10460

Northern Rocky Mountain Subalpine Woodland and Parkland

BpS Model/Description Version: Aug. 2020

|  |  |  |  |
| --- | --- | --- | --- |
| **Modelers** |  | **Reviewers** |  |
| Larry Kaiser | larry\_kaiser@blm.gov | Dana Perkins | dana\_perkins@blm.gov |
| Katie Phillips | cgphillips@fs.fed.us | Carly Gibson | cgibson@fs.fed.us |
| Randall Walker | rmwalker@fs.fed.us | John DiBari | jdibari@email.wcu.edu |

Reviewer: Robert Keane

Vegetation Type

Forest and Woodland

Map Zones

10, 19, 20

Geographic Range

Central and western Montana, and northern and central Idaho; limited distribution in northeastern Oregon and Washington.

Biophysical Site Description

Upper subalpine zone (6,000-9,500ft) on moderate to steep terrain (e.g., 40-70% slope). Landforms include ridgetops, mountain slopes, glacial trough walls and moraines, talus slopes, land and rock slides, and cirque headwalls and basins. Some sites have little snow accumulation because of high winds and sublimation, which increases summer drought conditions.

Patchy distribution of this type may be controlled by edaphic conditions, including soil depth and susceptibility to summer drought.

Vegetation Description

Forest communities range from nearly homogeneous stands of five-needled pines on the harshest, highest elevation sites to mixed species, including shade-tolerant subalpine fir, Engelmann spruce, and mountain hemlock on lower, moderate sites.

This Biophysical Site (BpS) has whitebark pine forests that occur in two high-mountain BPSs. On productive, upper subalpine sites, whitebark pine is the major seral species replaced by the more shade-tolerant subalpine fir, Engelmann spruce, and mountain hemlock, depending on geographic region ([Arno and Weaver 1990](#_ENREF_2)). These sites, referred to as “seral whitebark pine sites,” support upright, closed-canopy forests in the upper subalpine lower transition to timberline, just above or overlapping the elevational limit of the shade-intolerant lodgepole pine, and the two species often share dominance. Other minor species found with whitebark pine on these sites are Douglas-fir, limber pine, and alpine larch. Sites where whitebark pine is the only tree species able to dominate high-elevation settings successfully (called “climax whitebark pine sites”) are on harsh sites in the upper subalpine forests and at treeline on relatively dry, cold slopes ([Keane et al. 2012](#_ENREF_4)). Other species, such as subalpine fir, spruce, and lodgepole pine, can occur on these sites, but as scattered individuals with truncated growth forms. Alpine larch is often found on north-facing climax whitebark pine sites, often in association with sub-surface water ([Arno and Habeck 1972](#_ENREF_1)). Whitebark pine can also occur as krummholz, elfin forests, clusters, groves, tree islands, and timber atolls in the alpine treeline ecotone and as a minor seral in lower subalpine sites. Limber pine may be present in southeastern and eastern Idaho, but in these MZs it is not typically a subalpine species (it favors lower treeline habitat). In this harsh, windswept environment, trees are often stunted and flagged from wind damage.

Whitebark pine is a keystone and foundation species in many of these forests ([Tomback and Achuff 2010](#_ENREF_6)). Mature whitebark pine trees ameliorate local conditions on harsh sites and facilitate the establishment of less-hardy subalpine species. The seeds of whitebark pine provide an important food source for wildlife, particularly grizzly bears and Clark’s nutcrackers. Whitebark pine also depends exclusively upon Clark’s nutcrackers for seed dispersal and subsequent tree establishment.

BpS Dominant and Indicator Species

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** |
| PIAL | *Pinus albicaulis* | Whitebark pine |
| ABLA | *Abies lasiocarpa* | Subalpine fir |
| PIEN | *Picea engelmannii* | Engelmann spruce |
| LALY | *Larix lyallii* | Subalpine larch |
|  |  |  |
| TSME | *Tsuga mertensiana* | Mountain hemlock |

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

Disturbance Description

Fire regime is variable, typically mixed severity (25-75% top kill), with fire return interval (FRI) estimates ranging from 30- to 500-yr fires ([Morgan et al. 1994](#_ENREF_5); Arno 1986; Brown et al. 1994). As “seral” whitebark pine succeeds to subalpine fir over time, the fire regime shifts from mixed to stand-replacement severity (Keane 2001). Ignitions are frequent due to lightning, although fires seldom carry due to high-fuel moisture during most years and a possible lack of fuel from the slow-growing vegetation ([Keane and Parsons 2010](#_ENREF_3)). Individual tree torching is more common. Non-lethal surface fires may dominate where continuous light fuel loading (i.e., grasses) exists (Kapler-Smith and Fischer 1995), but fires are typically small in extent and are not modeled here. Recent dendroecological data collected in whitebark pine forests near Missoula, in western Montana, found numerous small fires (mean fire return interval [MFRI] <50yrs) punctuated by less frequent larger fires (MFRI, 75-100yrs) and implicated large-scale climate variability (e.g., the Little Ice Age) as a driver of temporal changes in the fire regimes of these forest systems (Larson 2005). In the model for this BpS, a 200- to 300-yr return interval was used for mixed-severity fires following the Keane (2001) “Seral Whitebark Pine Model” for the Northern Rockies region.

Mountain pine beetle is a natural agent of mortality affecting five-needle pine. Infestations occur periodically and are a natural agent of disturbance in these systems. During epidemics, mountain pine beetle typically kills most large whitebark pine. Snow, wind, and other weather events may cause damage and transitions between classes.

Fire Frequency

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Severity** | **Avg FI** | **Percent of All Fires** | **Min FI** | **Max FI** |
| Replacement | 396 | 46 | 100 | 1000 |
| Moderate (Mixed) | 336 | 54 |  |  |
| Low (Surface) |  |  |  |  |
| All Fires | 182 | 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

Fires can range from individual trees to hundreds of acres, although topography and continuity of fuel beds influence fire spread.

Adjacency or Identification Concerns

This BpS corresponds to cold upper subalpine and timberline habitat types (Pfister et al. 1977; Steele et al. 1983; Cooper et al. 1991), including ABLA/LUHI, PIAL/ABLA, LALY/ABLA, PIAL/LALY, and ABLA/XETE. Lower subalpine forests border at lower elevations, including lodgepole pine, Douglas-fir, Engelmann spruce, and subalpine fir types. Successional trajectory toward more shade-tolerant species in absence of fire.

Whitebark pine blister rust has decimated whitebark pine in the more mesic sites of whitebark pine ranges of this BpS (e.g., near Glacier National Park). Upper subalpine whitebark pine forests are rapidly declining throughout western North America because of the interacting and cumulative effects of historical and current mountain pine beetle (*Dendroctonus ponderosae* *Hopkins Coleopteran*: *Curculionidae*, *Scotlytinae*) outbreaks, fire exclusion policies, and the introduced pathogen *Cronartium ribicola*, which causes the disease whitepine blister rust in five-needle white pines (Keane and Arno 1993; Kendall and Keane 2001; Murray and Rasumussen 2003; Schwandt 2006; Tomback and Achuff 2010). To make matters worse, many feel that projected warmer future climates will severely reduce whitebark pine high-elevation habitat, restricting populations to the tops of mountains or to north of the Canadian border

Early grazing, fire suppression, and climate change may have altered natural fire frequency. Fire suppression tends to favor subalpine fir over whitebark pine. Subalpine fir stands are more likely to experience high-severity fire (due to lower crowns, greater crown bulk density, decreased fuel decomposition, etc.); this tends to shift the fire regime from mixed to stand replacement (Keane 2001). Live and dead trees are potential dendroclimatic resources.

Issues or Problems

Empirical data for the upper subalpine forest are generally sparse; quantifying fire regimes, succession, and other disturbances continues.

Native Uncharacteristic Conditions

Comments

In 2016, Robert Keane (rkeane@fs.fed.us) reviewed this model and made descriptive edits to the text and changes to the ages for each s-class, and increased the FRI for mixed fire in the Open classes from 143yrs to 200yrs to make all FRIs fall within the 200- to 300-yr range suggested for the “Seral Whitebark Pine Model” for the Northern Rockies region by Keane (2001). MZ10, MZ19, and MZ20 were combined during 2015 BpS review.

For MZ19, additional reviewers included Steve Barrett (sbarrett@mtdig.net), Evan Larson (lars2859@umn.edu), Susan Miller (smiller03@fs.fed.us), Steve Rawlings (srawlings@fs.fed.us), and Cathy Stewart (cstewart@fs.fed.us).

Peer review resulted in changes to the description, but no changes to the model. Two reviewers disagreed about the fire frequency -- one suggesting it be changed to 150yrs MFI, another suggesting it be changed to ~100yrs. No changes were made to the MFI.

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 | C | C | C | B | B | B | B | B | B | B |
| Tree | 10-25 | D | D | D | D | E | E | E | E | E | E |
| Tree | 25-50 | D | D | D | D | E | E | E | E | E | E |
| Tree | >50 | D | D | D | D | E | 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**

Class A 30 Early Development 1 - All Structures

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIAL | Pinus albicaulis | Whitebark pine | Upper |
| LALY | Larix lyallii | Subalpine larch | Upper |
| PICO | Pinus contorta | Lodgepole pine | Upper |
|  |  |  |  |

Description

Early succession after moderately long to long interval replacement fires, and highly variable mixed-severity fire intervals. On more productive sites, trees can establish immediately after fire. Whitebark pine, limber pine, and subalpine larch are typically early pioneers. Lodgepole pine may be present. Trees establish as clumps or scattered individuals. Higher elevation sites are dominated by herbaceous species.

This class encompasses the extended shrub-herb-shrub-grass-forb stage defined by Keane (2001) to represent the possibility of delayed conifer regeneration for 10-50yrs following high-severity fires at upper elevations. The severity of the fire and the site conditions dictate the duration of this stage. Vaccinium scoparium and *Luzula hitchcockii* are indicators.

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

Class B 31 Mid Development 1 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIAL | Pinus albicaulis | Whitebark pine | Upper |
| ABLA | Abies lasiocarpa | Subalpine fir | Upper |
| PIEN | Picea engelmannii | Engelmann spruce | Mid-Upper |
| PICO | Pinus contorta | Lodgepole pine | Upper |

Description

Stands dominated by small diameter, with a mix of shade-tolerant and -intolerant species. High elevation or harsh sites may exhibit krummholz growth forms. Whitebark pine and subalpine larch are typically early pioneers on harsh sites.

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

Class C 12 Mid Development 1 - Open

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIAL | Pinus albicaulis | Whitebark pine | Upper |
| LALY | Larix lyallii | Subalpine larch | Upper |
| PICO | Pinus contorta | Lodgepole pine | Upper |
|  |  |  |  |

Description

Stands dominated by small diameter, with a mix of shade-tolerant and -intolerant species. High elevation or harsh sites may exhibit krummholz growth forms. Whitebark pine (especially on southern aspects) and subalpine larch (especially on northern aspects) are typically early pioneers on harsh sites. Limber pine may also occur on these sites.

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

Class D 5 Late Development 1 - Open

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIAL | Pinus albicaulis | Whitebark pine | Upper |
| LALY | Larix lyallii | Subalpine larch | Upper |
| PICO | Pinus contorta | Lodgepole pine | Upper |
|  |  |  | Upper |

Description

Mid- to large-diameter mixed-conifer species in small to moderate size patches generally on southern aspects. Open canopy conditions occur on sites where soil is less developed or on wind-exposed, south-facing aspects. Whitebark pine (especially on southern aspects) and subalpine larch (especially on northern aspects) typically dominate.

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

Class E 22 Late Development 1 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIAL | Pinus albicaulis | Whitebark pine | Upper |
| ABLA | Abies lasiocarpa | Subalpine fir | Upper |
| PIEN | Picea engelmannii | Engelmann spruce | Upper |
|  |  |  |  |

Description

Mid- to larger diameter mixed-conifer species in small to moderate patches. Subalpine fir is likely to encroach upon these sites. As elevation increases and high snowpack becomes limiting, stands are often only composed of subalpine fir; the snow is too deep for whitebark pine.

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

Model Parameters

Deterministic Transitions

|  |  |  |  |
| --- | --- | --- | --- |
| **From Class** | **Begins at (yr)** | **Succeeds to** | **After (years)** |
| Early1:ALL | 0 | Mid1:CLS | 79 |
| Mid1:OPN | 80 | Late1:OPN | 149 |
| Mid1:CLS | 80 | Late1:CLS | 149 |
| Late1:OPN | 150 | Late1:OPN | 999 |
| Late1:CLS | 150 | 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 | 0.005 | 200 | Yes | 0 |
| Competition or Maintenance | Early1:ALL | Early1:ALL | 0.005 | 200 | Yes | 0 |
| Alternative Succession | Early1:ALL | Mid1:OPN | 0.01 | 100 | Yes | 0 |
| Insects or Disease | Mid1:OPN | Mid1:OPN | 0.002 | 500 | No | 0 |
| Insects or Disease | Mid1:OPN | Early1:ALL | 0.002 | 500 | Yes | 0 |
| Wind or Weather or Stress | Mid1:OPN | Early1:ALL | 0.003 | 333 | Yes | 0 |
| Replacement Fire | Mid1:OPN | Early1:ALL | 0.003 | 333 | Yes | 0 |
| Mixed Fire | Mid1:OPN | Mid1:OPN | 0.005 | 200 | No | 0 |
| Alternative Succession | Mid1:OPN | Mid1:CLS | 0.05 | 20 | Yes | 0 |
| Competition or Maintenance | Mid1:CLS | Mid1:CLS | 0.002 | 500 | No | 0 |
| Replacement Fire | Mid1:CLS | Early1:ALL | 0.002 | 500 | Yes | 0 |
| Insects or Disease | Mid1:CLS | Mid1:OPN | 0.003 | 333 | Yes | 0 |
| Insects or Disease | Mid1:CLS | Early1:ALL | 0.003 | 333 | Yes | 0 |
| Mixed Fire | Mid1:CLS | Mid1:OPN | 0.004 | 250 | Yes | 0 |
| Wind or Weather or Stress | Mid1:CLS | Mid1:OPN | 0.005 | 200 | Yes | 0 |
| Insects or Disease | Late1:OPN | Mid1:OPN | 0.001 | 1000 | Yes | 0 |
| Insects or Disease | Late1:OPN | Late1:OPN | 0.002 | 500 | No | 0 |
| Insects or Disease | Late1:OPN | Early1:ALL | 0.002 | 500 | Yes | 0 |
| Replacement Fire | Late1:OPN | Early1:ALL | 0.003 | 333 | Yes | 0 |
| Mixed Fire | Late1:OPN | Late1:OPN | 0.005 | 200 | No | 0 |
| Wind or Weather or Stress | Late1:OPN | Late1:OPN | 0.007 | 143 | No | 0 |
| Alternative Succession | Late1:OPN | Late1:CLS | 0.05 | 20 | Yes | 0 |
| Insects or Disease | Late1:CLS | Mid1:OPN | 0.002 | 500 | Yes | 0 |
| Insects or Disease | Late1:CLS | Late1:OPN | 0.002 | 500 | Yes | 0 |
| Insects or Disease | Late1:CLS | Early1:ALL | 0.003 | 333 | Yes | 0 |
| Mixed Fire | Late1:CLS | Late1:OPN | 0.004 | 250 | Yes | 0 |
| Replacement Fire | Late1:CLS | Early1:ALL | 0.005 | 200 | Yes | 0 |
| Wind or Weather or Stress | Late1:CLS | Late1:OPN | 0.006 | 167 | Yes | 0 |

References

Agee, J.K. 1993. Fire Ecology of Pacific Northwest Forest. Island Press: Washington, DC. 493 pp.

Aplet, G.H., R.D. Laven and F.W. Smith. 1988. Patterns of community dynamics in Colorado Engelmann spruce and subalpine fir forests. Ecology 69: 312-319.

Arno, S.F., Habeck, J.R., 1972. Ecology of alpine larch (*Larix lyallii* Parl.) in the Pacific Northwest. Ecological Monographs. 42, 417-450.

Arno, S.F., Weaver, T., 1990. Whitebark pine community types and their patterns on the landscape. In: Schmidt W.C., (Compilers), K.J.M. (Eds.), Proceedings -- Symposium on Whitebark Pine Ecosystems: Ecology and management of a high mountain resource. USDA Forest Service, Bozeman, MT., USA, pp. 118-130.

Arno, S.F. 2000. Fire in western forest ecosystems. Pages 97-120 in: J.K. Brown and J. Kapler-Smith, eds. Wildland fire in ecosystems: Effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42-vol. 2. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 257 pp.

Barbour, M.G. and W.D. Billings, eds. 2000. North American Terrestrial Vegetation. Cambridge University Press, Cambridge, UK. 708 pp.

Barrett, S.W. 2004. Altered fire intervals and fire cycles in the Northern Rockies. Fire Management Today 64(3): 25-29.

Barrett, S.W. 2004. Fire Regimes in the Northern Rockies. Fire Management Today 64(2): 32-38.

Barrett, S.W. 1994. Fire regimes on andesitic mountain terrain in northeastern Yellowstone National Park. International Journal of Wildland Fire 4: 65-76.

Barrett, S.W. 1996. The historical role of fire in Waterton Lakes National Park, Alberta. Contract final report on file, Fire Management Division, Environment Canada, Canadian Parks Service Waterton Lakes National Park, Waterton Townsite, ALTA. 32 pp.

Barrett, S.W. 2002. A Fire Regimes Classification for Northern Rocky Mountain Forests: Results from Three Decades of Fire History Research. Contract final report on file, Planning Division, USDA Forest Service Flathead National Forest, Kalispell MT. 61 pp.

Brown, J.K., S.F. Arno, S.W. Barrett and J.P. Menakis. 1994. Comparing the Prescribed Natural Fire Program with Presettlement Fires in the Selway-Bitterroot Wilderness. Int. J. Wildland Fire 4(3): 157-168.

Clagg, H.B. 1975. Fire ecology in high-elevation forests in Colorado. M.S. Thesis, Colorado State University, Fort Collins, Colorado.

Cooper, S.V., K.E. Neiman and D.W. Roberts. 1991. (rev.) Forest habitat types of northern Idaho: a second approximation. Gen. Tech. Rep. INT-236. Ogden, UT: USDA Forest Service, Intermountain Research Station. 143 pp.

Eyre, F.H., ed. 1980. Forest cover types of the United States and Canada. Washington, DC: Society of American Foresters. 148 pp.

Fule, P.Z., J.E. Crouse, T.A. Heinlein, M.M. Moore, W.W. Covington and G. Verkamp. 2003. Mixed-severity fire regime in a high-elevation forest: Grand Canyon, Arizona. Landscape Ecology (in press).

Hawkes, B.C. 1979. Fire history and fuel appraisal study of Kananaskis Provincial Park. Thesis, University of Alberta, Edmonton ALTA. 173 pp.

Hessburg, P.F., B.G. Smith, S.D. Kreiter, C.A. Miller, R.B. Salter, C.H. McNicoll and W.J. Hann. Historical and current forest and range landscapes in the Interior Columbia River Basin and portions of the Klamath and Great Basins. Part I: Linking vegetation patterns and landscape vulnerability to potential insect and pathogen disturbances. Gen. Tech. Rep. PNW-GTR-458. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 357 pp.

Keane, R.E., Parsons, R.A., 2010. A management guide to ecosystem restoration treatments: Whitebark pine forests of the Northern Rocky Mountains. USDA Forest Service Rocky Mountain Research Station, Fort Collins, CO, p. 123.

Keane, R.E., Tomback, D.F., Aubry, C.A., Bower, A.D., Campbell, E.M., Cripps, C.L., Jenkins, M.B., Mahalovich, M.F., Manning, M., McKinney, S.T., Murray, M.P., Perkins, D.L., Reinhart, D.P., Ryan, C., Schoettle, A.W., Smith, C.M., 2012. A range-wide restoration strategy for whitebark pine forests. USDA Forest Service Rocky Mountain Research Station, Fort Collins, Colorado, p. 108.

Keane, R.E., 2001. Successional dynamics: modeling an anthropogenic threat. In: Tomback, D., Arno, S., Keane, R. (Eds.), Whitebark Pine Communities: Ecology and Restoration. Island Press, Washington DC, USA, pp. 159-192.

Keane, R.E., P. Morgan and J.P. Menakis. 1994. Landscape assessment of the decline of whitebark pine (Pinus albicaulis) in the Bob Marshall Wilderness Complex, Montana, USA. Northwest Science 68(3): 213- 229.

Keane, R.E. and S.F. Arno. 1993. Rapid decline of whitebark pine in Western Montana: Evidence from 20-year remeasurements. Western Journal of Applied Forestry 8:44-47.

Kendall, K.C. and R.E. Keane. 2001. Whitebark pine decline: infection, mortality, and population trends. In: Tomback, D.F., S.F. Arno and R.E. Keane, (Eds), Whitebark Pine Communities: Ecology and Restoration. Island Press, Washington, DC, USA. pp. 221-242.

Kipfmueller, K.F. and W.L. Baker. 2000. A fire history of a subalpine forest in southeastern Wyoming, USA. Journal of Biogeography 27: 71-85.

Larson, E.R. 2005. Spatiotemporal variations in the fire regimes of whitebark pine (Pinus albicaulis) forests, western Montana, USA, and their management implications. M.S. Thesis, University of Tennessee, Knoxville. 232 pp.

Loope, L.L. and G.E. Gruell. 1973. The ecological role of fire in the Jackson Hole area, northwestern Wyoming. Quaternary Research 3(3): 425-443.

Morgan, P. and R. Parsons. 2001, Historical range of variability of forests of the Idaho Southern Batholith Ecosystem. University of Idaho. Unpublished.

Morgan, P., S.C. Bunting, Robert E. Keane, Arno, S.F., 1994. Fire ecology of whitebark pine (Pinus albicaulis) forests in the Rocky Mountains, USA. In: W.Schmidt, (Compilers), F.H. (Eds.), Proceedings of the international symposium Subalpine stone pines and their environment: The status of our knowledge, St. Moritz, Switzerland, pp. 136-142.

Morgan, P. and S.C. Bunting. 1990. Fire effects in whitebark pine forests. Pages 166-170 in: W.C. Schmidt and K.J. McDonald, compilers. Symposium on whitebark pine ecosystems: Ecology and management of a high-mountain resource, proceedings. Gen. Tech. Rep. INT-270. Ogden UT: USDA Forest Service, Intermountain Research Station.

Murray, M.P. and M. Rasumussen. 2003. Non-native blister rust disease on whitebark pine at Crater Lake National Park. Northwest Science 77:87-91.

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

Pfister, R.D., B.L. Kovalchik, S.F. Arno and R.C. Presby. 1977. Forest habitat types of Montana. General Technical Report, INT-34. USDA Forest Service, Intermountain Forest and Range Experiment Station.

Quigley, T.M. and S.J. Arbelbide, tech. eds. 1997. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins: volume 1. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 4 vol. (Quigley, Thomas M., tech. ed.; The Interior Columbia Basin Ecosystem Management Project: Scientific Assessment).

Schwandt, J.W. 2006. Whitebark pine in peril: a case for restoration. Report R1-06-28. USDA Forest Service, Forest Health and Protection, Missoula, MT, USA. Available online: http://www.fs.usda.gov/Internet/FSE\_DOCUMENTS/stelprdb5341409.pdf.

Schmidt, K.M., J.P. Menakis, C.C. Hardy, W.J. Hann and D.L. Bunnell. 2002. Development of coarse-scale spatial data for wildland fire and fuel management. Gen. Tech. Rep. RMRS-GTR-87. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 41 pp. + CD.

Sherriff, R., T.T. Veblen and J.S. Sibold, J.S. 2001. Fire history in high elevation subalpine forests in the Colorado Front Range. Ecoscience 8: 369-380.

Sibold, J. 2001. The forest fire regime of an upper montane and subalpine forest, Wild Basin, Rocky Mountain National Park. M.S. Thesis, University of Colorado, Boulder, CO.

Steele, R., S.V. Cooper, D.M. Ondov, D.W. Roberts and R.D. Pfister. 1983. Forest habitat types of eastern Idaho and western Wyoming. Gen. Tech. Rep. INT-144. Ogden, UT: USDA Forest Service, Intermountain Mountain Research Station. 122 pp.

Swetnam, T.W. and C.H. Baisan. 1996. Historical fire regime patterns in the Southwestern United States. Pages 11-32 in: C.D. Allen, ed. Fire effects in Southwestern Forests: Proceedings of the Second La Mesa Fire Symposium. 29-31 March 1994, Los Alamos NM; Gen. Tech. Rep. RM-GTR-286 Fort Collins CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Tande, G.F. 1979. Fire history and vegetation pattern of coniferous forests in Jasper National Park, Alberta. Canadian Journal of Botany 57: 1912-1931.

Tomback, D.F., Achuff, P., 2010. Blister rust and western forest biodiversity: ecology, values and outlook for white pines. Forest Pathology 40, 186-225.

USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (2002, December). Fire Effects Information System, [Online]. Available: http://www.fs.fed.us/database/feis/ [Accessed 5/23/03].

Veblen, T.T., K.S.Hadley, E.M. Nel, T. Kitzberger, M.S. Reid and R. Villalba. 1994. Disturbance regime and disturbance interactions in a Rocky Mountain subalpine forest. Journal of Ecology 82: 125-135.

Veblen, T.T. and T. Kitzberger. 2002. Inter-hemispheric comparison of fire history: The Colorado Front Range, U.S.A. and the Northern Patagonian Andes, Argentina. Plant Ecology, in press.

Veblen, T.T. and D.C. Lorenz. 1991. The Colorado Front Range: a century of ecological change. University of Utah Press, Salt Lake City, Utah.

Whipple, S.A. and R.L. Dix. 1979. Age structure and successional dynamics of a Colorado subalpine forest. American Midland Naturalist 101: 142-158.