LANDFIRE Biophysical Setting Model

***Biophysical Setting* 2111260** **Inter-Mountain Basins Montane Sagebrush Steppe**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 1/19/2006

Modeler 1	Dave Tart	dtart@fs.fed.us	**Reviewer**	Steve Kilpatrick	steve.kilpatrick@wgf.state.wy.us
Modeler 2	Stan Kitchen	skitchen@fs.fed.us	**Reviewer**	Klara Varga	klara@ida.net
Modeler 3			**Reviewer**		

Vegetation Type
Upland Savannah/Shrub Steppe

Dominant Species
ARTRV
PSSP6
FEID
POSE
SYMPH
BASA

Map Zone
21

Model Zone
☐ Alaska
☐ California
☐ Great Basin
☐ Great Lakes
☐ Hawaii
☐ Northeast
☐ Northern Plains
☑ N-Cent.Rockies
☐ Pacific Northwest
☐ South Central
☐ Southeast
☐ S. Appalachians
☐ Southwest

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

Scattered throughout the zone.

Biophysical Site Description

In MZ21, this type ranges from 6000ft and can occur up to 9900ft (Bridger-Teton National Forest) in the southern portion of the zone. In southwest MT, it could occur up to 9600ft (Lesica et al. 2005). The elevation range over multiple mapzones might be 4000-9900ft. It has been suggested, however, by a reviewer for MZ21, that this BpS 1126 perhaps end at approximately 9500ft so as to indicate that the grassland systems, with a few shrubs interspersed, might start above that elevation.

It is scattered in forest openings throughout the zone, and adjacent to lower forested areas.

This vegetation type is found on all aspects, although it rarely occurs on northerly slopes. Pure stands are found in areas with deeper soils and less topographic relief, but it is also common on slopes with a gradual shift to a mixed mountain shrub community on steeper slopes and in drainages. Precipitation ranges from 12-20in/year. Soils are deep, well drained. Soil moistures are udic (not dry for as long as 90 cumulative days) and soil temperatures cryic (very cold soils of the Rocky Mountain Region).

In the high valleys of southwestern MT, sagebrush was probably the historical dominant on sites having either coarse or clayey soils (Morris et al. 1976 in Arno and Gruell 1983). Grasses are poorly adapted to

**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

these soils, which have droughty surface conditions, whereas deep-rooting big sagebrush is well-adapted (Arno and Gruell 1983). On the widely distributed loamy soils, prior to 1900, sagebrush might have been restricted to small patches or widely spaced plants. The fine-textured soils have good potential to support dense stands of grass (Arno and Gruell 1983).

Vegetation Description

Mountain sagebrush steppe dominated by mountain big sagebrush, with a frequent presence of mountain snowberry, with a continuous grass and forb understory is believed to be a major presettlement vegetation type for within this map zone, although the exact composition of the community before settlement is unknown.

Dominant shrubs include mountain big sagebrush (Artemisia tridentata ssp. vaseyana), antelope bitterbrush (Purshia tridentata, in MZ10) and mountain snowberry (Symphoricarpos spp.). Other common shrubs include serviceberry (Amelanchier alnifolia), wild cherry (PRVI), rose, currant and rabbitbrush (CHRYS9). Other shrubs may be locally common.

Herbaceous cover is moderate to abundant ranging from 40-85%. Common grasses include: Festuca idahoensis, Agropyron spicata, Elymus elymoides, Elymus trachycaulus, Hesperostipa comata, Koeleria cristata and Poa secunda. Common forbs include Eriogonum umbellatum, Antennaria microphyla, Balsamorhiza sagittata, Lupinus spp, Delphinium spp, Castilleja spp, Geranium viscosissimum and Astragalus purshii.

This vegetation type may occur as inclusions within forested types.

Disturbance Description

GENERAL
Fire is a major disturbance factor for mountain big sagebrush (Blaisdell et al 1984, Johnson 2000). The fire return intervals (FRI) reported in the literature for this type vary from 10-70yrs (Hironaka et al. 1983, Miller and Rose 1999, Wright and Bailey 1982; Houston 1973; Arno and Gruell 1983) and up to 200yrs (Baker in press).

The model for MZ21 was based on the model for MZs 10 and 19; however, major quantitative changes were made. The model for MZs 10 and 19 employed an overall FRI of 26yrs (100yrs for replacement fire; 35yrs for mixed fire). The model for MZ21 was originally modeled with a FRI of 175yrs in A, 130yrs in B and 130yrs in C, for an overall FRI of 135yrs. Initial reviewers suggested an overall 50-70yr interval. After much debate, as described below, the Regional Lead chose an interval of 50yrs, which was accepted by Tart and Kitchen. An anonymous contributor disagreed and presented evidence to the contrary. The Regional Lead, therefore, chose an interval of 80yrs, which was then met with disapproval by Tart, Kitchen and others, which led to the request that these issues be elevated to LANDFIRE leadership. Kitchen recommended an interval of 60yrs in order to reach a compromise.

20-50 YEAR INTERVAL
Tart (personal correspondence) states that the studies most relevant to MZ21 are Houston (1973) and Arno and Gruell (1983). Neither reported the composite fire interval (CFI) over a large area. Houston (1973) reported single tree FI from 36-108yrs for the life of the tree up to 1970; the average for the subunits of the study area ranged from 53-96yrs on trees (adjacent to shrubland); they adjusted to account for fire frequencies prior to modern man, to get a (mean fire interval) MFI resulting in 32-62yrs on representative, unprotected sites for the period through 1890 (pre-suppression), with a mean of 49yrs. Also, to evaluate single-tree values, Houston used six groups of 2-3 cross-dated trees to account for missing scars. Trees

**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

within a group were 5-25m apart. The MFI resultant values ranged from 17-26yrs with a mean of 22yrs on representative, unprotected sites.

Arno and Gruel (1983) reported intervals between 22-60yrs, with a mean of 43yrs for the Douglas-fir/shrub/grass ecotone, based on tree fire scars adjacent to shrubland. They both report MFI values for either single trees or small areas (Tart personal correspondence).

However, an anonymous contributor (personal correspondence) states that Houston's (1973) value of 53-96yrs (and 32-62yrs in pre-Euro) is a composite fire interval estimate from 34 trees in a set of 7 units, within which trees were composited (Houston Table 1). The individual tree values are only given in the text as "36-108yrs" across the sample (p. 1112). Houston's "intrastand" estimates of 20-25yrs are CFI estimates. Note that these trees also are not scattered within the steppe as in the first sample, but are from along the forest ecotone (p. 1113). Thus, Houston's estimate of 20-25yrs requires correction for adjacency and for unburned area.

An anonymous contributor (personal correspondence) also states that Arno and Gruell also used an extreme form of targeting and a very insufficient sample size (n = 1) at 8 sites and did, in fact, make a composite at the other four sites. Houston (1973) and Arno and Gruel (1983) do need correction for unburned area and adjacency in both cases, as both were collected along the forest-grassland ecotone (an anonymous contributor, personal correspondence; Baker in press), and neither used cross-dated scars.

An anonymous contributor also states that Houston (1973) and Arno and Gruell (1983) are about grasslands, not mountain big sagebrush stands in the pre-Euro landscape (see below regarding adjacency issues). He also states that neither study cross-dated scars, so we really cannot tell whether fires did or did not burn among trees scattered across landscapes in the Houston study area or whether separate fire years really are valid in the Arno and Gruell study.

35-40 YEAR INTERVAL
Heyerdahl et al. (in press) document four large fires in Douglas-fir/mountain big sagebrush sites during their reporting period of 1700 to 1860 (figure 3b) and possibly two more between 1650 and 1700 (figure 2). Using these values gives MFIs of between 35-40yrs, or 37yrs on average. The range of variation in fire occurrence under this regime was 2-84yrs. In other words, between the years 1700-1860, on some portions of the landscape, fire had a point or plot interval of about 37yrs with intervals as short as two years and as long as 84yrs. This frequency is also comparable to the frequency estimated by modeling studies to exclude Douglas-fir (approximately 30yrs, Keane et al. 1990), and to that reconstructed from tree rings in Douglas-fir/mountain big sagebrush elsewhere in southwestern MT (20-40 mean intervals, Houston 1973, Arno and Gruell 1983, Littell 2002) where frequent past fires are also thought to have prevented the establishment of Douglas-fir. They believe that fires likely burned the area between plots with evidence of fire in the same year, including across historical sagebrush-grass plots (Heyerdahl et al in press).

Heyerdahl et al (in press) also state that after fire, mountain big sagebrush at sites in southwestern MT required up to 30yrs to return to >20% cover (Wambolt et al. 2001 in Heyerdahl et al. in press).

As per Tart (personal correspondence), another approach to estimating MFI in the shrub/grass areas beyond the forest ecotone is to consider only large fires documented from both sides or scattered across the shrub/grass area (Baker in press; Kitchen, personal communication). This method can be used with the data of Houston (1973) (see his Table 3) and Miller and Rose (1999) (see their Figure 4). Applying this approach to both data sets to calculate MFI for large fires for the period 1650 to 1890, the results are:

**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Miller and Rose (1999) between 27-34yrs MFI; Houston (1973) between 30-40yrs MFI. Using the more restrictive definitions of large fire for the period 1700-1890 gave an MFI of 32yrs for both study areas.

50 YEAR INTERVAL
According to Miller and Rose (1999) and Wright and Bailey (1982), there is a 50yr MFI. However, those studies did not take into account the limitations of fire history data or the recovery rate.

Based on what has been shown through different approaches and field experience of those who know the system, the estimate of total MFI for mountain big sagebrush steppe is between 40-80yrs (Kitchen, personal correspondence).

50+ YEAR INTERVAL
Welch and Criddle (2003) report greater than 50yr interval. They also report the following "10 biological and ecological characteristics of mountain big sagebrush do not support the idea that mountain big sagebrush evolved in an environment of frequent fires of 20-30yrs: (1) a life expectancy of 70yrs+ (2) highly flammable bark (this stringy bark makes excellent fire starting material); (3) production of highly flammable essential oils; (4) a low growth form that is susceptible to crown fires (5) nonsprouting; (6) seed dispersal occurs in late fall or early winter long after the fire season has ended; (7) lack of a strong seed bank in the soil; (8) seed lack anatomical fire resistance structures or adaptations – that is, a thick seed coat; (9) seeds must lie on the soil surface, which exposed them to higher temperatures than seeds that occur deeper in the soil; (10) seeds lack any adaptations for long distance dispersal, hence, mountain big sagebrush lack the ability for rapid reestablishment. Thus it appears that an estimated fire interval of 20-30yrs for mountain big sagebrush is too low and that the natural or normal fire interval is much longer, perhaps 50yrs or more."

70-200 YEAR INTERVAL and RECOVERY
Recovery rates should also be taken into account (Baker in press). Mountain big sagebrush has the fastest recovery rate of the three subspecies of big sagebrush (Johnson 2000; local data). Rates of recovery under the natural disturbance regime most likely were longer than we see in small burns today (anonymous contributor, personal correspondence). It is not necessarily preferred to use a fixed percent cover as a standard for recovery, as the percent cover of ARTRV varies widely with environment.

An anonymous contributor (personal correspondence) suggested a 70-200 year MFI interval. Recent data from long term vegetation transects collected over a twenty year period in WY suggest that the recovery of mountain sagebrush steppe communities following fire requires at least 25yrs in northwestern WY and at least 40yrs in southern WY to reach a late seral state with >30% sagebrush cover (Grand Teton National Park/Bridger Teton National Forest Fire Effects Monitoring Data, Southern Wyoming Fire Zone BLM Fire Effects Monitoring Data). If recovery rates are correlated with composite fire return intervals, fire return intervals may lie somewhere between 40-60yrs. However, recent data show that fire return intervals may be twice or more as long as recovery periods, indicating a fire return interval of 70-200yrs (Baker in press). If FRI is 2x as long as recovery, it might be that the FRI in this system is at least between 50yrs to at least 80yrs. However, the reason the range goes up to 200yrs is because Bruce Welch at USFS Provo Shrub Lab has observed that in large fires, ARTRV reseeds very slowly, creeping in from the edge at rates that suggest it will require perhaps 100yrs to fully recover. There is wide variation in recovery rate (Lesica et al 2005). In recent work and new data (Lesica et al. 2005), it seems that most ARTRV will not recover in 25-40yrs, but some will. So the lower end of recovery would be 25-40, and the upper end of the recover curve may be quite long, 100yrs. Thus, the 100yr figure gets multiplied by 2 to produce the high end estimate of 200yrs (Baker in press). The midpoint would probably lie in the 100yrs+ range (anonymous

**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

contributor, personal correspondence).

This methodology has been debated by some researchers. Some do not advocate the use of the 2 multiplier of the recovery rate, to arrive at the fire interval.

CORRECTION FACTORS – 60 VS 240yrs
An anonymous contributor (personal correspondence) advocates use of correction factors for most of the studies above. If applying correction factors to Heyerdahl's study, a fire rotation of between 240yrs (anonymous contributor, personal correspondence) is reached. Fire rotation is: (period of estimate)/fraction of area burned. He estimated the fires to be 10, 160, 70, 35, 100, 210, 30, 40, and 210 ha for a total of 865 ha, but each fire has unburned area. Using the 21% correction for sagebrush fires gives an estimated total of 683 ha burned in a study area of 1030 ha (66.3% of the area or a fraction of 0.663) over the period from 1700 to 1860 (160yrs). Thus, the fire rotation is estimated as: 160yrs/0.663 = 241yrs. The fire rotation/population mean fire interval is thus about 6 to 7 1/2 times the composite fire intervals, consistent with what has been seen in other empirical comparisons.

Kitchen (personal correspondence) counters that by stating that to calculate an accurate estimate of fire rotation using the anonymous contributor's approach, a basal area considerably smaller than the 1030 ha (study area) would have to be used. Just as one cannot assume a fire interval for the non-recording portions of the landscape, one also cannot assume a fire free period for the whole test period. Either assumption introduces bias. Therefore all of the unsampled but fire scarred portions of the landscape would have to be subtracted from the base study area before calculation. In other words, Heyerdahl's fire sizes are at most conservative estimates of actual areas burned and probably miss fires that went unrecorded. Kitchen therefore used a modified approach to arrive at a fire rotation interval. He visually added up total burn area from figure 2 as the anonymous contributor did and got 1340 ha in 11 fires. An unburned area correction factor should not be used. If it is assumed that the sampled area (portion of study area with fire record) was half the total study area (ball park guess looking at the map) or 515 ha then a fire rotation of 61.5yrs is reached.

Kitchen (personal correspondence) also counters the anonymous contributor's estimate by stating that in Heyerdahl's study, fire was largely lost from the system after 1860 (figure 2). Concurrent with that loss just 146yrs ago, the range and density of Douglas-fir and lodgepole pine trees has increased dramatically throughout the study area. The beginning of heavy use by livestock coincides with the late 1800's shift. If that much has changed in 146yrs, it is not possible that a fire rotation of 241yrs would have been sufficient to maintain the pre-1860 woodland/shrubland mosaic documented by this study.

ADJACENCY
Tart (personal correspondence) states that this BpS in this mapzone was occupied by a mosaic of grassland and varying densities of big sagebrush. The FRI of sagebrush PNV sites historically maintained as grasslands is generally reported to be 10-40yrs (Winward 1991; Arno and Gruel 1983; Houston 1973). The longer intervals reported by Baker in press and Welch and Criddle would imply that there was little grassland (Tart, personal correspondence).

There is some disagreement as to whether the sites studied by Arno and Gruell, and Houston, apply to PNV of mountain big sagebrush or sites invaded by sagebrush. The anonymous contributor states that in western MT (Sindelar 1981), grasslands invaded by ARTRV are not fire maintained, and instead livestock grazing removes the grass competition leading to ARTRV invasion.

**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

For those areas that might be maintained as grassland along ponderosa pine or Douglas-fir ecotones, FRI, reported as CFI, has been indicated between 10-40yrs (Winward 1984; Winward 1991; Johnson 2000; Miller and Tausch 2001; Tart 1996) and greater than 50yrs (Welch and Criddle 2003) and between 35-100yrs (Baker in press). Again, interpretation of the estimates and corrections used varies.

Estimating historic fire regimes for sagebrush ecosystems is tenuous at best and often based on fire scar and age structure data from adjacent forest types (eg, ponderosa pine and pinyon/juniper), shrub age structure and fuel characteristics. Mountain big sage is also adjacent to Douglas-fir and lodgepole pine and intervals for those could be used, which could range from 30-130yrs. This is a vegetation type for which we do not have much confidence in the intervals or interpretation of intervals in the literature (Romme, personal correspondence).

SEVERITY

The severity of fire is also debated in this system. While the majority of fires were likely stand-replacing, some mixed severity fire may have occurred, though there is little data documenting mixed severity fires (Sapsis and Kaufmann 1991). Mixed severity fires were likely small in area, but ignitions may have occurred as frequently as 5-20yrs. There were probably also portions of this system that never carried fire because of sparse fuel (Bushey 1987). Historic fires likely occurred during the summer months and were wind-driven events. Lightning ignitions are variable and affect fire frequency on regional landscapes in the Northern Rockies. Fire may spread from adjacent forested communities.

ERRORS, VARIABILITY AND SUMMARY

Just as there exists a potential for error from estimating a shorter than real FRI when compositing, there is also an opposing risk of estimating a longer than real FRI by using an incomplete record of fire (temporally due to missed fires or spatially due to underestimation of fire size, or both). Both sources of error should receive further attention (Kitchen, personal correspondence). If we base estimates of the extent of historical fires on the evidence recovered, much will be lost, as evidence tends to be lost due to decay, erosion, subsequent fires, etc. There is therefore a good probability we will consistently underestimate fire size and frequency. Missed fires result in longer than real estimates of fire rotation (Kitchen, personal correspondence).

There is much variability in the fire intervals in this system. In the late 1800s the interval was shorter than the early 1800s (Romme, personal correspondence). There was a big shift in the late 1800s with fire intervals, whereas it could have been longer in the early 1800s, more akin to present day, due to climate (Tausch, personal correspondence). Fire regimes also vary considerably across the biogeographic range of mountain big sagebrush, based on factors like elevation, soil depth, slope, aspect, adjacent vegetation, frequency of lightning and climate. The climate, slope, aspect, soil and elevation can vary widely and thus the fire interval for this system can be as low as 30yrs to several hundred years, depending on what is surrounding the system. Although an average value could be chosen, and perhaps it lies in the 50yr range, most fire intervals would probably not be at the average value (Tausch, personal correspondence).

We have no means to accurately measure historic fire frequency in sagebrush communities (Kitchen, personal correspondence), and there are conflicting opinions as to the approaches taken to determine MFI for these systems. We really do not know how fire might have behaved across the fuel threshold at the forest/shrubland ecotone. Therefore, we do not know how accurately proxy fire chronologies derived from fire-scarred trees predict fire regimes in nearby shrublands (Kitchen, personal correspondence).

When inputting differing fire probability values in VDDT, the following class percentages were output

---

**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

(early 0-13; mid 14-40; late 41--):
30-year interval: 35/45/20
50-year interval: 25/45/30
80-year interval: 15/45/40
100-year interval: 10/45/45

When the longer fire interval parameters were used in VDDT, the proportion of the landscape in the earlier classes declined. Tart and other experts felt that those percentages of the landscape successional classes were not indicative of what would have been found historically. Succession class A needed to incorporate grass/forbs, and it should have been more prevalent on the landscape. Whereas the anonymous contributor and others contended that there is no knowledge of what percentage of the successional classes could be found on the landscape historically.

After these issues were elevated to LANDFIRE leadership/guidance, the 50yr interval was decided upon. This interval is still considered on the longer side of the range by some (A Winward, pers comm). This interval was also that used in MZs 18 and 23. MZs 10 and 19 used a 26 FRI, and MZ22 used a 80 FRI.

Other disturbances, including drought stress, insects and native grazing, were present under presettlement conditions in this type. Most of these disturbances were mixed-severity, resulting in thinning of sagebrush. In MZ21, deer and elk, at high density, can use sagebrush on winter ranges.

Adjacency or Identification Concerns

Differentiation of Mountain Big Sagebrush Steppe from Wyoming Big Sagebrush may be difficult at the ecotone due to physical similarities and hybridization zones (ie, species concepts become blurred).

Adjacent plant associations on shallow clay soils are dominated by Wyoming big sagebrush. Shallow clay soil inclusions also support Artemisia arbuscula.

In MZ21, there is most commonly Douglas-fir and sometimes lodgepole pine encroachment. Douglas-fir trees have encroached into sagebrush-grasslands from historically stable tree islands and tree density has increased on the tree islands (Heyerdahl et al. in press). Mountain big sagebrush cover decreases rapidly as juniper dominance increases today (Miller et al. 2000 in Heyerdahl et al. in press).

Nearly all sagebrush communities today have been grazed and there are no refugia to use as reference conditions.

Some grassland systems are invaded by sagebrush today in larger quantities. These grassland systems might today have mountain big sage, and in pre-European settlement, might have had a bit of mountain sage. Pre-European settlement they would have been grassland systems, whereas today they might be confused for mountain big sagebrush systems. It might therefore be difficult to distinguish the early seral stages of this class from the grassland BpS 1139 system. It should be distinguished by elevational component.

Historically, this BpS in MZ21 was likely dominated by grassland such as that in succession class A along the forest ectonoe (Houston 1973; Arno and Gruel 1983). Since this type is largely interspersed with forest or occupies a narrow band adjacent to lower timberline, class A is likely to have dominated the landscape.

Mountain big sagebrush was probably not as abundant in presettlement conditions (Arno and Gruell

---

**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

1983), since the original vegetation of sagebrush-grass consisted of a dense cover of perennial grasses among which were scattered moderate-sized shrubs. Sagebrush might be invading grasslands due to fire exclusion, overgrazing by livestock and/or climate change.

Fire exclusion is a major effect of livestock grazing in dynamic sagebrush/grassland systems (Miller et al. 1994; Miller and Rose 1999; Gruel 1999; Miller et al. 2000; Miller and Eddleman 2001; Crawford et al. 2004).

Furthermore, in MZ21, there are non-native species such as Phleum pratense, Cynoglossum officinale and many others.

Currently, there's probably more in class C - denser cover. This would be similar to MZs 10 and 19 succession classes and departure.

Native Uncharacteristic Conditions

Shrub cover >45% cover or taller than one meter are uncharacteristic. Greater than 10% canopy cover by conifers can be considered uncharacteristic. Potential causes of encroachment include grazing and lack of fire, as well as climatic episodes favorable to tree regeneration.

Scale Description

Fires burn in patchy mosaics in this type, and scales ranged from small (tens of acres) to very large (possibly hundreds of thousands of acres).

In MZ21, occurences are on the scale of 10s-100s of acres, as opposed to other mapzones, where landscape-scale assessments could be in the order of 10000ac for mountain sagebrush steppe communities because of the mosaic nature of vegetation communities, the moderate to long fire mean return intervals and the extent of the vegetation community.

On the widely distributed loamy soils, prior to 1900, sagebrush might have been restricted to small patches or widely spaced plants (Arno and Gruell 1983).

Issues/Problems

There is a limited amount of information available on fire regimes and reference conditions in sagebrush due to modern overgrazing (the herbaceous component is severely impacted and current information cannot exclude the effects of cattle). There is much controversy surrounding FRIs within this system and how to define this system adjacent to grassland systems.

Comments

This model for MZ21 is based on the LANDFIRE (LF) model for the same BpS 1126 for MZs 10 and 19, created by Kathy Geier-Hayes (kgeierhayes@fs.fed.us), Steve Rust (srust@idfg.idaho.gov) and Susan Miller (smiller03@fs.fed.us), reviewed by Dana Perkins (dana_perkins@blm.gov), Carly Gibson (cgibson@fs.fed.us) and Mary Manning (mmanning@fs.fed.us). Original modelers for MZ21 were Bill Baker (bakerwl@uwyo.edu), Tim Klukas (tim_klukas@nps.gov), Reggie Clark (rmclark@fs.fed.us) and John Simons (john_simons@blm.gov). Original reviewers for MZ21 were Steve Kilpatrick, Klara Varga, Stan Kitchen (skitchen@fs.fed.us), Dave Tart and Brenda Fiddick. Because there were significant differences of opinion between the original modelers and the reviewers, no compromise could be reached. After an extensive model review process, LF leadership/guidance determined that the original modelers used an interpretation of the fire information available on sagebrush systems that did not represent the

---

**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

majority expert opinion/interpretation of the fire literature. Therefore, the original MZ21 model was altered to reflect majority opinion/interpretation of literature regarding the fire regime of this sagebrush system.

For MZs 10 and 19, modifications were made to the structural data to adhere to LANDFIRE standards (Pohl 11/14/2005).

For MZs 10 and 19, this BpS was adapted from the Rapid Assessment (RA) model R0SBMT (Mountain Sagebrush) by Mark Williams and reviewed by Bill Baker (bakerwl@uwyo.edu), Dennis Knight (dhknight@uwyo.edu), Ken Stinson (ken_stinston@blm.gov), Thor Stevenson (thor_stephenson@blm.gov), Gavin Lovell (gavin_lovell@blm.gov), Curt Yanish (curt_yanish@blm.gov) and Eve Warren (eve_warren@blm.gov).

For the Rapid Assessment, this model combined two additional Rapid Assessment models after peer-review: R0MTSBsb (workshop code MSHB2), modeled by Diane Abendroth (Diane_Abendroth@nps.gov) and reviewed by Dennis Knight (dhknight@uwyo.edu), Don Bedunah (bedunah@forestry.umt.edu), Shannon Downey (shannon_downey@blm.gov), Bill Baker (bakerwl@uwyo.edu), Ken Stinson (ken_stinson@blm.gov), Thor Stephenson (thor_stephenson@blm.gov), Curt Yanish (curt_yanish@blm.gov) and Gavin Lovell (gavin_lovell@blm.gov); and R0SBCL (workshop code CSAG1) modeled by George Soehn (george_soehn@blm.gov) and reviewed by Eldon Rash (erash@fs.fed.us) and Reggie Clark (rmclark@fs.fed.us).

Rapid Assessment (RA) peer review suggested lumping R0SBMT with R0MTSBsb as their disturbance regimes and vegetation composition were nearly identical. R0SBMT was very different from the model, R0SBCL in fire regime, but the other characteristics were the same. Based on the abundant peer review for R0SBMT, R0SBCL was combined here. Reviewers during RA disagreed about the range of fire frequency for this vegetation type, suggesting MFIs ranging from 25-135yrs. The model was originally developed with an MFI of 50yrs; based on peer review it was increased to 70yrs during the RA. See RA models for resulting changes.

Vegetation Classes

Class A **25 %**

Early Development 1 All Structure

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

1

Indicator Species and Canopy Position

FEID
Lower
PSSP6
Lower
Forbs
Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	30 %
Height	Herb 0m	Herb 0.5m
Tree Size Class	None	

- [x] Upper layer lifeform differs from dominant lifeform.

As per new instruction from MFSL, dominant lifeform is indicated in drop-down boxes, not upper layer. Grasses and forbs are the dominant lifeform in this class. They have a cover between 0-30% with a height of between 0-0.5m. Shrubs are the upper-layer lifeform and have <10% cover, as this class is dominated by grasses and recovering early shrubs.

Description

**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Shrub cover is low, and typically ranges from 0-10%. Five percent shrub cover indicates good establishment of a post-fire cohort. Herbaceous cover is variable, but is typically at least 30%. This class lasts approximately 13yrs, and then succeeds to mid-development open (class B).

Historically, this BpS in MZ21 was likely dominated by grassland such as that in succession class A along the forest ectonoe (Houston 1973; Arno and Gruel 1983). Since this type is largely interspersed with forest or occupies a narrow band adjacent to lower timberline, class A is likely to have dominated the landscape.

Replacement fire occurs at approximately every 50yrs.

Grazing occurs, but modeled infrequently (0.002 probability).

In this environment (and a number of the other grassland, shrub steppe types) forb density and cover are most responsive to climatic conditions. Hence fire response will vary according to precipitation patterns before and immediately after the fire. Grasses are less “ephemeral” and tend to respond to the fire directly. That’s why we elected to not identify specific forb species response.

Class B **45 %**

Mid Development 1 Open

Upper Layer Lifeform

☐ Herbaceous
☑ Shrub
☐ Tree

Fuel Model

6

Indicator Species and Canopy Position

ARTRV
Upper
FEID
Lower
PSSP6
Lower
ARTR4
Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11 %	30 %
Height	Shrub 0m	Shrub 1.0m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

(This class would also include shrubs >0.5m tall but <25% cover.)

Description

Shrub cover is <25%. Reaching 20% sagebrush cover following a stand-replacing fire takes between 10-33yrs (Tart, personal correspondence).

There is a 40% herbaceous canopy cover across this class.

Replacement fire causes transition to A every 50yrs, while insects (0.005 probability) and drought (100yrs), and native grazing (0.002 probability) may thin the stand, but maintain it in class B.

This class transitions to a late closed state after 30-40yrs.

Herbaceous cover is variable in this class. Native grazing on winter ranges by elk and deer typically may decrease sagebrush cover but doesn't cause a transition to another class. Insects and drought may occur but don't cause a transition to another class.

Purshia tridentata may be present.

**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class C **30 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model

2

Indicator Species and Canopy Position

ARTRV
Upper
PSSP6
Lower
FEID
Lower
ARTR4
Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	50 %
Height	Shrub 0m	Shrub 1.0m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Sagebrush cover is from 26-45%. Sagebrush cover rarely exceeds 40% cover, and >45% cover would be uncharacteristic. Mountain big sagebrush canopy cover is constrained by competition from herbaceous vegetation on all but the wettest sites (Tart 1996). Competition between herbs and sagebrush is less pronounced on cooler, wetter sites. High canopy cover of mountain big sagebrush only develops after removal of herbaceous vegetation. Some researchers believe that mountain big sagebrush can never exceed 25% cover (Pedersen et al. 2003) Understory vegetation has low cover in this class.

Insects (75yrs) and drought stress (100yrs) cause transitions to class B by thinning sagebrush cover every 50-100yrs. If no disturbance occurs, this condition can persist.

Native grazing occurs (0.002 probability), but maintains the stand.

Purshia tridentata may be present.

Replacement fire occurs every approximately 50yrs.

Class D **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Description

Disturbances

Fire Regime Group:** IV

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- ☑ Literature
- ☑ Local Data
- ☑ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	50	30	200	0.02	100
Mixed					
Surface					
All Fires	50			0.02002	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☑ Insects/Disease
- ☑ Wind/Weather/Stress
- ☑ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

References

Anderson, J, and R. Inouye. 2001. Landscape-scale changes in plant species abundance and biodiversity of a sagebrush steppe over 45 years. Ecological Monographs 71: 531-556.

Baker, W.L. In press. Fire and restoration of sagebrush ecosystems. Wildlife Society Bulletin, in press.

Blaisdell, J.P., R.B. Murray and E. Durant. 1982. Managing Intermountain rangelands -- Sagebrush-grass ranges. GTR INT-134. Ogden, UT. USDA Forest Service, Intermountain Forest and Range Experiment Station 41 pp.

Bunting, S.C., B.M. Kilgore and C.L. Bushey. 1987. Guidelines for Prescribed Burning Sagebrush-Grass Rangelands in the Northern Great Basin. USDA, USDA Forest Service. Intermtn. Res. Stat. GTR-INT-231.

Bushey, C.L. 1987. Short-term vegetative response to prescribed burning in the sagebrush/grass ecosystem of the northern Great Basin: three years of postburn data from the demonstration of prescribed burning on selected Bureau of Land Management districts. Final Report. Cooperative Agreement 22-C-4-INT-33. Missoula, MT: Systems for Environmental Management. 77 pp.

Gates, D.H. 1964. Sagebrush infested by leaf defoliating moth. J. Range Management. 17: 209-210.

Harniss, R.O. and R.B. Murray. 1973. 30 years of vegetal changes following burning of sagebrush-grass range. Journal of Range Management 26: 322-325.

Hironaka, M., M.A. Fosberg and A.H. Winward. 1983. Sagebrush-grass habitat types of southern Idaho. Bull.35. Univ. of Idaho, Forest, Wildl. And Range Exp. Statn. Moscow ID 44 pp.

Johnson, K.A. 2000. Artemisia tridentata spp. Vaseyana. In: Fire Effects Information System, [Online].

**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2004, September 10].

Johnson, J.R. and G.F. Payne. 1968. Sagebrush reinvasion as affected by some environmental influences. Journal of Range Management. 21: 209-213.

Lesica, P., Cooper and G. Kudray. 2005. Big sagebrush shrub-steppe postfire succession in southwest Montana. Montana Natural Heritage Program Natural Resource Information System. Montana State Library. Prepared for United States Department of the Interior Bureau of Land Management, Agreement Number: ESA010009.

Miller, F.F. and J.A. Rose. 1999. Fire History and western juniper encroachment in sagebrush steppe. J. Range Management 52: 550-559.

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

Sapsis, D.B. and J.B. Kauffman. 1991. Fuel consumption and fire behavior associated with prescribed fires in sagebrush ecosystems. Northwest Science. 65(4): 173-179.

Tisdale, E.W. 1994. SRM 402: Mountain big sagebrush. PAges 41-42 in: T.N. Shiflet, ed. Rangeland cover types of the United States. Denver, CO: Society for Range Management.

Welch, B. and C. Criddle. 2003. Countering Misinformation Concerning Big Sagebrush. Research Paper RMRS-RP-40. Ogden, UT: Department of Agriculture, Forest Service, Rocky Mountain Research Station. 28 pp.

Wright, H. and A. Bailey. 1982. Fire Ecology: United States and Southern Canada. John Wiley and Sons, NY, NY.

**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.