Picea glauca* | White spruce |

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

Disturbance Description

It is generally believed based on discussions that this type best fits in Fire Regime Group I. Ponderosa-pine-dominated forest and woodlands surround this vegetation type and influence the Fire Regime Group. There is a tendency toward Fire Regime Group III in the areas where white spruce becomes more prevalent. Stand-replacing disturbances are primarily associated with climatic fluctuations and include fire and insect (in late-development classes only, mountain pine beetle creates larger patch sizes; Ips beetles create smaller patches). Snowbreak and windthrow events may occur but are not modeled. The majority of the insect outbreaks generally occur in late-development types during periods of drought (such as that which the forest is currently experiencing). Tree mortality primarily occurs in ponderosa pines that are <7in DBH.

Surface and stand-replacing fire events occurred in this BpS. Stand-replacing fires were likely most common in higher elevation and northern slopes that were primarily dominated by spruce, with surface fires occurring most often in the moist ponderosa pine. Limited fire history information was available for high-elevation ponderosa pine and white spruce forests; however, researchers surmised that this type burned less frequently than lower-elevation types (Brown 2003; Brown et al. 2000), likely due to more moisture and cooler temperatures. Brown and others (Brown 2003; Brown et al. 2000) indicated fire return intervals (FRIs) of ~20-35yrs in the high-elevation ponderosa pine and white spruce woodlands and forests. Although spruce is a major component of this BpS, ponderosa pine is still often dominant, so the frequency is going to be a "combination." See Murphy (2017) for a synthesis of fire regimes in the Black Hills region.

There is some debate about whether mixed-severity fire would have occurred in this type based on tree ring and historical evidence.

Fire Frequency

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Severity** | **Avg FI** | **Percent of All Fires** | **Min FI** | **Max FI** |
| Replacement | 271 | 11 |  |  |
| Moderate (Mixed) | 120 | 24 |  |  |
| Low (Surface) | 45 | 65 |  |  |
| All Fires | 29 | 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

Scale varies widely. Includes gap phase dynamics (one to few tree mortality events) to watershed-scale events (mixed-severity fire or insect events in ponderosa pine to stand-replacing fire in spruce).

Adjacency or Identification Concerns

The most similar type to this BpS is the Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna-Low-elevation Woodland (BpS 11791), which occurs directly adjacent and primarily below in elevation. This type differs from Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna-Low-elevation Woodland (BpS 11791) because it has less frequent surface fires, more frequent mixed-severity fires, and more closed canopy forest. The white spruce vegetative component also distinguishes these two BpSs. The moister environment generally supports a higher site index than that of low-elevation ponderosa pine communities.

There is generally a greater component of aspen compared to Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna-Low-elevation Woodland (BpS 11791). More mosses and lichens are present in association with the moister, cooler conditions.

One reviewer commented that this BpS appears to have many questions about it and was not sure it should be a separate type. Essentially the difference is the presence of spruce, and these stands occur mainly on north-facing slopes in contrast to adjacent, more dominant pure ponderosa stands, which are well described by the Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna-Low-elevation Woodland (BpS 11791) model. It is thought that perhaps the area covered by this type is small enough that it should not be a separate model and that these stands should be included in the mid- or late closed classes of the Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna-Low-elevation Woodland ponderosa pine model. However, due to consensus from the other modelers/reviewers regarding this type, this model/description was retained. Perhaps it can be distinguished from the others also by elevation/aspect.

Due to extensive settlement and development in the Black Hills that began in the late 1800s, the forest structure and fire regime of this BpS have changed. There has been extensive timber harvest since the Custer Expedition in 1874 as well as >100yrs of fire exclusion. There are many private inholdings, with the majority located in the montane grasslands and riparian meadows included within this group. Some of those inholdings are being developed and include the construction of access roads. Several exotic plant species, including noxious weeds, are present. As noted in Parrish et al. (1996), riparian habitats have been altered by a wide array of contributing factors (roads, private land draining of wetlands, reduction or removal of beaver, grazing, haying, etc.). Livestock grazing occurs in many areas currently. Bison are no longer a wildlife component of the area (unless they are brought in to graze private land parcels).

Collected data show that both basal area and density have significantly increased in current forests compared to historical ones (Brown and Cook 2006; McAdams 1995). Historically, larger trees accounted for most of the basal area, whereas currently most of the forest basal area is comprised of small- to medium-size trees (Brown and Cook 2006; Brown et al. 2008; McAdams 1995). Fire exclusion is likely a primary factor contributing to these forest structural changes.

Issues or Problems

There is considerable debate over the role of mixed-severity and surface fires in the historical range of variability in this and other ponderosa pine forests in the northern and central Rockies (Baker and Ehle 2001; Baker and Ehle 2003; Barrett 2004; Veblen et al. 2000). However, dendrochronological studies continue to learn more about fire and climate history in portions of the Black Hills (e.g., Brown 2006; Brown 2003; Brown et al. 2000; Brown and Sieg 1996; Brown et al. 2008; Weink et al. 2004).

Reviewer during the 2017 BpS review suggested running the model with 50yr or 75yr mixed FRI. In the original model, there were one 100yr and four 200yr FRI mixed fires. Swaty changed all to 100yrs, which resulted in minimal changes to s-class percentages. Due to lack of citations and minimal change in model results, original model was kept.

Swaty suggests more effort on mixed fire modeling with this BpS in the future.

Native Uncharacteristic Conditions

Historically, without fire exclusion, it is expected that there would have been much less spruce than what currently exists on the landscape today. It is also expected that there is a greater canopy cover of conifer species (ponderosa pine and spruce) and less canopy cover of hardwoods (such as aspen and birch) in addition to less grassland openings (compare historical photos from 1874 to current photos of the same areas in Progulske [1974]). With denser canopies of conifers, it is generally expected that there is less herbaceous understory growth than occurred historically with a less dense canopy.

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

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

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| POTR5 | Populus tremuloides | Quaking aspen | Mid-Upper |
| BEPA | Betula papyrifera | Paper birch | Mid-Upper |
| ARUV | Arctostaphylos uva-ursi | Kinnikinnick | Lower |
| SYAL | Symphoricarpos albus | Snowberry | Lower |

Description

Aspen and birch shrublands with dense herbaceous cover of a variety of forbs.

Class A can generally be expected to have a dense herbaceous layer with a large diversity of forb species.

The upper-layer lifeform in this class could be either herbs or trees, but for the model, it is trees.

The estimate for this class is approximately 10-15% based on literature (Parrish et al. 1996). Fire exclusion has reduced fire frequency and altered extent of conifers (McAdams 1995; Sheppard and Battaglia 2002; Wienk et al. 2004. ).

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

Class B 8 Early Development 1 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| POTR5 | Populus tremuloides | Quaking aspen | Upper |
| BEPA | Betula papyrifera | Paper birch | Upper |

Description

Closed-canopy deciduous forest dominated by quaking aspen and paper birch. Birch tends to dominate on north aspects and moist slopes, while aspen will dominate on the remaining sites.

It is generally expected that this class would have made up approximately 10-15% of the landscape.

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

Class C 22 Mid Development 1 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| POTR5 | Populus tremuloides | Quaking aspen | Upper |
| BEPA | Betula papyrifera | Paper birch | Upper |
| PIPO | Pinus ponderosa | Ponderosa pine | Mid-Upper |
| PIGL | Picea glauca | White spruce | Mid-Upper |

Description

Conifers likely begin invading and constitute about 20% of the overstory.

This may not be mid-open but could be thought of as more of a mid-development stage (still existing hardwood canopy but it is being encroached upon by conifers, either/both spruce or ponderosa pine).

The canopy cover of the conifers only would be 10-25% at this stage, and they are 0-25m in height. This class overlaps in cover/height with Class E. However, the indicator species for Class C in the upper-layer lifeform are POTR5 and BEPA still, whereas the indicator species for Class E in the upper-layer lifeform have transitioned to PIPO and PIGL. They are therefore distinguished by upper-layer species.

It is generally expected that the extent of this class would likely be less today based on the hardwood component being less today.

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

Class D 30 Mid Development 2 - Open

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIPO | Pinus ponderosa | Ponderosa pine | Upper |
| PIGL | Picea glauca | White spruce | Upper |
| POTR5 | Populus tremuloides | Quaking aspen | Mid-Upper |
| BEPA | Betula papyrifera | Paper birch | Mid-Upper |

Description

In this class, it is expected that conifers continue to expand and would generally constitute about 50% of the tree overstory.

This class is generally considered to be a mid-development stage where the hardwoods are being replaced by a more dominant conifer component. The conifers are generally expected to become more mature with a greater portion of the area covered by a larger dominant number of conifers and where more hardwood individuals are becoming decadent or dying.

The canopy cover of the conifers is approximately 25-50% cover, and they are 10-25m in height. However, the canopy cover of all of the species combined could be 51-100%. However, so that there isn't overlap with Class E, this class was modeled with a 21-50% conifer canopy cover.

We would expect to see about 30% of this class on the landscape historically.

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

Class E 31 Late Development 1 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIPO | Pinus ponderosa | Ponderosa pine | Upper |
| PIGL | Picea glauca | White spruce | Upper |

Description

Dominated by dense stands of white spruce on north-facing slopes at higher elevations and pine-dominated stands on lower-elevation level areas and south-facing slopes at higher elevations. Pockets of deciduous trees and shrubs occur throughout.

See dominant species listed and canopy position. Class E loses the hardwood component and is entirely described as a conifer type.

It is expected that there is more of this generally closed canopy class for the present day (primarily associated with forest management practices and fire exclusion). However, current climatic conditions and insect activity are currently "unraveling" the ponderosa pine component of the closed late-development class (becoming much more open from ponderosa pine mortality) and may be adjusting the spatial extent back to what may have been expected more during historical conditions for this type. Because of the ongoing ponderosa pine mortality in the Black Hills and in this vegetation type (USDA Forest Service 2006), the proportion of live spruce to ponderosa pine is expected to be increasing. However, as ponderosa pine remnants continue to deteriorate, spruce individuals may also be lost due to their susceptibility to windthrow.

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

Model Parameters

Deterministic Transitions

|  |  |  |  |
| --- | --- | --- | --- |
| **From Class** | **Begins at (yr)** | **Succeeds to** | **After (years)** |
| Early1:ALL | 0 | Early1:CLS | 19 |
| Early1:CLS | 20 | Mid1:CLS | 39 |
| Mid1:CLS | 40 | Mid2:OPN | 79 |
| Mid2:OPN | 80 | Late1:CLS | 129 |
| Late1:CLS | 130 | 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 | 0.004 | 250 | Yes | 0 |
| Surface Fire | Early1:ALL | Early1:ALL | 0.0222 | 45 | No | 0 |
| Replacement Fire | Early1:CLS | Early1:ALL | 0.004 | 250 | Yes | 0 |
| Surface Fire | Early1:CLS | Early1:CLS | 0.0222 | 45 | No | 0 |
| Replacement Fire | Mid1:CLS | Early1:ALL | 0.004 | 250 | Yes | 0 |
| Mixed Fire | Mid1:CLS | Mid1:CLS | 0.01 | 100 | No | 0 |
| Surface Fire | Mid1:CLS | Mid1:CLS | 0.0222 | 45 | No | 0 |
| Insects or Disease | Mid2:OPN | Mid1:CLS | 0.001 | 1000 | Yes | 0 |
| Insects or Disease | Mid2:OPN | Early1:ALL | 0.001 | 1000 | Yes | 0 |
| Replacement Fire | Mid2:OPN | Early1:ALL | 0.004 | 250 | Yes | 0 |
| Mixed Fire | Mid2:OPN | Mid2:OPN | 0.005 | 200 | No | 0 |
| Surface Fire | Mid2:OPN | Mid2:OPN | 0.0222 | 45 | No | 0 |
| Insects or Disease | Late1:CLS | Mid2:OPN | 0.001 | 1000 | Yes | 0 |
| Insects or Disease | Late1:CLS | Mid1:CLS | 0.001 | 1000 | Yes | 0 |
| Insects or Disease | Late1:CLS | Early1:ALL | 0.002 | 500 | Yes | 0 |
| Replacement Fire | Late1:CLS | Early1:ALL | 0.003 | 333 | Yes | 0 |
| Mixed Fire | Late1:CLS | Mid2:OPN | 0.005 | 200 | Yes | 0 |
| Mixed Fire | Late1:CLS | Mid1:CLS | 0.005 | 200 | Yes | 0 |
| Mixed Fire | Late1:CLS | Late1:CLS | 0.005 | 200 | No | 0 |
| Surface Fire | Late1:CLS | Late1:CLS | 0.0222 | 45 | No | 0 |

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