11792

Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna - Savanna

BpS Model/Description Version: Aug. 2020

|  |  |  |  |
| --- | --- | --- | --- |
| **Modelers** |  | **Reviewers** |  |
| Cody Wienk | cody\_wienk@nps.gov | Peter Brown | pmb@rmtrr.org |
| Jeff DiBenedetto | jdibenedetto@fs.fed.us | Bill Schaupp | bschaupp@fs.fed.us |
| Chris Thomas | cthomas@fs.fed.us | Ken Marchand | kmarchand@fs.fed.us |

**Reviewed by:** Shannon Murphy

Vegetation Type

Forest and Woodland

Map Zones

29, 30

Model Splits or Lumps

This Biophysical Setting (BpS) is lumped with 1013.

Geographic Range

This BpS is located primarily in the lower elevations of the Black Hills in western South Dakota and northeastern Wyoming as well as southeastern Montana. But also includes small patches in southwestern North Dakota and northeastern Wyoming, including the Rochelle Hills of the Thunder Basin National Grassland. This describes areas in map zone (MZ) 29 and 30. In MZ29, it generally occurs east of the Bighorn and Laramie Ranges (including sections 331G, 331K, and 331F; subsections M334Aa, 331Mi, and 331Md).

This is the ponderosa pine savanna that is not in the Rocky Mountains.

Biophysical Site Description

The geology is typically sedimentary in origin. Often found on buttes, hogbacks, rocky outcrops, and steep, rocky slopes. Elevations range from 3,200-4,400ft, but in the southern Black Hills may be found up to 5,700ft on southern aspects. In eastern Montana and northeast Wyoming, it is also found on southern aspects.

Vegetation Description

This type is dominated by Rocky Mountain ponderosa pine and is often the only tree present. Understory composition varies, but Rocky Mountain juniper, common juniper, fringed sagebrush, skunkbush sumac, true-mountain mahogany (in southern Black Hills and the eastern Pine Ridge), and yucca are common woody species (one reviewer noted that under the historic fire regime, the occurrence of yucca would have been a bit lower than at present). Bur oak might occur in this system as well. Currant and chokecherry are found in the Montana portion of the BpS's range.

Regional lead asked about Rocky Mountain juniper (JUSC2) as an indicator for the Black Hills: JUSC2 really is a component and indicator of many of the ponderosa pine savanna areas. The species generally becomes more prominent in the pine savanna as the soils become more skeletal or as the soil profile and surface contain more rock fragments. There may be some sites where it is a very limited component. JUSC2 can also be considered an indicator for Thunder Basin. Rocky Mountain juniper is listed as present in late successional communities for ponderosa pine/ Idaho fescue, ponderosa pine/sun sedge, and ponderosa pine/bluebunch wheatgrass habitat types by Hanson and Hoffman (1988) for southeastern Montana. But it's not mentioned as present in the other ponderosa pine habitat types (ponderosa pine/common juniper, ponderosa pine/ chokecherry). Rocky Mountain juniper is not an indicator for ponderosa pine habitat types in southeastern Montana or western North Dakota.

Herbaceous species include needlegrasses, grama grasses, little bluestem, western wheatgrass, sedges, and bluebunch wheatgrass. There is Idaho fescue as far east as Ashland, Montana.

BpS Dominant and Indicator Species

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** |
| PIPO | *Pinus ponderosa* | Ponderosa pine |
| JUSC2 | *Juniperus scopulorum* | Rocky mountain juniper |
| RHTR | *Rhus trilobata* | skunkbush sumac |
| PSSP6 | *Pseudoroegneria spicata* | Bluebunch wheatgrass |
| PASM | *Pascopyrum smithii* | Western wheatgrass |
| CAREX | *Carex* | Sedge |
| SCSC | *Schizachyrium scoparium* | Little bluestem |
| QUMA2 | *Quercus macrocarpa* | Bur oak |

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

Disturbance Description

Historically fires in low-elevation ponderosa pine savannas were generally frequent, low-severity surface fires. Fire regimes of savannas are influenced by the frequent fires in the surrounding grasslands, which often carry into adjacent savannas and woodlands (Brown, 35536; Stambaugh, 90564). Fires occurred approximately every 5-25yrs, depending on the proportion of trees and grasses as well as variations in microclimate, topography, and fire reconstruction sampling method (Brown 2003; Brown and Sieg 1999; Fisher et al. 1987; Perryman and Laycock 2000; Shilts et al. 1980; Stambaugh et al. 2008). See Murphy (2017) for a synthesis of fire regimes in the ponderosa pine communities of the Black Hills and surrounding areas.

Generally frequent fires of low severity (Fire Regime Group I). Mixed-severity fire occurs in the closed canopy conditions, and stand-replacement fire is very infrequent (300yrs+). Low-severity fires are frequent and range from <10yrs to >20yrs (Brown and Sieg 1999; Fisher et al. 1987) but probably not >40yrs at the high end (3-70yrs range). The mean fire return interval (MFRI) is ~12-15yrs for low-severity fires.

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, 2003; Barrett 2004; Veblen et al. 2000). However, Brown (2006) argues that surface fire was the dominant mode of fire disturbance and that the role of mixed-severity fires is overstated.

In the Rapid Assessment (RA) workshop, review indicated that more mixed fire should occur in the early stage and that surface fire should be modeled in all structural stages. Peer review comments during the RA disagreed on the role of mixed and surface fire in this type. The majority of reviewers agreed with the original model's parameters for mixed fire but thought surface fire could be slightly less frequent. One reviewer contended that there is no evidence of mixed-severity fire in this type at all and that the overall MFRI should be ~25yrs.

For MZs 29 and 30, it was suggested that mixed fire be removed from this model; reviewers agreed, and therefore mixed fire is not in the model.

Variation in precipitation and temperature interacting with fire, tip moths, and ungulate grazing affects pine regeneration. Windthrow, storm damage and mountain pine beetles were minor disturbances in this type unless stands reached high densities. The interactions among drought, insects, and disease are not well understood.

Ips spp. of bark beetles can cause significant mortality among pole-sized and larger-diameter pines, especially those weakened by drought, fire injury, and the hail-related native disease *diplodia*. This serves to maintain the late-development open stage (Class D) and move the late-development closed stage (Class E) to the late-development open stage (Class D).

In ponderosa pine, bur oak occurs with fire-adapted species. When a stand-replacing fire occurs, system will get big patches of bur oak that will persist until the pine comes in. Bur oak is moderately shade-intolerant (according to <https://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/summary_of/tree_characteristics.htm>).

In the northern Black Hills, there is a separate bur oak community type with a long fire return interval (FRI).

Ponderosa pine -- *Juniperus scopulorum savanna* in the southern Black Hills has lots of rock exposure or sparsely grassed soils, which probably protected some of the juniper seed trees from being wiped out by fire.

Fire intervals found at Wind Cave National Park are among the shortest documented for northern ponderosa pine forests. Fire frequencies at Wind Cave sites are comparable to those found in southwestern United States ponderosa pine forests and some lower-elevation ponderosa pine sites in the northern Rocky Mountains (Brown and Sieg 1999).

In the Rochelle Hills, the mean fire-free interval (Weibull Median Probability Interval [WMPI]) of the non-suppression period is not statistically different from the mean fire-free interval of the suppression period. Although suppression period sample size is limited, our estimates of minimum frequencies should limit the power (lowering the chance of not detecting a difference when there is a difference) that greater sample numbers (fire years) would generate (Perryman and Laycock 2000).

Most of southern and southwestern forested areas of the Rochelle Hills have somewhat closed canopies, substantial amounts of litter accumulations, and relatively high tree densities. This set of circumstances will most likely lead to a future catastrophic fire, but it is unclear if fire exclusion activities have given rise to this condition or if this condition is a part of the natural cycle in the ecology of this system (Perryman and Laycock 2000).

Fire Frequency

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Severity** | **Avg FI** | **Percent of All Fires** | **Min FI** | **Max FI** |
| Replacement | 382 | 4 |  |  |
| Moderate (Mixed) |  |  |  |  |
| Low (Surface) | 15 | 96 | 3 | 70 |
| All Fires | 15 | 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

Disturbance patch size probably ranged from 10s-10,000s of acres.

Adjacency or Identification Concerns

This type is either surrounded by Northern Plains grasslands and shrublands or is a transition between Northern Plains grasslands and shrublands and higher-elevation coniferous forests. Ponderosa pine in this BpS has encroached into the Northern Plains grassland and shrubland types in many areas due to fire exclusion and grazing.

As this system model and description is a copy of 1117, this system will be difficult to distinguish from that one and is only distinguished by geography.

Invasive species in this system include cheatgrass, Japanese brome, crested wheatgrass, Kentucky bluegrass, and intermediate wheatgrass. Crested wheatgrass and cheatgrass are at lower elevations mostly. Cheatgrass has altered the fire frequency and extent.

Currently, there have probably been at least 5-10 fire cycles that have been missed due to exclusion, grazing, etc. Therefore, the system today would look much more like the late closed stage with ~50-80% canopy closure -- uncharacteristic. Also encroachment into prairies by pine and juniper is an issue today (juniper becomes more of an issue further east; it’s primarily ponderosa pine that is encroaching in the Nebraska area), although JUSC2 is an indicator, at least in the Black Hills. Generally, the juniper that is an issue with the prairies east of the Black Hills is the Eastern red cedar. As it continues to be incorporated into windbreaks, it continues to invade into new areas.

Hardwoods exist in drainages, which encompass a separate BpS. In Nebraska, there is green ash, chokecherry, hackberry, and American elm, which get crowded out by the ponderosa pine.

Currently expanding into grasslands and shrublands because of fire exclusion, grazing, and natural expansion from Holocene rebound (Norris 2006).

Issues or Problems

Native Uncharacteristic Conditions

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 | 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 | C | C | C | C | C | B | B | B | B | B |
| Tree | 5-10 | C | C | C | C | C | B | B | B | B | B |
| Tree | 10-25 | D | D | D | D | D | D | D | D | D | D |
| Tree | 25-50 | D | D | D | D | D | D | D | D | D | D |
| Tree | >50 | D | D | D | D | D | D | D | D | D | D |

Succession class letters A-E are described in the Succession Class Description section. Some classes use a leafform distinction where a qualifier is added to the class letter: Brdl (broadleaf), Con (conifer), or Mix (mixed conifer and broadleaf). UN refers to uncharacteristic native or a combination of height and cover that would not be expected under the reference condition. NP refers to not possible or a combination of height and cover which is not physiologically possible for the species in the BpS.

**Description**

Class A 5 Early Development 1 - All Structures

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| NAVI4 | Nassella viridula | Green needlegrass | Mid-Upper |
| PASM | Pascopyrum smithii | Western wheatgrass | Mid-Upper |
| PSSP6 | Pseudoroegneria spicata | Bluebunch wheatgrass | Mid-Upper |
| CAREX | Carex | Sedge | Low-Mid |

Description

This community is dominated by herbaceous and woody species, including the graminoids -- needlegrasses, western wheatgrass, bluebunch wheatgrass, sedges, Idaho fescue, and little bluestem in moister areas -- and various shrubs including skunkbush sumac and snowberry. Ponderosa pine seedlings are scattered and found in small clumps.

Little bluestem will also be indicator species. Needlegrasses can be tall up to 1m, but other graminoids are typically <0.5m.

Upper-layer lifeform is not the dominant lifeform; shrubs are the upper layer, perhaps, but cover is <20%.

*Maximum Tree Size Class*  
Seedling <4.5ft

Class B 2 Mid Development 1 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIPO | Pinus ponderosa | Ponderosa pine | Upper |

Description

Multi-story stands of small and medium trees with saplings and seedlings coming in as clumps. Understory is sparse. Some juniper might be present -- could be an outlier. Grasses and shrubs are shaded out.

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

Class C 8 Mid Development 1 - Open

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIPO | Pinus ponderosa | Ponderosa pine | Upper |
| NAVI4 | Nassella viridula | Green needlegrass | Lower |
| PASM | Pascopyrum smithii | Western wheatgrass | Lower |
| PSSP6 | Pseudoroegneria spicata | Bluebunch wheatgrass | Lower |

Description

Predominantly single-story stands with a few pockets of regeneration. Low shrubs such as skunkbush sumac and western poison ivy are common as well as grasses and forbs. Graminoids could have up to 70-80% cover. Rocky Mountain juniper present in patches.

Carex spp. and little bluestem will also be indicator species.

Upper-layer lifeform is not the dominant lifeform; graminoids could have up to 60-80% cover (Hansen and Hoffmann 1988). Grasses co-dominate.

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

Class D 80 Late Development 1 - Open

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIPO | Pinus ponderosa | Ponderosa pine | Upper |
| NAVI4 | Nassella viridula | Green needlegrass | Lower |
| PASM | Pascopyrum smithii | Western wheatgrass | Lower |
| PSSP6 | Pseudoroegneria spicata | Bluebunch wheatgrass | Lower |

Description

Predominantly single-story stands of large ponderosa pine with pockets of smaller size classes (replacement). Snowberry, skunkbush sumac, and patches of Rocky Mountain juniper. Understory is dominated by shrub species, grasses, and western poison ivy. Graminoids could have up to 70-80% cover.

Upper-layer lifeform is not the dominant lifeform; graminoids could have up to 60-80% cover. Grasses co-dominate. Carex spp, and little bluestem will also be indicator species

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

Class E 5 Late Development 1 - Closed

Indicator Species

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol** | **Scientific Name** | **Common Name** | **Canopy Position** |
| PIPO | Pinus ponderosa | Ponderosa pine | Upper |

Description

This is a somewhat uniform late-development stage, multi-story stands of large, medium, small, and seedling ponderosa pine. Shrubs and grasses are sparse. This type generally >70% canopy cover. DBH is less in this class than late-open.

*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:OPN | 29 |
| Mid1:CLS | 26 | Late1:CLS | 95 |
| Mid1:OPN | 30 | Late1:OPN | 80 |
| Late1:OPN | 81 | Late1:OPN | 999 |
| Late1:CLS | 96 | 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:CLS | 1 | 1 | Yes | 25 |
| Replacement Fire | Early1:ALL | Early1:ALL | 0.02 | 50 | Yes | 0 |
| Surface Fire | Early1:ALL | Early1:ALL | 0.03 | 33 | No | 0 |
| Alternative Succession | Mid1:OPN | Mid1:CLS | 1 | 1 | Yes | 40 |
| Replacement Fire | Mid1:OPN | Early1:ALL | 0.0015 | 667 | Yes | 0 |
| Surface Fire | Mid1:OPN | Mid1:OPN | 0.0667 | 15 | No | 0 |
| Replacement Fire | Mid1:CLS | Early1:ALL | 0.0033 | 303 | Yes | 0 |
| Insects or Disease | Mid1:CLS | Mid1:CLS | 0.02 | 50 | No | 0 |
| Surface Fire | Mid1:CLS | Mid1:OPN | 0.0667 | 15 | Yes | 0 |
| Alternative Succession | Late1:OPN | Late1:CLS | 1 | 1 | Yes | 40 |
| Replacement Fire | Late1:OPN | Early1:ALL | 0.0015 | 667 | Yes | 0 |
| Insects or Disease | Late1:OPN | Late1:OPN | 0.02 | 50 | No | 0 |
| Surface Fire | Late1:OPN | Late1:OPN | 0.0667 | 15 | No | 0 |
| Wind or Weather or Stress | Late1:CLS | Late1:OPN | 0.002 | 500 | Yes | 0 |
| Replacement Fire | Late1:CLS | Early1:ALL | 0.0033 | 303 | Yes | 0 |
| Insects or Disease | Late1:CLS | Late1:OPN | 0.004 | 250 | Yes | 0 |
| Surface Fire | Late1:CLS | Late1:OPN | 0.0667 | 15 | Yes | 0 |

References

Baker, W.L. and D.S. Ehle. 2001. Uncertainty in surface-fire history: The case of ponderosa pine forests in the western United States. Canadian Journal of Forest Research 31: 1205-1226.

Baker, W.L. and D.S. Ehle. 2003. Uncertainty in fire history and restoration of ponderosa pine forests in the western United States. Pages 319-333 in: P.N. Omi and L.A. Joyce, tech. eds. Fire, fuel treatments, and ecological restoration: conference proceedings; 2002 April 16-18; Fort Collins, CO. Proceedings RMRS-P-29. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station.

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.

Bock, J.H. and C.E. Bock. 1984. Effects of fires on woody vegetation in the pine-grassland ecotone of the southern Black Hills. American Midland Naturalist 112: 35-42.

Brown, P.M. 2003. Fire, climate, and forest structure in ponderosa pine forests of the Black Hills. Fort Collins, CO: Colorado State University. 103 p. Dissertation.

Brown, P.M. 2006. Climate effects on fire regimes and tree recruitment in Black Hills ponderosa pine forests. Ecology. 87(10): 2500-2510.

Brown, P.M. and C.H. Sieg. 1999. Historical variability in fire at the ponderosa pine - Northern Great Plains prairie ecotone, southeastern Black Hills, South Dakota. Ecoscience 6(4): 539-547.

Fischer, W.C. and B.D. Clayton. 1983. Fire ecology of Montana forest habitat types east of the Continental Divide. Gen. Tech. Rep. INT-141. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 83 pp.

Fisher, R.R., M.J. Jenkins and W.F. Fischer. 1987. Fire and the prairie-forest mosaic of Devils Tower National Monument. American Midland Naturalist. 117: 250-257.

Furniss, R.L. and V.M. Carolin. 1977. Western forest insects. Misc publication #1339. 654 pp. USDA Forest Service.

Girard, M.M., H. Goetz and A.J. Bjugstad. 1989. Native woodland habitat types of southwestern North Dakota. USDA Forest Service Research Paper RM-281.

Hansen, P.L. and G.R. Hoffman. 1988. The Vegetation of the Grand River, Cedar River, and Sioux and Ashland Districts of the Custer National Forest: GTR-RM-157. USDA Forest Service

Kegley, S.J., R.L. Livingston and K.E. Gibson. 1997. Pine engraver, Ips pini in the western United States. Forest Insect and Disease Leaflet 122. USDA Forest Service. 8 pp.

Little, E.L., Jr. 1971. Atlas of United States trees. Vol. 1. Conifers and important hardwoods. USDA Forest Service. Misc. Pub. No. 1146, Washington, D.C.

Marriott, H. J. and D. Faber-Langendoen. 2000. Black Hills Community Inventory. Volume 2: Plant Community Descriptions. The Nature Conservancy and Association for Biodiversity Information, Minneapolis, MN.

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

Murphy, Shannon K. 2017. Fire regimes of ponderosa pine communities of the Black Hills and surrounding areas. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/fire\_regimes/Black\_Hills\_ponderosa\_pine/XX.pdf [2017, June]. (this document is in review and expected to be published online by approximately June 2017)

NatureServe. 2013. International Ecological Classification Standard: Terrestrial Ecological Classifications of the United States and Canada. NatureServe Central Databases. Arlington, VA, U.S.A. (There is now a 2013 version).

Perryman, B.L. and W.A. Laycock. 2000. Fire history of the Rochelle Hills Thunder Basin National Grasslands. J. Range Manage 53: 660–665.

Potter and Green. 1964. Ecology of ponderosa pine in western North Dakota. Ecology 45: 10-23.

Shilts, De.M., R.W. Klukas, B.L. Freet, and T. Oliverius. 1980. Fire management plan: Wind Cave National Park. Hot Springs, SD: U.S. Department of the Interior, Wind Cave National Park. 60 p. On file with: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT.

Shinneman, D.J. and W.L. Baker. 1997. Nonequilibrium dynamics between catastrophic disturbances and old-growth forests in ponderosa pine landscapes of the Black Hills. Conservation Biology 11: 1276-1288.

Sieg, C.H., D. Meko, A.T. DeGaetano and W. Ni. 1996. Dendroclimatic potential in the northern Great Plains. Pages 295-302 in: Dean et al., eds. Tree Rings, Environment and Humanity. Radiocarbon.

Stambaugh, M.C., R.P. Guyette, E.R. McMurry, J.M. Marschall, and G. Willson. 2008. Six

centuries of fire history at Devils Tower National Monument with comments on

regionwide temperature influence. Great Plains Research: A Journal of Natural and Social

Sciences. Lincoln, NE: University of Nebraska. 18(2): 177-187.

Veblen, T.T., T.T. Kitzberger and J. Donnegan. 2000. Climatic and human influences on fire regimes in ponderosa pine forests in the Colorado Front Range. Ecological Applications. 10(4): 1178-1195.

Wendtland, K.J. and J.L. Dodd. 1992. The fire history of Scotts Bluff National Monument. Pages 141-143 in: D.D. Smith and C.A. Jacobs (Eds.) Proceedings of the 12th North American Prairie Conference. University of Northern Iowa, Cedar Falls, IA.