10550

Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland

BpS Model/Description Version: Aug. 2020

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Vegetation Type

Forest and Woodland

Map Zones

29

Geographic Range

Common in the mountains of Wyoming and minor portion of the Pryor Mountains in the upper montane and lower subalpine zones. This would occur in ECOMAP sections M331B and M331I (Cleland et al. 2007). This type occurs in the Bighorn Mountains of Wyoming as well as the Laramie Peak Range.

Biophysical Site Description

This Biophysical Setting (BpS) occurs between approximately 7,000ft (above foothill forests dominated by ponderosa pine and Douglas-fir) to 9,500ft. This type is restricted to north slopes at lower elevations. Slopes may be gentle to moderately steep (e.g., 0-60% slope).

Vegetation Description

Lodgepole pine, Engelmann spruce and subalpine fir are the dominants of this BpS. Lodgepole pine is more common on drier sites and spruce and fir are more common on more mesic sites (such as north-facing slopes). Common associated species include aspen, grouse whortleberry, common juniper, heartleaf arnica, russet buffaloberry, elk sedge and various grasses.

Because of its relative intolerance for the forest understory environment, lodgepole pine traditionally has been considered a pioneer or seral species to forests dominated by Engelmann spruce and subalpine fir. However, some of the Bighorn National Forest map zone (MZ)29 is too dry to support spruce-fir forests and lodgepole pine perpetuates itself in some areas (Despain 1973 in Meyer et al. 2005).

BpS Dominant and Indicator Species

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** |
| PICO | *Pinus contorta* | Lodgepole pine |
| PIEN | *Picea engelmannii* | Engelmann spruce |
| ABLA | *Abies lasiocarpa* | Subalpine fir |
| VASC | *Vaccinium scoparium* | Grouse whortleberry |

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

Disturbance Description

Primarily moderately long to long-interval stand replacement fires. Mixed-severity and surface fires may occur rarely in small patch sizes (i.e., <1,000s of acres) for this group, but are not modeled here.

Insects (mountain pine beetle) affect approximately 0.1% of the landscape every year and will either open the canopy, (maintaining or causing a transition to Classes C and D), or replace the vegetation, causing a transition to early-development conditions (Class A). Stand replacing insect outbreaks typically only occur in closed-canopy forests (Classes B and E).

Blister rust might have occurred during the historic range of variability (HRV) period - at relatively low levels during cool periods and at higher levels during warm, moist periods such as the early 1500s early 1700s (Meyer et al. 2005).

Blowdown events occur rarely (once every 500-1,000yrs), and are replacement events, causing a transition to early-development conditions (Class A).

For MZ29, changed replacement fire to higher and more frequent to get correct percentages in classes.

The HRV for succession and processes during the reference period for both individual stands and the landscape in the Bighorn Mountains would have been broad. Different sites on any specific burn can experience different successional trajectories, resulting in doghair stands of lodgepole in some areas, stands of average or below average tree density elsewhere, and a full variety of combinations of invading aspen, spruce, fir and lodgepole pine across the landscape (in Meyer et al. 2005).

Meyer et al. (2005) suggest that the mean fire return interval (FRI) of stand-replacing fires in the last 100yrs in high elevation types within the Bighorns is still within the range of means during the HRV period, despite fire suppression efforts. Recent fire records for the Bighorn National Forest suggest that fires still play an important role on the Bighorn National Forest, but fire suppression efforts have lengthened the mean FRI during the last 50yrs (Meyer et al. 2005).

Surface fires in lodgepole pine have been observed in the Bighorns, and because of the thin bark, some trees are killed. Surface fires may have burned through lodgepole pine forests in the Bighorn National Forest at intervals as short as 40-80yrs (Meyer et al. 2005). They were not modeled here.

Fire Frequency

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Severity** | **Avg FI** | **Percent of All Fires** | **Min FI** | **Max FI** |
| Replacement | 116 | 100 | 30 | 300 |
| Moderate (Mixed) |  |  |  |  |
| Low (Surface) |  |  |  |  |
| All Fires | 116 | 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

Patch sizes are generally 1,000s-10,000s of acres in variable mosaics, including forest land and meadows. Landscape are never in equilibrium, except possibly considering very large scales that exceed 300,000ac.

Adjacency or Identification Concerns

In Wyoming, this group is adjacent to lodgepole pine and upper subalpine groups, and will be found above Douglas-fir and ponderosa types in elevation. Vegetation classes may vary significantly.

Secondary succession initiated today could have quite different trajectories than 200-300yrs ago because of the warmer and wetter climatic conditions of the last century (in Meyer et al. 2005).

This type might be confused with the Subalpine Spruce Fir Forests 1056. This system, however, incorporates more of the lodgepole and is at somewhat lower elevations and might be drier. Note that some of the Engelmann spruce/subalpine fir should be keyed to 1056 as well as 1050/1055 in MZ29.

Blister rust increased in 1900s. At present time, dwarf mistletoe occurs at higher levels than in the HRV (Meyer et al. 2005).

In the Bighorns, a full range of size and age class structures probably existed during the HRV period, ranging from young to older even-aged stands of lodgepole, many having developed after fires in the 1600s and 1700s to uneven-aged stands that hadn't burned for centuries and were dominated primarily by Engelmann spruce and subalpine fir. The fires would have killed many of the big trees from time to time, and they probably burned over large areas. Consequently, tree size would have ranged from uniformly small trees after the stand was recently burned to very large trees with small trees when the stand hadn't been disturbed for long periods. Since the late 1800s, both human-caused fire and timber harvest have converted areas with large, old trees to stands of younger, smaller trees, with the exception that timber harvesting could extend into areas that hadn't burned for centuries, such as on leeward slopes or in ravines. When timber harvesting in those areas doesn't provide sufficient time to allow regrowth of old trees, age and size class structure is outside of the HRV. Across the rest of the landscape where disturbances were historically more common, the variety of age and size class structures with and without clearcutting is probably within the HRV; both clearcutting and intense fires would create the kind of size class structure characteristic of even-aged stands, and currently, the forest stands have not been cut more frequently than the rate at which fires have burned stands. However, because planned rotation times are shorter than natural FRIs, the average harvested stand won't be able to achieve old-growth characteristics and thus stand age and size structure may eventually exceed the HRV (Meyer et al. 2005).

In the Bighorns, due to thinning and selective harvesting, percent canopy cover is probably lower than that of the HRV (Meyer et al. 2005).

In the Bighorns, under existing conditions, tree densities might still fall within the moderately broad HRV, because even though trees have been partially or completely removed on about 20% of the landscape, fires may have removed half of that anyway if fire suppression had not been practiced. Canopy gap density and cover may be slightly below the HRV, but after 20yrs, these variables return to more natural conditions (Meyer et al. 2005). Stand variables averaged at the landscape scale could go beyond the HRV because of the abundance of older forests, mineral soil disruption or compaction, snag density and abundance of coarse woody debris (Meyer et al. 2005).

Issues or Problems

This system will be highly heterogeneous and dynamic; this system has a very wide range of variability.

Native Uncharacteristic Conditions

There might be lower canopy cover and less old-growth today in parts of the Bighorns.

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 | 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 | UN | UN | UN | UN | UN | UN | UN | UN | UN | UN |
| Tree | 0-5 | C | C | C | B | B | B | B | UN | UN | UN |
| Tree | 5-10 | C | C | C | B | B | B | B | UN | UN | UN |
| Tree | 10-25 | D | D | D | D | E | E | E | UN | UN | UN |
| Tree | 25-50 | UN | UN | UN | UN | UN | UN | UN | UN | UN | UN |
| Tree | >50 | UN | UN | UN | UN | UN | UN | UN | UN | UN | UN |

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 17 Early Development 1 - All Structures

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PICO | Pinus contorta | Lodgepole pine | Upper |
| PIEN | Picea engelmannii | Engelmann spruce | Upper |

Description

These are seedling/sapling trees <1" DBH, and generally <6ft in height

Range of 3-50% of a landscape, depending on climatic conditions and size of landscape. Early succession after moderately long to long interval replacement fires. Buttery and Gillam's (1987) HSS 1, 2. Time in class is dependent on scale and intensity of disturbance, but generally moves out within 20yrs and goes to a mid-closed stage, B. Alternatively, succession, under the right conditions, can move to a closed stage.

*Maximum Tree Size Class*  
Seedling <4.5ft

Class B 34 Mid Development 1 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PICO | Pinus contorta | Lodgepole pine | Upper |
| PIEN | Picea engelmannii | Engelmann spruce | Lower |

Description

This is dog hair lodgepole <5" DBH and 25ft tall.

Range of 5-50% of a landscape, depending on climatic conditions and size of landscape. Saplings to poles in size. Buttery and Gillam's (1987) HSS 3B, 3C. Includes classic "dog hair" stands.

There is probably more of this class in current vs. historical conditions, at least in the Bighorns (Meyer et al. 2005).

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

Class C 8 Mid Development 1 - Open

Indicator Species

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

Description

This is open grown pole sized lodgepole <9" DBH and 35ft in height.

Range of 3-50% of a landscape, depending on climatic conditions and size of landscape. Saplings to poles. Buttery and Gillam's (1987) HSS 3A. Succession primarily to the late open stage. Alternately, under the right conditions, succession can also occur toward a late closed stage.

There is probably more of this class in current vs historical conditions, at least in the Bighorns (Meyer et al. 2005).

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

Class D 10 Late Development 1 - Open

Indicator Species

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

Description

Range of 2-15% of a landscape, depending on climatic conditions and size of landscape. Edaphic conditions control the density of this class. Moderate to large-diameter mixed conifer, generally on south aspects and shallow, intermittent rocky soils.

There is probably less old growth in current vs. historical conditions (Meyer et al. 2005).

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

Class E 31 Late Development 1 - Closed

Indicator Species

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

Description

Range of 15-50% of a landscape, depending on climatic conditions and size of landscape. Moderate to large-diameter trees largely on mesic sites (e.g., north slopes). This is closed lodgepole stands of <9" DBH and <50ft tall.

There is probably less old growth in current vs historical conditions (Meyer et al. 2005).

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

Model Parameters

Deterministic Transitions

|  |  |  |  |
| --- | --- | --- | --- |
| **From Class** | **Begins at (yr)** | **Succeeds to** | **After (years)** |
| Early1:ALL | 0 | Mid1:CLS | 20 |
| Mid1:OPN | 21 | Late1:OPN | 80 |
| Mid1:CLS | 21 | Late1:CLS | 80 |
| Late1:OPN | 81 | Late1:CLS | 300 |
| Late1:CLS | 81 | 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** |
| Alternative Succession | Early1:ALL | Mid1:OPN | 0.002 | 500 | Yes | 0 |
| Replacement Fire | Early1:ALL | Early1:ALL | 0.003 | 333 | Yes | 0 |
| Insects or Disease | Mid1:OPN | Mid1:OPN | 0.001 | 1000 | No | 0 |
| Alternative Succession | Mid1:OPN | Late1:CLS | 0.001 | 1000 | Yes | 0 |
| Wind or Weather or Stress | Mid1:OPN | Mid1:OPN | 0.0015 | 667 | No | 0 |
| Replacement Fire | Mid1:OPN | Early1:ALL | 0.01 | 100 | Yes | 0 |
| Insects or Disease | Mid1:CLS | Early1:ALL | 0.0001 | 10000 | Yes | 0 |
| Wind or Weather or Stress | Mid1:CLS | Mid1:OPN | 0.001 | 1000 | Yes | 0 |
| Insects or Disease | Mid1:CLS | Mid1:OPN | 0.0015 | 667 | Yes | 0 |
| Replacement Fire | Mid1:CLS | Early1:ALL | 0.01 | 100 | Yes | 0 |
| Wind or Weather or Stress | Late1:OPN | Mid1:OPN | 0.001 | 1000 | Yes | 0 |
| Insects or Disease | Late1:OPN | Mid1:OPN | 0.001 | 1000 | Yes | 0 |
| Wind or Weather or Stress | Late1:OPN | Late1:OPN | 0.001 | 1000 | No | 0 |
| Insects or Disease | Late1:OPN | Late1:OPN | 0.001 | 1000 | No | 0 |
| Competition or Maintenance | Late1:OPN | Late1:OPN | 0.001 | 1000 | No | 0 |
| Replacement Fire | Late1:OPN | Early1:ALL | 0.01 | 100 | Yes | 0 |
| Insects or Disease | Late1:CLS | Early1:ALL | 0.0001 | 10000 | Yes | 0 |
| Wind or Weather or Stress | Late1:CLS | Late1:OPN | 0.001 | 1000 | Yes | 0 |
| Insects or Disease | Late1:CLS | Mid1:OPN | 0.0015 | 667 | Yes | 0 |
| Replacement Fire | Late1:CLS | Early1:ALL | 0.01 | 100 | Yes | 0 |

References

Alexander, R.R., G.R. Hoffman and J.M Wirsing. 1986. Forest vegetation of the Medicine Bow National Forest in southeastern Wyoming: a habitat type classification. Research Paper RM-271. Fort Collins, CO: Rocky Mountain Forest and Range Experiment Station.

Alexander, R.R. 1988. Forest vegetation on national forests in the Rocky Mountain and Intermountain regions: habitat types and community types. General Technical Report RM-162. Fort Collins, CO: Rocky Mountain Forest and Range Experiment Station.

Amman, G.D., M.D. McGregor, D.B. Cahill and W.H. Klein. 1977. Guidelines for reducing losses of lodgepole pine to the mountain pine beetle in unmanaged stands in the Rocky Mountains. General Technical Report INT-36. Ogden, UT: USDA Forest Service, Intermountain Research Station.

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.

Baker, W.L. and R. Knight. 2000. Roads and forest fragmentation in the southern Rocky Mountains. Pages 97-122 in: R. Knight, F.W. Smith, W.H. Romme and W.L. Baker, eds. Forest fragmentation in the Southern Rocky Mountains. Boulder, CO: University Press of Colorado.

Baker, W.L. 2000. Measuring and analyzing forest fragmentation in the Rocky Mountains and western United States. Pages 55-94 in: R. Knight, F.W. Smith, W.H. Romme and W.L. Baker, eds. Forest fragmentation in the Southern Rocky Mountains. Boulder, CO: University Press of Colorado.

Baker, W.L. and K.F. Kipfmueller. 2001. Spatial ecology of pre-Euro-American fires in a southern Rocky Mountain subalpine forest landscape. The Professional Geographer 53(2): 248-262.

Baker, W.L. 1994. Landscape structure measurements for watersheds in the Medicine Bow National Forest using GIS analysis. Department of Geography and Recreation, Univ. of Wyoming. Prepared under agreement with the USDA Forest Service, Medicine Bow NF. On file at Medicine Bow-Routt NFs and Thunder Basin NG Supervisor's Office, Laramie, WY.

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. 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.

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.

Bartos, D.L. 2001. Landscape dynamics of aspen and conifer forests. Pages 5-14 in: W.D. Shepperd, D. Binkley, D.L. Bartos, T.J. Stohlgren and L.G. Eskew, compilers. 2001. Sustaining aspen in western landscapes: symposium proceedings; 13-15 June 2000; Grand Junction, CO. Proceedings. RMRS-P-18. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 460 pp.

Buechling, A. and W.L. Baker. 2004. A fire history from tree rings in a high-elevation forest of Rocky Mountain National Park. Canadian Journal of Forest Research 34: 1259-1273.

Buskirk, S.W., W.H. Romme, F.W. Smith and R. Knight. 2000. An overview of forest fragmentation in the Southern Rocky Mountains. Pages 3-14 in: R. Knight, F.W. Smith, W.H. Romme and W.L. Baker, eds. Forest Fragmentation in the Southern Rocky Mountains. Boulder, CO: University Press of Colorado.

Buttery, R.F. and B.C. Gillam. 1987. Forested ecosystems. In: R.L. Hoover and D.L. Wills, eds. Managing forested lands for wildlife. Colorado Division of Wildlife in cooperation with USDA Forest Service, Rocky Mountain Region, Denver, CO.

Cleland, D.T.; Freeouf, J.A.; Keys, J.E.; Nowacki, G.J.; Carpenter, C.A.; and McNab, W.H. 2007. Ecological Subregions: Sections and Subsections for the conterminous United States. Gen. Tech. Report WO-76D [Map on CD-ROM] (A.M. Sloan, cartographer). Washington, DC: U.S. Department of Agriculture, Forest Service, presentation scale 1:3,500,000; colored

Coleman, M.D., T.M. Hinckley, G. McNaughton and B.A. Smit. 1992. Root cold hardiness and native distribution of sub-alpine conifers, Canadian Journal of Forest Research. 22(7): 932-938.

Crane, M.F. 1982. Fire ecology of Rocky Mountain Region forest habitat types. Report prepared under contract to USDA Forest Service Region 2.

Despain, D.G. 1973. Vegetation of the Big Horn Mountains in relation to substrate and climate. Ecological Monographs 43:329-355.

Despain, D.G. and R.E. Sellers. 1977. Natural fire in Yellowstone National Park. Western Wildlands, summer 1977.

Dillon, G.K., D. Knight and C. Meyer. 2003. Historic variability for upland vegetation in the Medicine Bow National Forest. Department of Botany, Univ. of Wyoming: prepared under agreement with the USDA Forest Service Medicine Bow NF 1102-0003-98-043.

Graham, R.T. A.E. Harvey, M.F. Jurgensen, T.B. Jain, J.R. Tonn and D.S. Page-Dumrose. 1994. Managing coarse woody debris in forests of the Rocky Mountains. Research Paper INT-RP-477. Fort Collins, CO: USDA Forest Service, Intermountain Research Station.

Honaker, J.J. 1995. Fire history in the Tie Camp area of the Sierra Madre Mountains, WY. Master’s Thesis, Dept. of Botany, Univ. of Wyoming, Laramie, WY.

Jones, G.P. and S.M. Ogle. 2000. Characterization abstracts for vegetation types on the Bighorn, Medicine Bow, and Shoshone National Forests. Laramie. Prepared for USDA Forest Service, Region 2, by George Jones and Steve Ogle, WYNDD, UW, Laramie WY.

Kane, T.L., B.G. Brown and R. Sharman. 1999. A preliminary climatology of upper level turbulence reports. Preprints, 8th Conf. on Aviation, Range and Aerospace Meterology, 10-15 January, Dallas, TX, American Meteorology Society, 363-367.

Kaufmann. M.R. 1992. Carbon, water, and nutrient relations – distinguishing functional features of old growth lodgepole pine forests in the southern Rocky Mountains. In: Old-growth forests in the Southwest and Rocky Mountain Regions proceedings of a workshop. Gen. Tech. Report RM-213. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

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

Kipfmueller, K.F. 1997. A fire history of a subalpine forest in southeastern Wyoming. Thesis. University of Wyoming. Laramie, WY.

Kipfmueller, K.F. and W.L. Baker. 1998a. A comparison of three techniques to date stand-replacing fires in lodgepole pine forests. Forest Ecology and Management 104: 171-177.

Kipfmueller, K.F. and W.L. Baker. 1998b. Fires and dwarf mistletoe in Rocky Mountain lodgepole pine ecosystem. Forest Ecology and Management 108: 77-84.

Knight, D.H. 1987. Ecosystem studies in the subalpine coniferous forests of Wyoming. In: Management of subalpine forests: building on 50 years of research: proceedings of a technical conference. General Technical Report RM-149. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Knight, D.H. 1994. Mountains and Plains, The Ecology of Wyoming Landscapes. New Haven, CT: Yale University Press. 338 pp.

Knight, D.H. and W.A. Reiners. 2000. Natural patterns in southern Rocky Mountain landscapes and their relevance to forest management. Pages 15-30 in: R. Knight, F.W. Smith, W.H. Romme and W.L. Baker, eds. Forest fragmentation in the Southern Rocky Mountains. Boulder, CO: University Press of Colorado.

Knight, D.H., A.D. Anderson, G.T. Baxter, K.L. Diem, M. Parker, P.A. Rechard, P.C. Singleton, J.F. Thilenius, A.L. Ward and R.W. Weeks. 1975. Final report: the Medicine Bow ecology project: the potential sensitivity of various ecosystem components to winter precipitation management in the Medicine Bow Mountains, Wyoming. Prepared for the Division of Atmospheric Water Resources Management, Bureau of Reclamation, USDI, Denver, CO by the Rocky Mountain Forest and Range Experiment Station, USDA Forest Service and the Wyoming Water Resource Research Institute.

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.

Lundquist, J.E. In press. An interpretation of landscape scale spatial patterns in a lodgepole pine forest infected by dwarf mistletoe. Copy on file at Medicine Bow-Routt NFs and Thunder Basin NG Supervisor’s Office, Laramie, WY.

Mehl, M. 1992. Old-growth descriptions for the major forest cover types in the Rocky Mountain region. In: Old-growth forests in the Southwest and Rocky Mountain regions. Proceedings of a workshop. Gen. Tech. Report RM-213. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Merrill, E.H., T.W. Kohley, M.E. Herdendorf, W.A. Reiners, K.L. Driese, R.W. Marrs and S.A. Anderson. 1996. Wyoming GAP analysis project final report. University of Wyoming Department of Physiology and Department of Botany, Wyoming Cooperative Fish and Wildlife Research Unit and USGS Biological Resources Division. Available: http://www.sdvc.uwyo.edu/wbn/abstract.html.

Meyer, C.B. and D.H. Knight. 2001. Historic variability of upland vegetation in the Bighorn National Forest, Wyoming. Draft report, November 30, 2001.

Meyer, C.B., D.H. Knight and G.K. Dillon 2005. Historic range of variability for upland vegetation in the Bighorn National Forest, Wyoming. RMRS-GTR-140. USDA Rocky Mountain Research Station.

Moir, W.H. 1992. Ecological concepts in old-growth forest definition. In: Old-growth forests in the Southwest and Rocky Mountain regions. Proceedings of a workshop. Gen. Tech. Report RM-213. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

NatureServe. 2006. International Ecological Classification Standard: Terrestrial Ecological

Classifications. NatureServe Central Databases. Arlington, VA, U.S.A. Data current as of

18 July 2006.

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

Pennanen, J. 2002. Forest age distribution under mixed-severity fire regimes - A simulation-based analysis for middle boreal Fennoscandia. Silva Fennica: quarterly issues: 36(1): 213-231.

Renkin, R.A. and D.G. Despain. 1992. Fuel moisture, forest type and lightning-caused fire in Yellowstone National Park. Canadian Journal of Forest Research 22: 37-45.

Rignot, E., D.G. Despain and F. Holecz. 1999. The 1988 Yellowstone Fires Observed by Imaging Radars. Joint Fire Science Conf. and Workshop, Boise ID. Published by the Univ. of Idaho and the Int. J. of Wildland Fire.

Romme, W.H., M.L. Floyd, D. Hanna and J.S. Redders. 1999. Landscape condition analysis for the South Central Highlands Section, southwestern Colorado & northwestern New Mexico. Draft report to San Juan National Forest, Durango, CO.

Romme, W.H. 2002. Range of natural variability in subalpine landscape structure on the Bighorn National Forest, Wyoming: a hypothesis. Unpublished report prepared for the Bighorn National Forest. On file at Medicine Bow-Routt NFs and Thunder Basin NG Supervisor’s Office, Laramie, WY.

Romme, W.H. 1977. Vegetation in relation to elevation topography, and fire history in a Wyoming montane watershed. Master’s Thesis, Department of Botany, Univ. of Wyoming, Laramie, WY.

Romme, W.H. 1980. Fire frequency in subalpine forests of Yellowstone National Park. proceedings of the fire history workshop. Oct 20-24, 1980. Gen. Tech Report RM-81. Fort Collins, CO: USDA Rocky Mountain Research Station.

Romme, W.H. and D.G. Despain. 1989. Historical perspectives on the Yellowstone fires of 1988. BioScience 39(10): 695-699.

Romme, W.H. 1982. Fire and landscape diversity in subalpine forests of Yellowstone National Park. Ecological Monographs 52(2): 199-221.

Romme, W.H. and D.H. Knight. 1981. Fire frequency and subalpine forest succession along a topographic gradient in Wyoming. Ecology 62: 319-326.

Rothermel, R.C., R.A. Hartford and C.H. Chase. 1994. Fire growth maps for the 1988 Greater Yellowstone Area fires. Gen.Tech.Rep. INT-304. Fort Collins, CO: USDA Forest Service. Intermountain Research Station.

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.

Schrupp, D.L., W.A. Reiners, T.G. Thompson, L.E. O'Brien, J.A. Kindler, M.B. Wunder, J.F. Lowsky, J.C Buoy, L. Satcowitz, A.L. Cade, J.D. Stark, K.L. Driese, T.W. Owens, S.J. Russo and F. D'Erchia. 2000. Colorado Gap Analysis Program: A geographical approach to planning for biological diversity - final report. Denver, CO: USGS Biological Resource Division, Gap Analysis Program and Colorado Division of Wildlife.

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.

Tinker, D.B. 1999. Coarse woody debris in Wyoming lodgepole pine forests. Ph.D. dissertation. University of Wyoming. Laramie, WY.

Tinker, D.B. and D.H. Knight. 2001. Temporal and spatial dynamics of coarse woody debris in harvested and unharvested lodgepole pine forests. Ecological Modeling 141(2000): 125-149.

Turner, M.G., R.H. Gardner and R.V. O’Neill. 2001. Landscape ecology in theory and practice. Springer-Verlag, New York.

Turner, M.G., W.H. Romme, R.H. Gardner and W.W. Hargrove. 1997. Effects of fire size and pattern on early succession in Yellowstone National Park. Ecological Monographs: vol 67(4): 411-433.

Turner, M.G., W.H. Romme, R.H. Gardner, R.V. O'Neill and T.K. Kratz. 1993. A revised concept of landscape equilibrium: disturbance and stability on scaled landscapes. Landscape Ecology 8: 213-227.

Turner, M.G., W.W. Hargrove, R.H. Gardner and W.H. Romme. 1994. Effects of fire on landscape heterogeneity in Yellowstone National Park, Wyoming. Journal of Vegetation Science 5.5.