PRE AND POSTSETTLEMENT FIRE REGIMES IN MOUNTAIN BIG SAGEBRUSH COMMUNITIES: THE NORTHERN INTERMOUNTAIN REGION

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SUMMARY

This paper summarizes, in three parts, past and current fire history work being conducted. We present results of fire return intervals across 10 sites in mountain big sagebrush/Idaho fescue plant communities. We also have included two tables of proposed fire regimes for a number of sagebrush plant associations based on ongoing work in eastern Oregon and northeastern California.

INTRODUCTION

Fire is a primary disturbance process in sagebrush steppe communities, influencing plant dynamics, composition, and structure. The balance between woody and herbaceous vegetation is highly influenced by the length of fire return intervals. Prior to settlement, fire regimes (Table 1) were spatially complex, changing across the landscape with fuels, topography, and ignition sources. In Oregon, mean fire return intervals varied across different mountain big sagebrush communities from 15 to several hundred years. Fire regimes have changed since Eurasian settlement in the late 1800s (Gruel 1999, Miller and Rose 1999, Miller and Tausch 2001, Swetnam et al. 1999, Tausch 1999). As a result pinyon and juniper woodlands and shrub density and cover in the more mesic sagebrush steppe communities have significantly increased. Pinyon and juniper woodlands have expanded as much as 5 to 10 times in area and 2 to 20 times in density within occupied areas (Cottam and Stewart 1940, Burkhardt and Tisdale 1976, Tausch et al. 1981, Miller and Rose 1995, 1999, Miller and Tausch 2001). The majority of this expansion has occurred in the more productive mountain big sagebrush cover type. However, western juniper has also invaded aspen, mountain mahogany, and riparian communities below 7,000 ft in the northwestern portion of the Great Basin (Miller and Rose 1995, Wall et al. 2001). Many private landowners and public land management agencies have been attempting to reintroduce fire to restore range health, improve livestock grazing conditions, and enhance wildlife habitat. However, knowledge and documentation describing presettlement fire regimes across different cover types throughout this region are limited.

OBJECTIVES

The overall purpose of this paper is to describe several proposed fire regimes, which characterize different mountain big sagebrush plant associations in the northwestern portion of the Intermountain shrub region. Specific objectives are to:

1. Report fire return intervals documented for the mountain big sagebrush/Idaho fescue plant association based on research results.
2. Propose several tentative fire regimes for plant associations based on ongoing work using tree age structure and charred material.

Table 1. Characteristics of fire regimes.

Fire Regimes are defined by the following characteristics: *1. temporal* - seasonality, fire return interval (variability); *2. spatial* - size/extent, spatial complexity; *3. magnitude* - fire intensity, fire severity.
Fire regimes are a function of physical and biotic factors
Physical factors - Climate and weather patterns - Topography - Ignition sources Biotic factors- Plant life history characteristics and fire adaptations - Spatial and temporal patterns of fuel quantity, structure and flammability

Part I: *Fire Regimes in mountain big sagebrush/Idaho fescue association*

STUDY AREA

The study area was located in the High Desert and Klamath Ecological Provinces, which encompass portions of southeast and south central Oregon and northeastern California (Fig. 1). Soils across the study sites are Argixerolls and Haploxerolls derived from igneous materials. Fire scar samples were collected across 10 stands representing the mountain big sagebrush (*Artemisia tridentata* spp *vaseyana*)/Idaho fescue (*Festuca idahoensis*) plant association. Bitterbrush (*Purshia tridentata*) was a co-dominant in several of the communities and curlleaf mountain mahogany (*Cercocarpus ledifolius*) in one community. The presence of presettlement ponderosa pine (*Pinus ponderosa*) adjacent to or growing within these communities was the primary determining factor for documenting pre and post-settlement fire regimes for these communities.

METHODS

Sample sites were selected opportunistically. We reconnaissanced a large region for presettlement ponderosa pine trees associated with mountain big sagebrush steppe communities. Presettlement fire-scarred trees are scarce in these areas due to low tree densities and past harvest. Several of the sites were small islands surrounded by shrub

steppe and currently being encroached by western juniper. Other sites, such as Pine Mountain and Dead Indian, were located at the edge of a forest shrub steppe ecotone (Fig. 2). We sampled trees that were growing at the edge of the forest community, single trees growing in the adjacent shrub steppe community, and forest edges fingering out into the shrub steppe community. Our assumption was that fire did not stop at the forest edge or in some cases the micro-community edge. Fuels were contiguous and in most cases ground fuels were heavier in the shrub steppe due to a greater abundance of shrubs and grasses than in the ponderosa pine understory. Similar age structures of post-settlement pine and juniper trees and their synchrony of establishment following the last fire also supports our assumption that fire did not stop at the ecotone between the two communities.

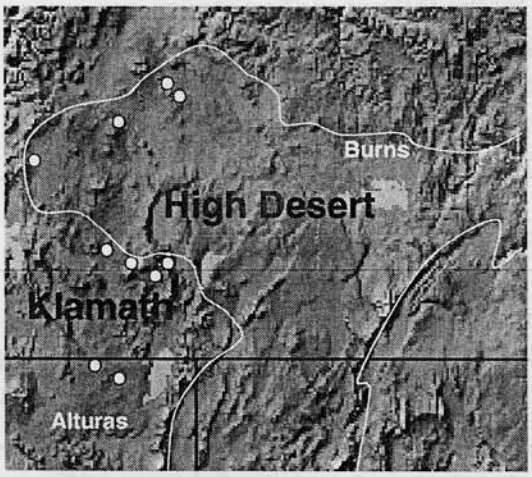

Figure 1. Mountain big sagebrush (Ë%) study site locations in the High Desert and Klamath Ecological Provinces.

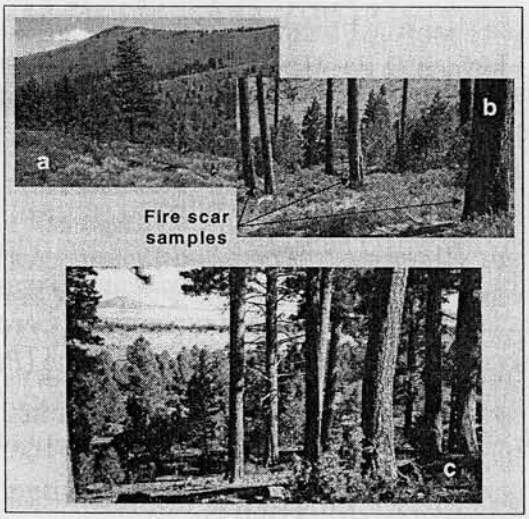

Figure 2. Pine Mountain (a&b) and Dead Indian (c) sample stands, with fire scarred trees in photo b.

FIRE HISTORY

Mountain big sagebrush steppe and juniper woodlands - Fire scar samples were collected in clusters of 3 to 5 trees (< 2.5 ac.) where available (Fig. 2 & 3). Sampling in clusters provided a more complete record than individual trees due to the variability of fire scarring among trees (Kilgore and Taylor 1979). Tree samples were prepared and measured as described by Arno and Sneck (1977) at the University of Arizona Tree Ring Laboratory. All samples were cross-dated with core samples collected from each site to identify the exact year of each fire event (Stokes and Smiley 1968, Fritts 1976). Fire frequency, fire interval variability, and season were determined for each cluster across the region. Season of burn was determined by the position of the scar in the ring (Fritts 1976).

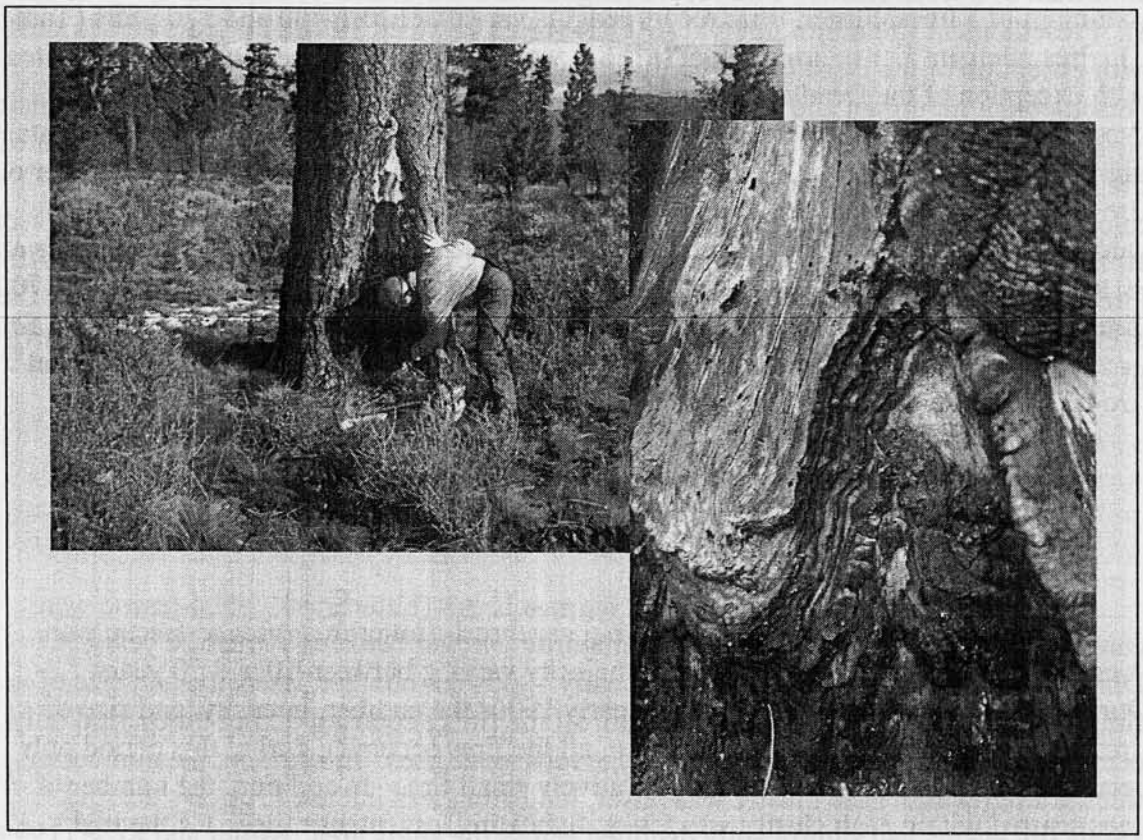

Figure 3: Fire scar trees on the Squaw Mountain study

DATA ANALYSES

The statistics module in the FHX2 fire history program (Grissino-Mayer 1995) was used to summarize and evaluate fire intervals and seasonality. Fire histories for all sites were split as presettlement, scars occurring prior to 1870, and postsettlement, fire scars occurring after 1899. The split was based on historical records documenting the arrival of livestock across this region (Oliphant 1968, Miller et al. 1994) and their impact on fire regimes through the reduction of fine fuels (Burkhart and Tisdale 1976, Miller

Rose 1999). We considered the time interval between 1871 and 1899 as an adjustment period. Miller and Rose (1999) reported that fire occurrence and size began decreasing during this time period.

RESULTS

Approximately 200 fire scars were collected across eastern Oregon and northeastern California. The earliest fire scars collected were 1467 on Pine Mountain and 1517 in the upper Chewaucan River basin (Table 2). However, due to limited sampling depth and incomplete records (caused by burn-out of old fire scars by more recent fires) we calculated MFRI across the 10 sites beginning between 1600 and 1830 with a minimum of 3 trees/cluster. Fire record lengths varied between 400 and 170 years (Table 3). Presettlement fire return interval (MFRI) varied between 10 and 20 years across sites, with exception of the Dead Indian study site where the MFRI was less than 10 years. Presettlement minimum and maximum intervals (years between fires) across the mountain big sagebrush/Idaho fescue cover type were 3 and 32 years. Due to the limited number of fire events occurring between 1900 and 2001 across all sites, MFRI could not be calculated for this time period (Figure 4). Fire occurrence was significantly less across all 10 sites between 1900-2001 compared to the frequency of events occurring prior to 1870. Fire has not occurred across 6 of the 10 sites during the past 100 years and only 1 or 2 fire events have occurred on the remaining 4 sites during this time period. The most recent fire event recorded occurred 50 years ago.

DISCUSSION

Mean Fire Return Intervals

Presettlement MFRI in mountain big sagebrush-(bitterbrush)/Idaho fescue were consistently less than 20 years, with the majority varying between 10 and 20 years. During the period between 1870 and the early 1900s the number, intensity, and size of fires began to decline. On the Chewaucan, all the fires occurring during this period only occurred within one cluster indicating relatively small fires. In addition, the number of trees scarred within each cluster was fewer, indicating less intense fires. By the mid 1900s fire events had significantly declined across the study area. Miller and Rose (1999) concluded that the introduction of livestock in the Chewaucan River basin in the late 1860s significantly affected fire return intervals through the reduction of fine fuels. Fire suppression in the National Forests began in the early 1900s; however, intensive suppression on rangelands did not begin until after World War II. Fire events become noticeably absent after 1950 across all sites (Fig. 4).

The results suggest that the presettlement fire regime across much of this plant association was low intensity and highly frequent (Table 4). We propose that under the presettlement fire regime the majority of the mountain big sagebrush-(bitterbrush)/Idaho fescue plant association was dominated by a herb layer with a widely scattered and patchy shrub layer.

Table 2. Mean fire return intervals (MFRI) and number of fire events across 10 mountain big sagebrush (bitterbrush) / Idaho fescue sites in central and southeastern Oregon and northeastern California.

Parameters	Site									
	Pine Mountain 1	Pine Mountain 2	Chewaucan Lower	Chewaucan Mid	Chewaucan Upper	Picture Rock Pass	Squaw Mt	Devils Garden	Dead Indian	Cinder Butte
					Presettlement					
Period	1740-1870	1626-1870	1780-1870	1650-1870	1600-1870	1751-1870	1820-1870	1800-1870	1830-1870	1750-1870
# Events	10	17	6	19	20	8	10	4	7	7
MFRI	12.6	14.8	17.2	11.7	14.1	16	12.2	17.3	6.2	16.5
Min Interval	7	4	12	3	3	5	7	11	3	-
Max Interval	23	32	26	28	25	32	25	25	10	-
					Postsettlement					
Period	1900-2001	1900-2001	1900-2001	1900-2001	1900-2001	1900-2001	1900-2001	1900-2001	1900-2001	1900-2001
# Events	1	2	0	0	0	0	3	0	2	0
MFRI	-	-					>34		>37.5	
Min Interval	84	36					15		8	
Max Interval		>50					>63		>67	
Last Event	1914	1950	1869	1897	1869	1863	1938	1871	1934	1860s
Sample Size	4	5	3	3	4	2	4	3	4	2

Table 3. Fire scar dates across sites.

Pine Mountain 1	Pine Mountain 2	Chewaucan Lower	Chewaucan Mid	Chewaucan Upper	Picture Rock Pass	Squaw Mt	Devils Garden	Dead Indian
	1467			1517	1751	1820	1802	1830
	1626			1527	1756	1828	1813	1835
	1661			1565	1771	1838	1829	1842
	1668			1592	1800	1845	1855	1845
	1710			1601	1810	1869	1871	1855
	1727			1610	1823	1883		1862
	1740			1632	1855	1890		1867
1742		1657	1657	1863	1900			1871
1755		1678	1678		1915			1875
	1759		1688	1688		1938		1893
1778	1778		1693	1693				1926
1785	1785		1703					1934
1793			1706					
	1796		1717	1717				
1807	1807		1723	1723				
1819	1819		1736					
1829	1829		1740					
1845			1743					
1855	1855			1757				
1886	1886		1768	1768				
1914	1914		1771	1771				
	1950	1783	1783					
			1792					
			1806					
	1809	1809						
		1814						
	1829	1829	1829					
			1839					
	1841	1841						
			1849					
	1855	1855	1855					
	1869	1869	1869					
	1879							
		1880						
	1889							
	1897							

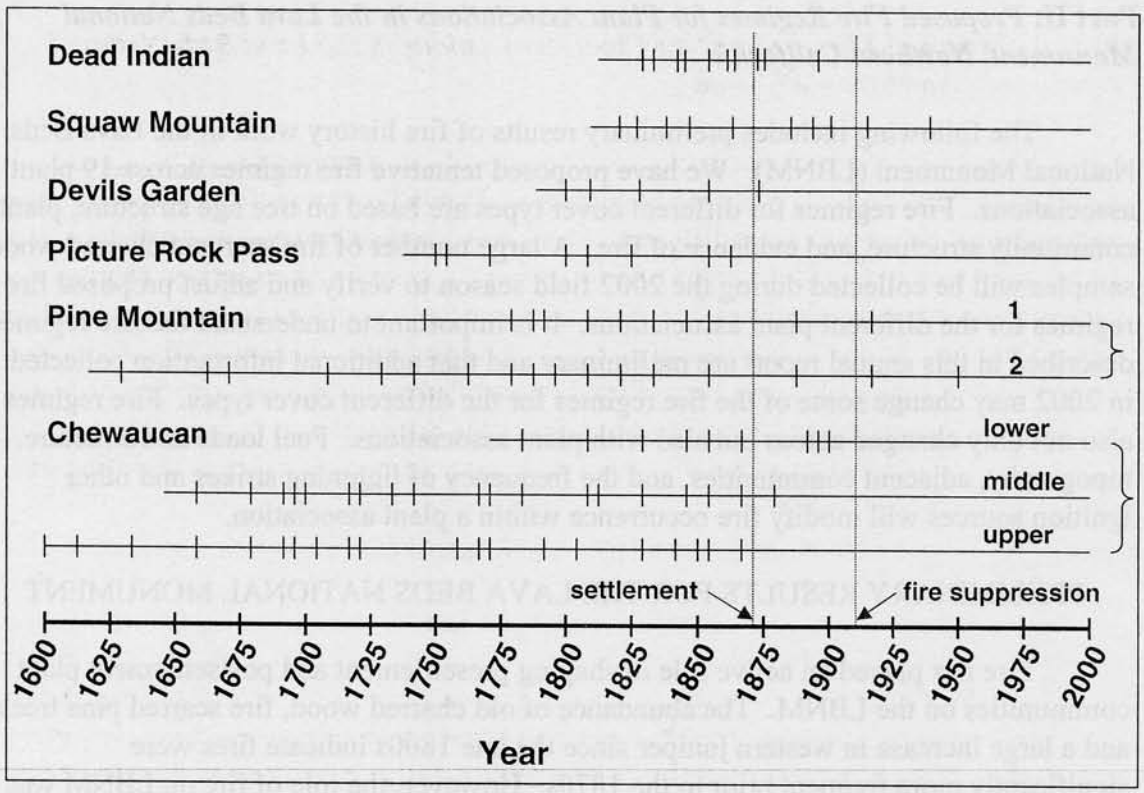

Figure 4. Chronology of fire occurrences among the different stands sampled in mountain big sagebrush / Idaho fescue plant association.

Table 4. Presettlement fire regime characteristics in the mountain big sagebrush bitterbrush) / Idaho fescue cover type for the High Desert and Klamath Ecological Provinces.

Frequency	High (MFRI = 10-20 years)
Season	Mid summer through fall
Primary Ignition	Lightning
Size	Varied
Complexity	Varied
Severity	Low
Intensity	Low

Part II: ***Proposed Fire Regimes for Plant Associations in the Lava Beds National Monument, Northern California***

The following includes preliminary results of fire history work in the Lava Beds National Monument (LBNM). We have proposed tentative fire regimes across 19 plant associations. Fire regimes for different cover types are based on tree age structure, plant community structure, and evidence of fire. A large number of fire scar and charred wood samples will be collected during the 2002 field season to verify and adjust proposed fire regimes for the different plant associations. It is important to understand the fire regimes described in this annual report are preliminary and that additional information collected in 2002 may change some of the fire regimes for the different cover types. Fire regimes also not only changed across but also with plant associations. Fuel loads and structure, topography, adjacent communities, and the frequency of lightning strikes and other ignition sources will modify fire occurrence within a plant association.

PRELIMINARY RESULTS FOR THE LAVA BEDS NATIONAL MONUMENT

Fire has played an active role in shaping presettlement and postsettlement plant communities on the LBNM. The abundance of old charred wood, fire scarred pine trees, and a large increase in western juniper since the late 1800s indicate fires were significantly more frequent prior to the 1870s. However, the role of fire on LBNM was spatially diverse across the monument (Table 5). For example, presettlement mean fire return intervals (MFRI) varied from 10-20 years in some plant communities to greater than 150 years in other communities. The complexity of fire regimes in the LBNM is largely determined by varying fuel loads, topography, and terrain dissected by rock outcrops (mostly recent lava flows).

Evidence supports that fire has played an active but complex role in plant communities across the LBNM. The more arid plant communities, dominated by Thurber and western needlegrass, were probably characterized by relatively long MFRI of 60 to 100 years, which supported a shrub steppe community with few juniper. However, in the more arid western needlegrass communities, fire return intervals were considerably longer, allowing the development of old growth juniper woodlands. On some of the recent lava flows and rock outcrops, fires were rare or absent allowing juniper trees to exceed ages of 500 (very possibly >1000) years. In contrast, fire return intervals were relatively short (10 to 20 years) in the wetter more productive communities dominated by bluebunch wheatgrass and Idaho fescue. Under the presettlement fire regime the herbaceous layer with an open scattered stand of shrubs would have dominated these communities. Western juniper has expanded and/or increased in density into many of these sites since the 1870s, suggesting a change in fire regimes. The 2002 field season will allow us to significantly expand and verify the fire history story on the LBNM proposed in this annual report.

Table 5. Proposed Mean Fire Return Intervals and last fire event for plant communities measured in the LBNM.

Community	Cover Type	Last Fire(s)	Estimated MFRI	Juniper Status
JUOC/ARTRV/STOC	JUOC/ARTRV-PUTR-CELE/STOC	1730s*	150+	Old Growth
JUOC/ARTRV/STOC	JUOC/ARTRV-PUTR-CELE/STOC	1840s*	150+	early
ARTRV-(Ribes)/STTH-STOC	ARTRV-PUTR/AGSP-STTH-STOC	1941/1860s*	50-100	early
JUOC/ARTRV/STOC	CELE-ARTRV-PUTR/AGSP-STOC	1860s*	70+	mid
ARTRV-CHMI/AGSP-STTH-STOC				
ARTRV/AGSP-STTH-STOC	PUTR-ARTRV/AGSP-STOC	1941/1880s*	<60	early
ARTRV/STOC	ARTRV-PUTR/STOC-STTH-AGSP	1941	50-100	early
AGSP-STTH-STOC	ARTRV/AGSP-STTH-STOC	1973	50-100	early
ARTRV/AGSP-STTH	ARTRV/AGSP-STTH	1986	30-70	early
AGSP-STTH-STOC				
ARTRV-CELE/FEID-AGSP	ARTRV/AGSP-STTH-STOC	1996	30-70	early
ARTRV/AGSP-STTH	ARTRV/AGSP-STTH	1994	30-70	early
PIPO/FEID	PIPO/FEID	1870s*	10-20	mid
JUOC/CELE/FEID	PIPO/FEID	1870s*	10-20	mid
ARTRV/FEID-AGSP	ARTRV/FEID-AGSP	1941	10-20	early
ARTRV/FEID-AGSP	ARTRV-PUTR/FEID-AGSP	1890s*	10-20	mid
ARTRV/FEID-AGSP	ARTRV-PUTR/FEID-AGSP	1941/1860s*	10-20	Post-mixed
ARTRV/FEID-AGSP	ARTRV-PUTR/FEID-AGSP	1986/1941	10-20	early
CELE-ARTRV/AGSP-STOC-STTH	CELE-ARTRV/AGSP-STOC-STTH	Late 1800s*	50-100[1]	mid-late
ARTRV-CHMI/ AGSP-STOC-STTH	ARTRV-CHMI/ AGSP-STOC-STTH	Late 1800s*	50-100[1]	mid
CELE	PIPO/CELE?/FEID	Late 1800s*	10-20	early

Last Fire: estimated from tree age structure and/or LBNM fire map; fire dates with * are estimates which will be verified with charred wood samples in 2002.

MFRI: tentative proposed mean fire return interval based on fuel type, tree age structure, and evidence of fire, to be reevaluated in 2002

Juniper Status: Successional status of juniper woodland on the site

JUOC = western juniper, PIPO=ponderosa pine, ARTRV = mt big sagebrush, CELE=curlleaf mt. mahogany, CHMI=Chamaebatiaria millifolium, PUTR=bitterbrush, AGSP=bluebunch wheatgrass, FEID=Idaho fescue, STOC=western needlegrass, STTH= Thurber needlegrass

Part III: Proposed Fire Regimes for Plant Associations in Eastern Oregon and Northern California:

Presettlement fire regimes were highly variable among mountain big sagebrush associations ranging from high-frequency low-intensity fires to low-frequency high-intensity fires (Table 6). In several of the more productive mountain big sagebrush plant associations, fires were frequent (MFRI = 10-20 yrs) and low intensity (Miller and Rose 1999, Miller and Tausch 2001, EOARC data). At the other end of the spectrum, infrequent (MFRI > 100 years) high-intensity fires characterized some of the less productive plant associations on pumice soils (EOARC data). Plant associations with relatively short fire regimes were probably grass dominated with a low density of shrubs. As MFRI increased, the physiognomy shifted from grassland to shrub steppe. Sparse stands of western juniper probably became established as MFRI > 50 years. Since the late 1800s, fire events have generally decreased across the mountain big sagebrush series, especially those where presettlement MFRI were < 100 years. The result has been an increase in shrub cover and density and decline in the herb layer, and often a shift from shrub steppe to western juniper woodlands.

Table 6. Proposed presettlement fire regimes and community physiognomy for different sagebrush plant associations in northeastern California.

Association	MFRI (yrs)	Intensity	Community Structure
ARTRV-SYOR/BRMA	10-20	light	Open shrub - Grassland
ARTRV/STCO	10-20	light	Open shrub - Grassland
ARTRV/FEID	10-20	light	Open shrub - Grassland
ARTRV/AGSP-FEID	15-25	light	Open shrub - Grassland
ARTRV/AGSP	15-35	light-moderate	Open shrub - Grassland
ARTRV/AGSP-STTH	30-70	moderate-high	Shrub steppe
ARTRV/STTH	50-100	high	Shrub steppe
ARTRV/STOC	50-100+ >200	moderate-high	Shrubsteppe Open juniper shrub steppe Juniper woodland
ARTRW/FEID	20-30	moderate	Grassland
ARTRW/AGSP	30-50	moderate-high	Open shrub grassland
ARTRW/STTH	35-100+	high	Shrub steppe
ARTRW/STOC	>100	high	Shrub steppe
ARTRW/ORHY	>100	high	Shrub steppe
ARTRT/ELCI	<50	low-moderate	Grassland to shrub steppe
ARTRT/AGSP	30-100	moderate-high	Shrub steppe
ARAR/FEID	10-20	light	Grassland
ARAR/AGSP	20-50	light-moderate	Open shrub grassland
ARAR/POSA	100-200	moderate	Shrub steppeTree shrub sav

ARAR=low sagebrush, ARTRW=Wyoming big sagebrush, ARTRV = mt. big sagebrush, SYOR=Symphoricarpus oreophilus, AGSP=bluebunch wheatgrass, BRMA=mountain brome, ELCI=basin wildryegrass, FEID=Idaho fescue, ORHY=Indian ricegrass, OSA=Sandberg bluegrass, STCO=Columbia needlegrass, STOC=western needlegrass, STTH= Thurber's needlegrass

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