Ecology of the Wyoming big sagebrush alliance in the northern Great Basin: 2004 Progress Report

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Wyoming Big Sagebrush Program

Introduction

This progress report presents a summary of research findings in the Wyoming big sagebrush alliance of eastern Oregon and northern Nevada. The report includes results from the 2001, 2002, and 2003 field seasons. The results and comments made in the report are still preliminary, as data analysis and projects are still ongoing.

The purpose of the "*Wyoming Big Sagebrush Program*" is to provide a better understanding of the ecology and management of this sagebrush alliance. The ***ecology*** focus is directed towards; (1) determining the biological potentials of the alliance and how these potentials impact interpretation of habitat guidelines, (2) develop a classification system of plant associations within the alliance, (3) determine the effects of environmental characteristics influencing development of plant associations, (4) determine the short and long-term effects of wild and prescribed fire to plants and invertebrates, and (5) determine effects of long-term climate variability to productivity, plant composition, and vegetation dynamics. The ***management*** effort involves development of guidelines and management alternatives in the Wyoming big sagebrush alliance focusing on fire and livestock grazing. We are attempting to develop a risk assessment of community susceptibility to cheatgrass or other weed invasion after fire disturbance and to develop grazing guidelines following fire in the sagebrush steppe. Define community susceptibility to fire will assist in development of appropriate management actions and assist in predicting outcomes of fire in the Wyoming sagebrush alliance.

I. Vegetation Characteristics of the Wyoming Big Sagebrush Alliance Across its Northwestern Range

Kirk Davies, Jon Bates, and Rick Miller

Summary

The Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis* (Beetle & A. Young) S.L. Welsh) alliance is the most extensive of the big sagebrush complex in the Intermountain West (Miller and Eddleman 2000, Tisdale 1994). This alliance provides critical habitat for many sagebrush obligate and facultative wildlife species as well as a forage base for livestock production. Limited information on vegetation structure, composition, and spatial heterogeneity has resulted in disagreement over describing the vegetation potential for meeting management goals across the Wyoming big sagebrush alliance. Our goal was to provide information describe the spatial heterogeneity of late seral Wyoming big sagebrush plant associations across the northwestern portion of the sagebrush biome. Our objectives were to; 1) describe vegetation characteristics in relatively undisturbed Wyoming big sagebrush plant communities; 2) determine if distinct plant associations could be defined; and 3) compare stand level vegetation characteristics with greater sage grouse habitat guidelines developed by the Bureau of Land Management et al. (2000) and Connelly et al. (2000). We intensively sampled 107 relatively, undisturbed high ecological condition sites across three ecological provinces (High Desert, Humboldt, and western Snake River) in eastern Oregon and northern Nevada in 2001 and 2002. Using multivariate analysis, differences in species composition and functional group cover values indicated grouping Wyoming big sagebrush communities into associations by dominant perennial bunchgrass species was appropriate. Five Wyoming big sagebrush associations were identified; bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Smith), Thurber's needlegrass (*Stipa thurberiana* Piper), needle-and-thread (*Stipa comata* Trin. & Rupr.), Idaho fescue (*Festuca idahoensis* Elmer), and bluebunch wheatgrass/Thurber's needlegrass. Using a strict interpretation of the Bureau of Land Management et al. (2000) habitat guidelines, none of the high ecological condition sites met sage grouse nesting or brood-rearing habitat requirements and only 30% met the sub-optimum brood-rearing habitat requirements. Guidelines developed by Connelly et al. (2000) for breeding and brood-rearing habitats in arid sagebrush communities were met by 18% and 63% of the sites, respectively. These results strongly supporting the suggestion by Connelly et al. (2000) that local expert judgment be used due to the variability across the sagebrush biome. The winter habitat requirements were identical for both guidelines and were met on 70% of the sites. Individual plant associations within the Wyoming big sagebrush alliance varied in their vegetation cover among plant functional groups. The underlying problem with current guidelines is a scale issue. When guidelines are interpreted, they imply stand or landscape scale, but they were largely developed from smaller scale information. Guidelines also did not differentiate between sagebrush species or subspecies. Management is applied at stand or landscape levels, therefore information is required that reflects these scales. Vegetation cover guidelines for wildlife habitat could be improved

by incorporating our survey of the Wyoming big sagebrush alliance across the northwestern portion of the sagebrush biome. Guidelines also need to recognize that different sagebrush alliances and associations have varying vegetation cover potentials.

Introduction

The reduction of intact Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis* (Beetle & A. Young) S.L. Welsh) communities in the Intermountain West has increased habitat concerns for many sagebrush obligate species including sage grouse (*Centrocercus urophasianus*), sage sparrows (*Amphispiza belli*), Brewer's sparrows (*Spizella* breweri), sage thrashers (*Oreoscoptes montanus*), and pygmy rabbits (*Brachylagus idahoensis*). Because of wildlife, other ecological concerns, and the importance of this alliance to the western livestock industry, there is a need to develop state-of-the-art management objectives and decision-making criteria to maintain or enhance the viability of the sagebrush ecosystem. However, there is limited information describing the heterogeneity of vegetation cover and structure across the Wyoming big sagebrush alliance. Passey et al. (1982) and Jensen (1990) came the closest to confronting this issue, but these efforts had small sample sizes. Passey et al. (1982) sampled only seven and Jensen (1990) sampled only four Wyoming big sagebrush sites. Vegetation analysis was limited in the Jensen (1990) study to biomass weight estimates. In addition to employing a weight estimate technique, Passey et al. (1982) also measured cover and composition. However, Passey et al. (1982) cover results are difficult to interpret because areas with higher productivity had lower vegetation cover than some lower producing sites.

Vegetation cover guidelines for sage grouse by the Bureau of Land Management et al. (2000) and Connelly et al. (2000) have recently been developed. Cover requirements were based on a few selected wildlife studies assessing sage grouse life history needs, though there is some question as to how the habitat requirements could be extrapolated from these studies (Schultz 2004). Specifically, the data from these studies do not support the height and cover requirements (Schultz 2004). Ignoring this, developing guidelines from these studies have several potential problems. These studies look at what habitat was utilized or had greater survival success. This does not determine if the sagebrush community[1] can produce this habitat at a landscape[2] or even a stand level[3]. Second, these studies only represent a small portion of the sagebrush community. Because of lack of data in our region, guidelines have been based on studies conducted outside of our area. Extrapolating results from one sagebrush species or subspecies to another or to different geographic areas may not be appropriate.

Another concern with using these selected wildlife studies to develop management guidelines for nesting habitat is that the methods used for measuring vegetation potentially over-estimate shrub cover if scaled up to stand or community level (Miller et al. 2003, EOARC data file). Sage-grouse nest under sagebrush plants, and many of these studies measured vegetation cover in the immediate vicinity of a nest area, which may

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[1] Plant community – an assemblage of species across the landscape with one dominant overstory species.
[2] Landscape – a heterogeneous land area composed of many plant communities.
[3] Stand – a continuous, relatively homogenous area with one dominant overstory species and one or two dominant understory species.

not be representative of stand or landscape vegetation cover. Even with excluding the nest site (4 m^2), Sveum et al. (1998) found nest areas to have almost three times as much shrub cover as random locations throughout the landscape. Sage grouse are selecting denser patches of cover, which reflects the variability within the plant community, not the mean. These wildlife studies also rarely distinguish between subspecies of big sagebrush, further limiting their usefulness to developing guidelines.

Neither sage grouse management guidelines distinguish between sagebrush species nor subspecies, which can have profound difference in production and cover. For example, Passey et al. (1982) found annual production on mountain big sagebrush communities to be up five times greater than Wyoming big sagebrush communities. Connelly et al. (2000) addressed this to a degree by developing different sage grouse habitat requirements for mesic and arid sites. They also recognized gaps in our knowledge and variation in regional habitat characteristics (Tisdale and Hironaka 1981) and recommended implementation of guidelines based on quantitative data from monitoring sage grouse populations and habitat and the judgment of local biologists. Management objectives also need to be tailored to the individual subspecies of the big sagebrush complex because of differing environmental characteristics influencing vegetation structure and composition and varying responses to grazing and disturbance (Barker and McKell 1983, Beetle and Young 1965, Blaisdell et al. 1982, Hironaka 1978, McArthur and Plummer 1978, Morris et al 1976, Tisdale 1994, Winward and Tisdale 1977).

The objectives of this study were to 1) determine the variability and range of vegetation characteristics of high condition Wyoming big sagebrush sites in the northwest portion of the sagebrush biome, 2) determine if distinct plant associations could be defined for this alliance, and 3) compare the biological potentials of the Wyoming big sagebrush alliance to both sage grouse management guidelines.

Methods and Statistics

Site Selection

During February, March, and April of 2001 and 2002, Bureau of Land Management (BLM) offices in Lakeview, Vale, Burns, and Winnemucca were contacted to obtain locations of Wyoming big sagebrush communities in high ecological condition in the High Desert, Humboldt, and western Snake River Ecological Provinces. Most of the sites were within the High Desert or Humboldt Ecological Provinces with a few located in the western edge of the Snake River Ecological Province (Fig. 1). Sites were sampled from north of Westfall, Oregon, south to Winnemucca, Nevada and from Lakeview, Oregon east to the Oregon-Idaho border. Sites within these locations were sampled from late May to the first part of July. Sites were selected by the following criteria; 1) understory dominance by large perennial bunchgrasses and forbs, 2) exotic/introduced species were a minor to nonexistent component, 3) evidence of restricted livestock use (Passey et al. 1982), and 4) stands were dominated by mature sagebrush with limited recruitment of new shrubs. We measured 107 sites that met these criteria. We attempted to sample in areas with an array of different site characteristics (slope, elevation, aspect, soil, dominant grass species, etc) to quantify variation across the Wyoming big sagebrush alliance and within plant associations.

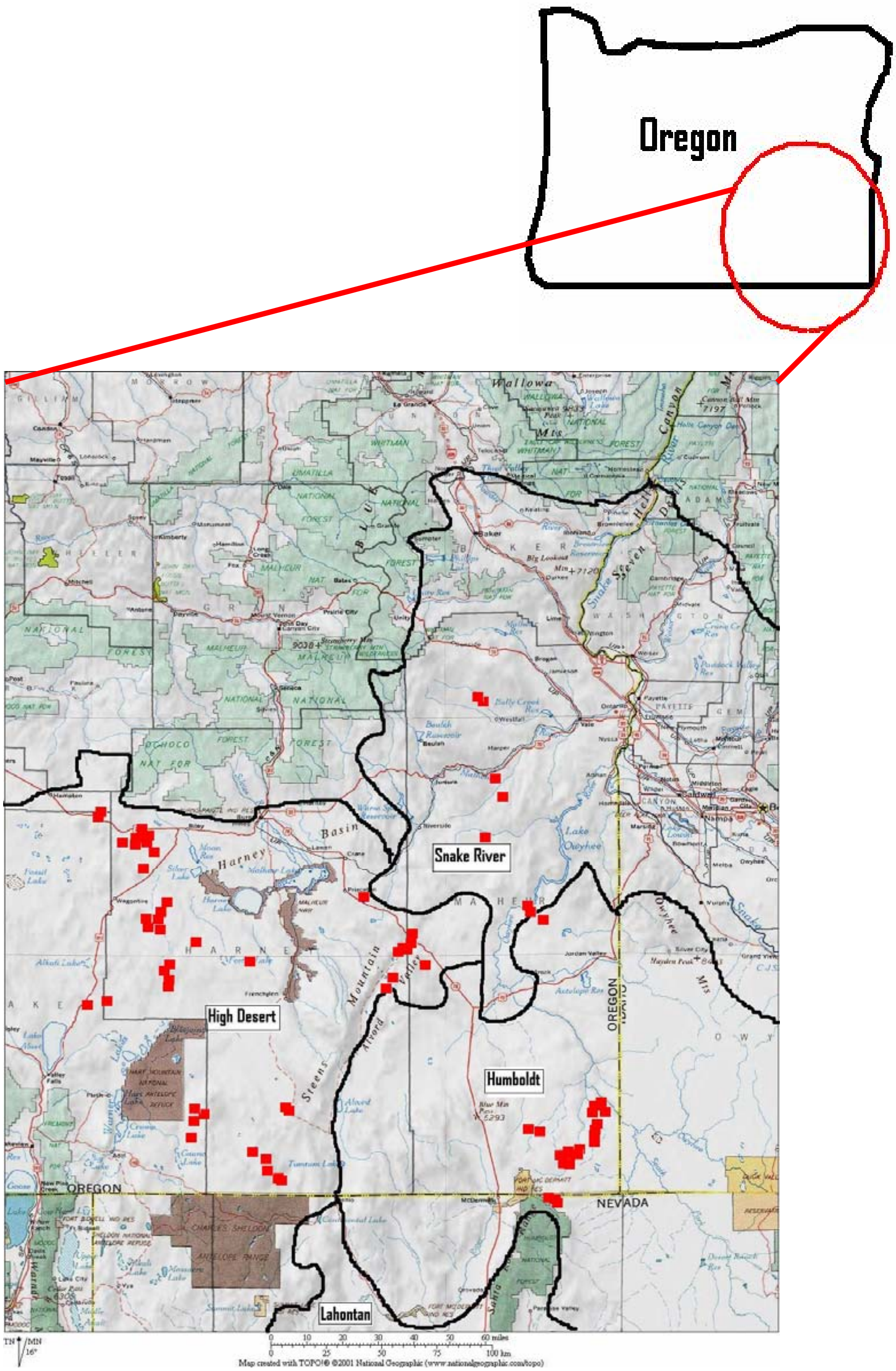

Figure 1. Red squares represent areas where Wyoming big sagebrush sites were sampled. Ecological province boundaries (bold black lines) are derived from Anderson et al. (1998) and Bailey (1994).

Sampling

One 80 X 50 m plot was used to sample each site. Five, 50 m transects were laid out at 20 m intervals starting at the beginning of the main transect tape. Shrub canopy cover was measured using the line intercept method (Canfield 1941). Dead canopy cover was recorded separate from live. Canopy gaps up to 15 cm were included in canopy cover estimates. Individual shrub species and total shrub cover were determined using the line intercept method (Canfield 1941). Herbaceous canopy cover was visually estimated by species using 0.2 m^2 frames located at 3 m intervals on the transect lines (starting at 3 m and ending at 45 m) resulting in 15 frames per transect and 75 frames per plot. For some of the analyses, herbaceous cover was grouped into 5 functional groups; Sandberg's bluegrass (POSA), tall perennial grass, annual grass, perennial forbs, and annual forbs. Functional groups simplify analysis and allow comparisons among sites with different species composition. The purpose of using functional groups is to combine species that respond similarly to environmental perturbation and to reduce data to a simpler form for analysis and presentation (Boyd and Bidwell 2002). Total herbaceous cover was the sum of all herbaceous species. Species lists were compiled for each 0.4 ha plot for estimating species richness.

Statistical Analysis

Means, minimums, maximums, standard errors, and other parametric statistics (S-plus 2000) were generated to summarize the range of vegetation characteristics of the Wyoming big sagebrush alliance in the northwestern portion of the sagebrush biome. The alliance was classified into five associations by dominant perennial bunchgrasses based on cluster analysis and personal judgment. Parametric statistics, similar to those used for the entire alliance, were used to summarize the vegetation characteristics of each association. A Multiple Response Permutation Procedure (MRPP) was used to test for species composition homogeneity within associations (PC-ORD version 4). Analysis of variance (ANOVA) was used to determine if differences existed among vegetation cover estimates by association and family-wise comparisons using the Tukey-Kramer method was used to determine which associations were different from each other (S-plus 2000). Vegetation cover characteristics by site were compared to Bureau of Land Management et al. (2000) and Connelly et al. (2000) guidelines.

Results and Discussion

Summary of Vegetation Characteristics

Herbaceous cover

Across the sites sampled, herbaceous vegetation cover was extremely variable (Table 1). Perennial grass cover and total herbaceous cover varied more than six- and seven-fold (respectively) between minimum and maximum values. Herbaceous cover was largely composed of high seral perennial bunchgrasses. Cover of annual grass was low on most sites sampled. Mean perennial forb cover was 4.1%, accounting for less than 20% of the total herbaceous cover across the sites.

Shrub cover

Shrub canopy cover was highly variable across the sites sampled (Table 2.). Combining live and dead shrub cover increased overall canopy cover values more than just measuring live shrub cover. Thus, any monitoring of shrub cover must clearly define the measuring protocol that will be used.

Table 1. Variability of functional group percent canopy cover values across all sites measured.

STATISTIC	POSA	PG	AG	PF	AF	Total herb
Mean	5.39	12.19	0.61	4.13	0.59	22.91
Median	5.28	10.85	0.05	3.61	0.37	21.92
Min	0.0	4.5	0.0	0.0	0.02	5.9
Max	13.21	18.3	9.8	11.9	5.6	46.5
Standard Error	0.23	0.45	0.14	0.27	0.07	0.66

POSA= Sandberg's bluegrass, PG = Perennial grass, AG = Annual Grass, PF = Perennial forb,
AF = Annual forb, and Total Herb = Total herbaceous

Table 2. Summary of shrub percent canopy cover values for all sites measured.

STATISTIC	Sagebrush Cover (live)	Sagebrush Cover (dead)	Other Shrub Cover	Total Live Cover [a]	All Shrub Cover [b]
Mean	12.3	3.9	1.1	13.4	17.3
Median	11.9	3.5	0.4	12.3	17.0
Min	3.2	0.6	0.0	4.8	8.6
Max	25.1	11.5	8.4	26.9	35.5
Standard Error	0.41	0.22	0.17	0.43	0.47

[a] Total live cover is the combination of live sagebrush cover and live other shrub cover.
[b] All shrub cover is the combination of live and dead sagebrush cover and all other shrub cover.

Wyoming big sagebrush site classification

The Wyoming big sagebrush alliance in the High Desert, western Snake River, and Humboldt Ecological Provinces are characterized by over 230 different plant species

(Appendix 1). Species encountered include: 15 shrub species, 2 tree species, 20 perennial grass species, 5 annual grass species, 127 perennial forb species, and 68 annual forb species.

Initially, cluster analysis by species composition was utilized to group similar plant communities into associations. The National Vegetation Classification Standard defines an association as a physiognomically uniform group of vegetation stands that share one or more diagnostic (dominant, differential, indicator, or character) overstory and understory species. Though different associations were formed, none could easily be recognized in the field. No indicator species were consistently present or exclusive for any of the associations, but there was some clustering of sites by dominant perennial bunchgrasses. For a vegetation classification system to be useful, it must be uncomplicated and easily implemented in the field. Building from some of the patterns we observed in the cluster analysis and our desire for simplicity, we formed five associations grouped by dominant late seral perennial bunchgrasses. Passey et al. (1982) reported similar difficulties with classifying vegetation groups, which resulted in them using personal judgment from their field experience to form associations.

The Wyoming big sagebrush alliance (ARTRW8) plant associations we classified were: ARTRW8/AGSP (*Agropyron spicatum* (Pursh) Schibn. & Smith bluebunch wheatgrass), ARTRW8/STTH (*Stipa Thurberiana* Piper Thurber's needlegrass), ARTRW8/FEID (*Festuca idahoensis* Elmer Idaho fescue), ARTRW8/STCO2 (*Stipa comata* Trin. & Rupr. needle-and-thread), and ARTRW8/AGSP-STTH- co-dominance of bluebunch wheatgrass and Thurber's needlegrass (the lower cover value contributed at least 40% of their combined cover value). Because the dominant shrub is Wyoming big sagebrush in all of the associations, when referring to the association only the dominant perennial grass code will be used in the remainder of this section. Late seral communities in the AGSP association appeared to be the most abundant in the region, and were represented with 63 sites sampled. Second most common was the STTH association with 16 sites, third was the FEID association with 14 sites, and both the STCO2 and AGSP-STTH associations had 7 sites.

Species composition within groups after excluding dominant perennial bunchgrass species used for grouping was more homogenous than expected by chance ($p < 0.0001$, $A = 0.0325$). A is the chance-correct within-group agreement. If A is > 0, then there is more homogeneity than expected by chance within groups. If all individuals within a group are identical then $A = 1$. If there is less agreement within groups than expected by chance then $A < 0$ (McCune and Grace 2002). Sites within an association had similar species compositions, while species composition varied among associations. Inclusion of the dominant perennial bunchgrass species in the analysis increased homogeneity within associations and increased heterogeneity between associations ($p < 0.0001$, A = 0.1968). This classification of the Wyoming big sagebrush alliance by dominant perennial grass is statistically sound, simple, and useful. The historic classification of rangelands by dominant shrub and dominant perennial grass species is still valid today.

Many of the functional group cover values were significantly different among associations (Table 3). The FEID association had a mean of 19.4% for perennial grass cover, almost twice that of any of the other associations. The STCO2 association had a mean POSA cover of 1.6%, which was significantly less than the other associations. The

STCO2 association also had the smallest mean perennial forb cover at 0.3%, which ranged from eight to sixteen times less than the other associations.

Annual grass cover was different between a few of the associations, but generally was very low. Annual grass cover was mainly composed of cheatgrass (*Bromus tectorum* L.), though native annual grasses (*Vulpia* sp.) were also present on many sites. Cheatgrass presence on these relatively undisturbed areas may be a threat if fire disturbance occurs, especially in the STTH association (Bates et al. 2004).

High degrees of variability in functional group and total herbaceous cover values existed within and among plant associations (Fig. 2-6). Total herbaceous cover was significantly different between all associations ($p < 0.05$) except for AGSP vs. AGSP-STTH and STTH vs. STCO2 associations. The FEID association had the largest mean total herbaceous cover (28.7%) followed by the AGSP association (24.1%), and the AGSP-STTH association (22.1%). The STTH and STCO2 associations mean total herbaceous cover was 17.1% and 13.9%, respectively. The STCO2 association produced less than half of herbaceous cover of the FEID association. Delineating the Wyoming big sagebrush alliance into associations for management purposes is supported by the differences in the associations' ability to produce herbaceous cover.

Unlike the herbaceous functional groups, Wyoming big sagebrush cover was not significantly different between most of the associations ($p > 0.05$) (Table 3), although the AGSP-STTH association's mean Wyoming big sagebrush cover (16.8%) was significantly higher than any of the other associations ($p < 0.05$). All the other associations' mean Wyoming big sagebrush cover values were not different from each other ($p > 0.05$), which was due to the high degree of variability within plant associations. The other associations' means for Wyoming big sagebrush cover ranged between 9.9% and 13.5%.

Table 3. Mean percent cover of functional groups by association with standard error.

Functional Groups	**Association**				
	AGSP	*STTH*	*STCO2*	*FEID*	*AGSP-STTH*
Sandberg's bluegrass	6.0±0.27 c	4.8±0.37 bc	1.6±0.78 a	4.5±0.39 b	6.7±1.23 c
Perennial Grass	11.9±0.46 b	8.8±0.36 a	11.0±1.97 ab	19.4±1.20 c	9.4±0.88 a
Annual Grass	0.8±0.22 b	0.4±0.24 ab	0.8±0.22 b	0.02±0.01 a	0.7±0.27 b
Perennial Forb	4.8±0.36 c	2.5±0.42 b	0.3±0.09 a	4.4±0.44 c	5.0±1.20 c
Annual Forb	0.6±0.11 ab	0.8±0.18 ab	0.2±0.06 a	0.4±0.10 ab	0.4±0.04 b
Wyoming big sagebrush	12.0±0.48 a	13.5±0.91 a	9.9±2.28 a	11.1±0.90 a	16.8±2.44 b

Different lower case letters indicate significant ($p < 0.05$) differences among associations by functional group.

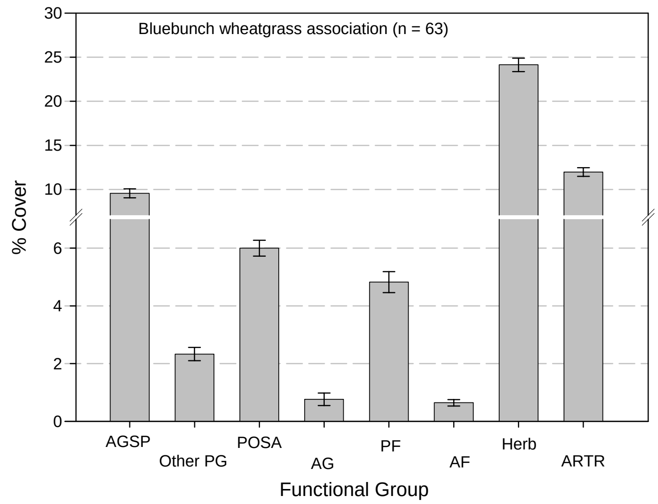

Figure 2. AGSP association's mean functional group cover values with standard error bars. AGSP = bluebunch wheatgrass, Other PG = Other Perennial Grass, POSA = Sandberg's bluegrass, AG = Annual Grass, PF = Perennial Forb, AF = Annual Forb, Herb = Total herbaceous, and ARTR = Wyoming Big Sagebrush.

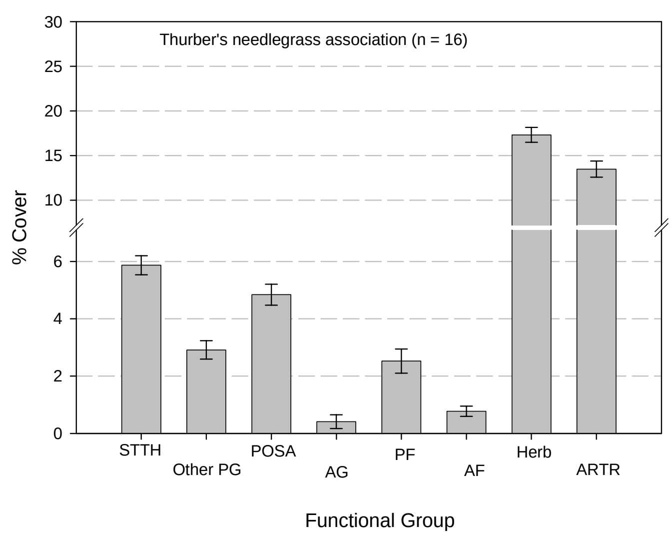

Figure 3. STTH association's mean functional group cover values with standard error bars. STTH = Thurber's needlegrass, Other PG = Other Perennial Grass, POSA = Sandberg's bluegrass, AG = Annual Grass, PF = Perennial Forb, AF = Annual Forb, Herb = Total herbaceous, and ARTR = Wyoming Big Sagebrush.

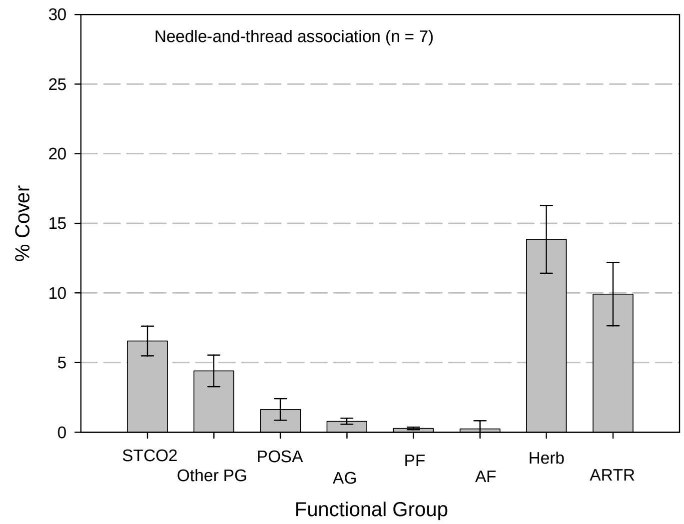

Figure 4. STCO2 association's mean functional group cover values with standard error bars. STCO2 = needle-and-thread, Other PG = Other Perennial Grass, POSA = Sandberg's bluegrass, AG = Annual Grass, PF = Perennial Forb, AF = Annual Forb, Herb = Total herbaceous, and ARTR = Wyoming Big Sagebrush.

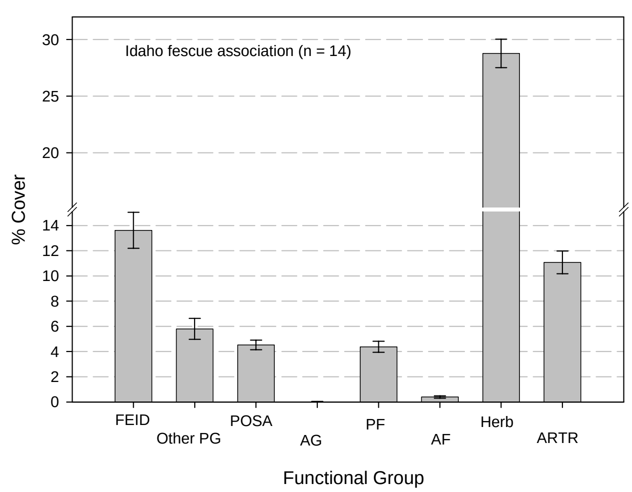

Figure 5. FEID association's mean functional group cover values with standard error bars. FEID = Idaho fescue, Other PG = Other Perennial Grass, POSA = Sandberg's bluegrass, AG = Annual Grass, PF = Perennial Forb, AF = Annual Forb, Herb = Total herbaceous, and ARTR = Wyoming Big Sagebrush.

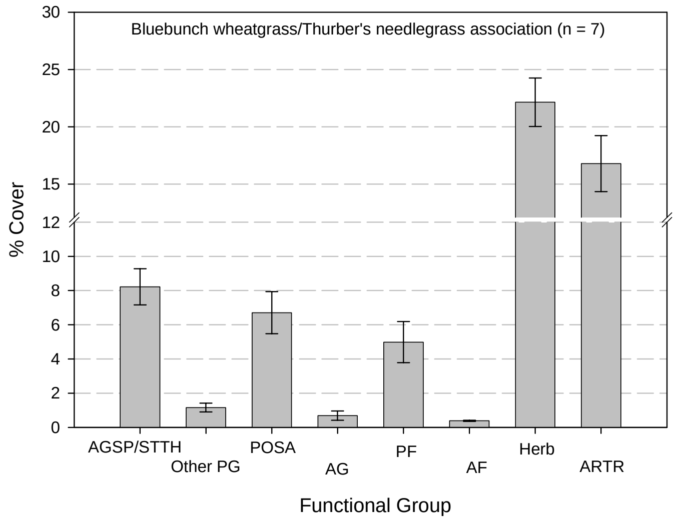

Figure 6. AGSP-STTH association's mean functional group cover values with standard error bars. AGSP-STTH = bluebunch wheatgrass-Thurber's needlegrass, Other PG = Other Perennial Grass, POSA = Sandberg's bluegrass, AG = Annual Grass, PF = Perennial Forb, AF = Annual Forb, Herb = Total herbaceous, and ARTR = Wyoming Big Sagebrush.

Management Implications

Concern for facultative and obligate sagebrush wildlife species heightens the need for information about the vegetation characteristics of all sagebrush alliances. Current guidelines for greater sage-grouse were based on studies which did not represent stand or landscape vegetation potentials. These guidelines were designed for specific seasonal habitat requirements, but in practice, are often interpreted/applied at inappropriately large scales. Additionally, the guidelines do not distinguish among the different sagebrush species or subspecies. Our study used standard rangeland survey methods to estimate vegetation cover at the stand level. Rangeland survey methods focus on larger units of land to adequately describe stand or landscape vegetation. Comparing vegetation characteristics of sites from our study to sage grouse guidelines indicated that guideline habitat requirements need to be adjusted for the Wyoming big sagebrush alliance in the High Desert, western Snake River, and Humboldt Ecological Provinces. The guidelines are a good starting point for management of sage grouse habitat, but the habitat requirements should be exclude due to the variability of the sagebrush biome. Connelly et al. (2000) guideline's habitat requirements should not be interpreted as standards (Schultz 2004), instead habitat requirements should be developed regionally. Connelly et al. (2000) suggested using local expertise to develop requirements, which would account for the variability across the sagebrush biome. Caution is advised when developing or implementing habitat vegetation requirements for extensive areas because there may be sites lacking the potential to provide adequate habitat for the species in question.

Bureau of Land Management et al. (2000) Guidelines

The Bureau of Land Management et al. (2000) guidelines (Table 4) appear to be based on Connelly et al. (2000) guidelines (Table 5) for mesic sagebrush sites and are probably not tenable for the Wyoming big sagebrush alliance. For instance, none of the high ecological condition sites sampled in this study met the Bureau of Land Management et al. (2000) optimum nesting or optimum brood-rearing habitat requirements (Table 6). The main reasons for not meeting optimum nesting and optimum brood-rearing habitat requirements were; 1) tall forb (≥ 18 cm) cover did not equal or exceed 10% cover on any sites, and 2) sagebrush cover did not meet minimum cover requirements. Sagebrush cover equaled or exceeded 15% cover on less than a quarter of the sites and 10% cover on about 70% of the sites. Many forbs in this alliance, especially perennials, have a prostrate growth form. Thus, tall forb cover rarely exceeded 5% in these communities. Furthermore, about 30% of the sites sampled had less than 10% sagebrush cover. The limited biological potential of sites to produce tall (≥18 cm) herbaceous cover and 10% or greater sagebrush cover resulted in less than 30% of the sites meeting sub-optimum brood rearing habitat requirements. We found that although sites may be capable of producing high cover in one functional group, it was highly unlikely that they would produce high cover across several functional groups. For example, the site with the maximum perennial grass cover (28.31%) had only 2.99% perennial forb cover. The lack of any high ecological condition sites meeting either the optimum nesting or optimum brood-rearing habitat requirements and the limited number meeting the sub-optimum brood-rearing habitat requirements strongly suggest that these requirements are unachievable on a stand or landscape scale across the northwestern range of the Wyoming big sagebrush alliance.

Connelly et al. (2000) Guidelines

Connelly et al. (2000) guidelines for arid sagebrush sites suggested habitat requirements (Table 5) are more reasonable, but require adjustments to better match with the biological capabilities of the Wyoming big sagebrush alliance in High Desert, western Snake River, and Humboldt Ecological Provinces. They defined breeding habitat as areas where lekking, nesting, and early brood-rearing occur. Brood-rearing habitats were defined as areas used from late June to early November. The requirements are not compatible with the majority of the Wyoming big sagebrush alliance in our region (Table 6). Only 19 of our sites met the suggested arid sites breeding habitat requirements. Suggested values for brood-rearing habitat on arid lands were met by 67 of our sites. Their winter habitat requirements were the same as the Bureau of Land Management et al. (2000) winter habitat requirements.

Table 4. Bureau of Land Management et al. (2000) habitat requirements for greater sage-grouse.

	Optimum Nesting		Optimum brood-rearing		Suboptimum brood-rearing		Wintering	
	Height (cm)	Canopy (%)	Height (cm)	Canopy (%)	Height (cm)	Canopy (%)	Height (cm)	Canopy (%)
Sagebrush	40-80	15-25	40-80	10-25	40-80	≥ 14	≥ 25-30[b]	10-30
Grass-forb	≥ 18	25[a]	≥ 18	25[a]	≥ 18	15	N/A	N/A
Area[c]	> 80		> 40		> 40		> 80	

[a] at least 15% grass canopy cover and 10% forb canopy cover
[b] at least 25 to 30 cm exposed above the snow level
[c] percentage of seasonal habitat needed with indicated conditions

Table 5. Connelly et al. (2000) habitat requirements for greater sage-grouse.

	Breeding		Brood Rearing		Winter	
	Height (cm)	Canopy (%)	Height (cm)	Canopy (%)	Height (cm)	Canopy (%)
Mesic sites						
Sagebrush	40 – 80	15 – 25	40 – 80	10 – 25	25 – 35 [b]	10 – 30
Grass-forb	> 18	≥ 25[a]	variable	> 15	N/A	N/A
Arid Sites						
Sagebrush	30 – 80	15 – 25	40 – 80	10 – 25	25 – 35	10 – 30
Grass-forb	> 18	≥ 15	Variable	> 15	N/A	N/A
Area[c]	> 80		> 40		> 80	

[a] at least 15% grass canopy cover and 10% forb canopy cover
[b] 25 to 35 cm exposed above the snow level
[c] percentage of seasonal habitat needed with indicated conditions

Table 6. Number and percent of high condition Wyoming big sagebrush sites by associations that met the guidelines habitat requirements.

		BLM et al. (2000) Guidelines				Connelly et al. (2000) Arid Site Guidelines		
Association	# of Sites	Nesting	Opt. rearing	Subopt. rearing	Wintering	Breeding	Brood-rearing	Wintering
AGSP	**63**	**0** (0%)	**0** (0%)	**21** (33%)	**43** (68%)	**12** (19%)	**43** (68%)	**43** (68%)
STTH	**16**	**0** (0%)	**0** (0%)	**3** (19%)	**15** (93%)	**2** (13%)	**9** (56%)	**15** (93%)
STCO2	**7**	**0** (0%)	**0** (0%)	**0** (0%)	**3** (43%)	**0** (0%)	**1** (14%)	**3** (43%)
FEID	**14**	**0** (0%)	**0** (0%)	**3** (21%)	**9** (64%)	**1** (7%)	**9** (64%)	**9** (64%)
AGSP/ STTH	**7**	**0** (0%)	**0** (0%)	**5** (71%)	**5** (71%)	**4** (57%)	**5** (71%)	**5** (71%)
TOTAL	**107**	**0** (0%)	**0** (0%)	**32** (30%)	**75** (70%)	**19** (18%)	**68** (64%)	**75** (70%)

Wyoming Big Sagebrush Associations and Guidelines

Individual associations varied in their ability to meet Connelly et al. (2000) and Bureau of Land Management et al. (2000) sage grouse habitat guideline requirements. No sites from any of the associations met the Bureau of Land Management et al. (2000) optimum nesting or brood-rearing habitat requirements. Sub-optimum brood-rearing habitat requirements were met by a few sites in all of the associations except for the STCO2 association (Table 6). Both the sub-optimum brood-rearing (BLM et al. 2000) and breeding habitat (Connelly et al. 2000) requirements were not achieved on any of the STCO2 sites sampled and are largely unrealistic for the STTH, FEID, and AGSP associations. The STCO2 association is less capable of meeting these habitat requirements than some of the other associations. The varying ability of different associations to meet habitat requirements suggests individual association's vegetations characteristics need to be acknowledged in management.

Guidelines verses Stand Level Cover Potentials

The Bureau of Land Management et al. (2000) sage grouse guidelines were not met across the Wyoming big sagebrush alliance in the High Desert, western Snake River, and Humboldt Ecological Provinces. These guidelines may be more realistic for more mesic sagebrush communities (e.g. mountain big sagebrush), but that should be investigated and validated before implementation as well. Granted, 2001 and 2002 had below average precipitation, but climatic variation is not addressed in either of the guidelines. Even with below average precipitation, some of the sites sampled should have met either the optimum nesting or optimum brood-rearing habitat requirements if the requirements were corresponding to the biological potential of the Wyoming big sagebrush alliance in the northwest portion of the sagebrush biome. Habitat guidelines have to account for interannual variation in vegetation production due to natural processes.

The Bureau of Land Management et al. (2000) guidelines were based on research conducted at small scales for specific habitat requirements of sage grouse at a few locations. The difficulty with using these select studies to develop management guidelines for habitat is that; 1) the methods used for measuring vegetation potentially over-estimate plant cover, and 2) the sampling scales do not reflect stand or landscape vegetation characteristics (Miller et al. 2003, EOARC data file). For example, when sage grouse nest were located, nest cover was estimated using two transects intersecting over the nest location, which was under a shrub (Klott and Lindzey 1990, Sveum et al. 1998) or using four transects radiating out from the observation location (Wallestad and Schladweiler 1974, Connelly et al. 1991). These methods over-estimate cover when applied to stands or landscapes because transects are measuring specific, non-random areas, which may have more cover than the surrounding landscape (EOARC file data, Miller et al. 2003). In the case of the observation being a nest, it is located under a shrub and thus that shrub is, in effect, measured twice. In addition, measuring only around the nest is of insufficient scale to represent stand or landscape vegetation cover. These small-scale measurements do not adequately describe vegetation cover at a scale useful to management and under sample the surrounding community.

Another difficulty presented by the guidelines and all studies describing sagebrush cover is that they do not account for heterogeneity of shrub cover at the stand or landscape level. For example, in a stand with 12% average shrub cover, it was found that shrub cover varied from 0% to 45% along 10 m intervals located on five, 50 m transects (EOARC file data, Miller et al. 2003). In addition, sage grouse likely select patches of higher shrub cover than the average of the surrounding landscape. For example, Sveum et al. (1998) found nest areas (excluding nest site) had about 20% shrub cover but random locations throughout the landscape averaged about 7%.

A Possible Solution?

Connelly et al. (2000) recognized there are gaps in our existing knowledge of sage grouse and their habitat. They suggested using input from local biologist and quantitative data to proper implement sage grouse guidelines at the local level, which we support. Connelly et al. (2000) sage grouse guidelines are a good starting point from which improve can be implemented as more data is gathered. The lack of information regarding vegetation characteristics in the Wyoming big sagebrush alliance has partly been resolved with our work, but long-term variability and vegetation characteristics in other regions of this alliance needs to be investigated. We also recommend surveys of other sagebrush species and subspecies in this area and other areas to further fine-tune existing guidelines. Critical to our region would be surveys of the mountain big sagebrush (*Artemisia tridentata* Nutt. ssp. *vaseyana* (Rydb.) Beetle), Basin big sagebrush (*Artemisia tridentata* Nutt. ssp. *tridentata*), and low sagebrush (*Artemisia arbuscula* Nutt.) alliances.

We suggest guidelines be modified to include the potential range of variability of vegetation characteristics across the Wyoming big sagebrush alliance. Our survey of the vegetation characteristics of the Wyoming big sagebrush alliance in the High Desert, western Snake River, and Humboldt Ecological Provinces can be used for this purpose.

Guidelines for plant associations should mandate standardized methods for measuring vegetation characteristics, especially when exceedingly different values are estimated with the various methods that have been used. Small differences in measuring protocols can result in different estimated values. However, methods used to measure cover around a nest should not be used to describe stand or landscape cover and vice versa. Monitoring should occur at the stand level because 1) most management occurs at this level, 2) sage grouse life history needs are met at this scale, and 3) this is the largest scale habitat can be easily manipulated by management, with the exception of prescribed burning. Inconsistency in sampling methodology has confounded interpretation of vegetation measurements resulting in controversy over the development and implementation of habitat guidelines.

Conclusions

Differences in Wyoming big sagebrush associations' composition, functional group cover, and other vegetation characteristics (excluding perennial bunchgrasses used for grouping) indicate that the biological potential varies by association. Management and guidelines must recognize that potential vegetation characteristics, important for sage-grouse habitat, vary across associations and within individual associations. Forming associations by dominant high seral perennial bunchgrass species is a convenient, practical, and informative classification of the Wyoming big sagebrush alliance. Dividing the alliance into associations by dominant perennial grass improves management by grouping sites with similar vegetation characteristics and potentials.

Both Connelly et al. (2000) and the Bureau of Land Management et al. (2000) sage grouse habitat guidelines could be improved by recognizing species and subspecies of sagebrush, accounting for individual association's vegetation potential and interannual variation, and dictating a standardized protocol for vegetation sampling at a stand level.

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Appendix 1. Species list for Wyoming big sagebrush sites sampled in the study area.

Scientific name	Common name	Scientific name	Common name
Trees and Shrubs		Annual Grasses	
Juniperus occidentalis	western juniper	*Bromus japonicus*	Japanese brome
Juniperus utahensis	Utah juniper	*Bromus tectorum*	cheatgrass
Artemisia arbuscula	low sagebrush	*Vulpia bromoides*	brome fescue, six-weeksfescue
Artemisia rigida	scabland sagebrush	*Vulpia microstachys*	small fescue
Artemisia spinescens	bud sage	*Vulpia octoflora*	six-weeks fescue
A. tridentata ssp. tridentata	basin big sagebrush		
A. tridentata ssp. wyomingensis	Wyoming big sagebrush		
A. tridentata ssp. vaseyana	mountain big sagebrush	Perennial Forbs	
Artemisia tripartita	threetip sagebrush	*Achillea millefolium*	common yarrow
Atriplex canescens	fourwing saltbrush	*Agoseris glauca*	short-beaked or pale agoseris
Atriplex confertifolia	shadscale saltbrush	*Agoseris grandiflora*	large-flowered agoseris
Atriplex spinosa	spiny hopsage	*Agoseris sp.*	False-dandelion
Chrysothamnus nauseosus	gray rabbit-brush	*Allium sp*	wild onion
Chrysothamnus viscidiflorus	green rabbit-brush	*Allium acuminatum*	taper-tip onion
Eurotia lanata	winterfat	*Allium lemmonii*	Lemmon's onion
Peraphyllum ramosissimum	squaw apple	*Allium nevadense*	Nevada onion
Purshia tridentata	bitter-brush	*Allium tolmiei*	Tolm's onion
		Antennaria dimorpha	low pussy-toes
		Arabis sp.	rockcress
		Arabis drummondi	rockcress
Perennial Grasses		*Arabis holboellii*	Holboell's rockcress
Agropyron cristatum	**crested wheatgrass**	***Arabis sparsiflora***	sicklepod rockcress
Agropyron desertorum	**(desert) crested wheatgrass,**	***Arenaria franklinii***	Franklin's sandwort
Agropyron spicatum	**bluebunch wheatgrass**	***Aster scopulorum***	lava aster
Agropyron smithii	**western wheatgrass**	***Astragalus sp.***	Milkvetch; locoweed
Carex sp.	**sedge**	***Astragulas alvordensis***	Alvord milkvetch
Elymus cinereus	**giant Great Basin wildrye**	***Astragalus atratus***	Owhyee milkvetch
Elymus triticoides	**creeping or beardless**	***Astragalus curvicarpus***	sickle or curve-pod milkvetch
Festuca idahoensis	**Idaho fescue**	***Astragalus cusickii***	Cuskick's milkvetch
Koeleria cristata	**prairie Junegrass**	***Astragalus eremiticus***	hermit vetch
Oryzopsis hymenoides	**Indian ricegrass**	***Astragalus filipes***	threadstalk or basalt milkvetch
Poa sp.	**bluegrass**	***Astragalus lentiginosus***	speckle-pod milkvetch
Poa cusickii	**Cusick's bluegrass**	***Astragalus obscurus***	obscure or arcane milkvetch
Poa nervosa	**Wheeler's bluegrass**	***Astragalus purshii***	woolly-pod milkvetch
Poa nevadensis	**Nevada bluegrass**	***Balsamorhiza hookerii***	Hooker's balsamroot
Poa sandbergii	**Sandberg's bluegrass**	***Balsamorhiza sagittatata***	arrowleaf balsamroot
Poa scabrella	**pine bluegrass**	***Balsamorhiza serrata***	serrate balsamroot
Sitanion hystrix	**bottlebrush squirreltail**	***Calochortus bruneaunis***	Bruneau mariPOSA lily
Stipa comata	**needle-and-thread grass**	***Calochortus macrocarpus***	sagebrush mariPOSA
Stipa speciosa	**desert needlegrass**	***Calochortus nuttallii***	Nuttall's sego lily
Stipa thurberiana	**Thurber's needlegrass**	***Castilleja sp.***	paintbrush
		Castilleja chromosa	desert (wavy-leaf) paintbrush
		Castilleja linariaefolia	narrow-leaved paintbrush
		Castilleja pilosa	parrot-headed paintbrush
		Chaenactis douglasi	false-yarrow
		Crepis sp.	hawksbeard
		Crepis acuminata	long-leaved hawksbeard

Appendix 1 continued**.** Species list for Wyoming big sagebrush sites sampled in the study area.

Scientific name	Common name	Scientific name	Common name
Perennial Forbs cont.		Perennial Forbs cont.	
Crepis intermedia	tapertip or grey hawksbeard	*Lupinus arbustus*	perfume lupine
Crepis modocensis	modoc hawksbeard	*Lupinus argenteus*	silvery lupine
Crepis occidentalis	western hawksbeard	*Lupinus caudatus*	tailcup lupine
Cryptantha humilis	roundspike cryptantha	*Lupinus leucophyllus*	velvet lupine
Delphinium andersonii	desert or Anderson's larkspur	*Lygodesmia spinosa*	spiny skeletonweed
Delphinium bicolor	little Montane larkspur	*Machaeranthera canescens*	hoary aster
Delphinium depauperatum	slim or dwarf larkspur	*Malacothrix glabrata*	smooth desertdandelion
Delphinium nuttallianum	upland larkspur	*Malacothrix torreyi*	Torrey's desertdandelion
Dodecatheon pauciflorum	darkthroat shooting star	*Mentzelia laevicaulis*	lemon flwrd blazing star
Erigeron aphanactis	rayless shaggy fleabane	*Mertensia longiflora*	long-flowered bluebells
Erigeron bloomeri	scabland fleabane	*Mertensia oblongifolia*	sagebrush bluebells
Erigeron chrysopsidis	dwarf yellow fleabane	*Microseris nutans*	nodding microseris
Erigeron filifolius	thread-leaf fleabane	*Microseris troximoides*	false agoseris
Erigeron linearis	desert yellow daisy	*Oenothera caespitosa*	tufted evening-primrose
Erigeron poliospermus	cushion fleabane	*Oenothera deltoides*	hairy eve.-primrose
Erigeron pumilus	shaggy fleabane	*Oenothera tanacetifolia*	tansy-leaf evening primrose
Eriogonum caespitosum	mat buckwheat	*Penstemon cusikii*	Cusick's penstemon
Eriogonum douglasii	Douglas' buckwheat	*Penstemon deustus*	scabland penstemon
Eriogonum microthecum	slenderbush eriogonum	*Penstemon humilis*	lowly penstemon
Eriogonum ochrocephalum	whitewoolly buckwheat	*Penstemon laetus*	gay penstemon
Eriogonum ovalifolium	cushion buckwheat	*Penstemon speciosus*	showy penstemon
Eriogonum sphaerocephalum	round-headed eriogonum	*Perideridia bolanderi*	Bolander's yampah
Eriogonum strictum	strict buckwheat	*Phacelia hastata*	silverleaf phacelia
Eriogonum umbellatum	sulfur buckwheat	*Phlox hoodii*	Hood's phlox
Eriophyllum lanatum	Oregon sunshine	*Phlox longifolia*	long-leaf phlox
Frasera albicaulis	white-stemmed frasera	*Phlox muscoides*	moss or musk phlox
Fritillaria pudica	yellow bell	*Phoenicaulis cheiranthoides*	daggerpod
Halogeton glomeratus	saltlover, halogeton	*Ranuculus glaberrimus*	sagebrush buttercup
Haplopappus acaulis	stemless goldenweed	*Scutellaria angustifolia*	narrowleaf skullcap
Haplopappus stenophyllus	narrow-leaf goldenweed	*Scutellaria antirrhinoides*	snapdragon or nose skullcap
Leptodactylon pungens	prickly phlox	*Scutellaria nana*	dwarf scutellaria
Lewisia rediviva	bitterroot	*Senecio canus*	woolly groundsel
Linum perenne	blue flax	*Senecio integerrimus*	one-stemmed butterweed
Lithospermum ruderale	Columbia puccoon;stoneseed	*Silene douglasii*	Douglas' silene
Lomatium sp.	biscuit-root	*Townsendia florifera*	showy Townsend daisy
Lomatium cous	Cous	*Townsendia hookeri*	Hooker's Townsend daisy
Lomatium donnellii	Donnell's desert-parsley	*Trifolium andersonii*	fiveleaf clover
Lomatium dissectum	giant lomatium	*Trifolium macrocephalum*	big-head clover
Lomatium foeniculaceum	desert parsley or biscuitroot	*Verbascum thapsus*	common mullein
Lomatium macrocarpum	large-fruit lomatium	*Viola beckwithii*	Beckwith's violet
Lomatium nevadense	Nevada desert-parsley	*Viola purpurea*	purplish violet
Lomatium packardiae	Malheur lomatium	*Viola trinervata*	desert pansy, Rainier violet
Lomatium triternatum	nine-leaf lomatium	*Zigadenus paniculatus*	panicled death-camas
Lomatium vaginatum	broadsheath lomatium	*Zigadenus venuosus*	meadow death-camas

Appendix 1 continued**.** Species list for Wyoming big sagebrush sites sampled in the study area.

Scientific name	Common name	Scientific name	Common name
Annual Forbs		Annual Forbs cont.	
Agoseris heterophylla	annual agoseris	*Linanthus pharamaceoides*	thread-stemmed linanthus
Alyssum alyssoides	pale alyssum	*Linanthus septentrionalis*	northern linanthus
Alyssum desertorum	desert alyssum	*Lupinus brevicaulis*	sand or short stmed lupine
Amsinckia tessellata	tessellate fiddleneck	*Lupinus microcarpus*	chick lupine
Blepharipappus scaber	rough eyelashweed	*Lupinus uncialis*	lilliput or inch-high lupine
Camissonia claviformis	club-frt. eve.-primrose	*Madia sp.*	tarweed; madia
Camissonia scapoidea	Piaute suncup	*Madia exigua*	little tarweed
Chaenactis macrantha	bighead dustymaiden	*Madia gracilis*	gumweed; common tarweed
Chaenactis xantiana	fleshcolor pincushion	*Mentzelia albicaulis*	white-stemmed mentzelia
Cirsium sp.	thistle	*Microsteris gracilis*	pink microsteris
Cirsium utahense	Utah thistle	*Microsteris lindleyi*	Lindley's microsteris
Cirsium vulgare	spear, bull or common thistle	*Mimulus sp*	monkey-flower
Clarkia pulchella	pink fairies; ragged robbin	*Mimulus cusickii*	Cuskick's monkey flower
Collinsia parviflora	little blue-eyed Mary	*Mimulus nanas*	dwarf purple monkey flower
Collomia grandiflora	large-flowered collomia	*Mimulus sudsdorfii*	Suksderf's monkey flower
Collomia linearis	narrow-leaf collomia	*Navarretia breweri*	yellow-flowered navarretia
Cryptantha sp.	white forget-me-not	*Navarretia divaricata*	white-flowered mt. navarretia
Cryptantha ambigua	obscure cryptantha	*Orthocarpus hispidus*	hairy owl-clover
Cryptantha circumscissa	cushion cryptantha	*Phacelia humilis*	low phacelia
Cryptantha intermedia	common cryptantha	*Phacelia linearis*	thread-leaf phacelia
Cryptantha torreyana	Torrey's cryptantha	*Plectritis macrocera*	white plectritis
Cryptantha watsonii	Watson's cryptantha	*Polemonium micranthum*	annual littlebells polemonium
Descurainia pinnata	western tansymustard	*Polygonum douglasii*	Douglas' knotweed
Draba verna	spring whitlow	*Ranunculus testiculatus*	hornseed or bur buttercup
Epilobium minutum	sm.-flwed willowweed	*Sisymbrium altissimum*	Hill tumblemustard
Epilobium paniculatum	autumn willow-herb	*Tragopon dubis*	yellow salsify
Eriastrum sparsiflorum	few-flowered eriastrum		
Eriogonum cernuum	nodding buckwheat		
Eriogonum maculatum	spotted buckwheat		
Eriogonum vimineum	broom buckwheat		
Galium aparine	goose-grass		
Galium bifolium	low mountain bedstraw		
Gayophytum decipiens	deceptive groundsmoke		
Gayophytum diffusum	spreading groundsmoke		
Gayophytum racemosum	blackfoot groundsmoke		
Gayophytum ramosissimum	hairstem, pinyon groundsmoke		
Gilia capillaris	miniature gilia		
Gilia inconspicua	shy, or sinuate gilia		
Gilia leptomeria	sand gilia		
Gilia sinuata	sinuate gilia, rosy gilia		
Lactuca serriola	prickly lettuce		
Layia glandulosa	white daisy tidytips		

II. Summary of Vegetation and Environmental Characteristics of Sites Sampled in the Vale, Burns, Lakeview, and Winnemucca BLM Districts

Kirk Davies, Jon Bates, and Rick Miller

Numbers of high condition Wyoming big sagebrush sites sampled in individual BLM districts do not imply that different BLM districts have more or less high condition sites than other districts. Each BLM district has appendices for the sites sampled within their borders. Each appendix is partitioned into "A" and "B" sections.

Section "A" is a vegetation cover summary for those sites. POSA = Sandberg's bluegrass, Artrw8 = Wyoming big sagebrush, Agsp = bluebunch wheatgrass, Stth = Thurber's needlegrass, Stco2 = needle-and-thread, Feid = Idaho fescue, and Agsp-Stth = co-dominance of bluebunch wheatgrass and Thurber's needlegrass (the lower cover value contributed at least 40% of their combined cover value).

Section "B" is a summary of site and soil characteristics. Sites location on individual topography maps are given as well as their UTM coordinates. Also included in the site description are land form, elevation, aspect, and slope. Soil characteristics reported are soil order, suborder, depth, surface texture, total carbon, and carbon/nitrogen ratio.

In the Burns BLM District 54 high condition Wyoming big sagebrush sites were sampled. The sites sampled were from all five associations. The bluebunch wheatgrass (AGSP) association was best represented with 32 sites, second was the Thurber's needlegrass (STTH) and Idaho fescue (FEID) associations with 8 sites each, the needle-and-thread (STCO2) with 4 sites, and the co-dominant bluebunch wheatgrass/Thurber's needlegrass (AGSP/STTH) with 2 sites (Appendix 1-3).

Across the Lakeview BLM District we sampled 14 high condition Wyoming big sagebrush sites. The sites sampled were from only four of the associations; 6 AGSP association sites, 3 STTH association sites, 3 STCO2 association sites, and 2 AGSP association sites (Appendix 4).

We sampled 5 high condition Wyoming big sagebrush sites in the Winnemucca BLM District. Three of the sites sampled were from the AGSP association, both FEID and AGSP/STTH each contributed 1 site (Appendix 5).

We sampled 34 high condition Wyoming big sagebrush sites in the Vale BLM District. Most of the sites sampled, 22, belonged to the AGSP association, the STTH and STCO2 associations contributed 5 sites each, and 2 sites belonged to the AGSP/STTH association (Appendix 6-7).

Appendix 1A. North Burns BLM District Vegetation Summaries for Wyoming Big Sagebrush Plant Associations.

Site Description		Understory Cover (%)								Shrub Cover (%)			
Site	Plant Association	POSA	Perennial Grass	Perennial Forb	Annual Grass	Annual Forb	Litter	Moss & Crust	Bare-Rock	Artrw8 Live	Artrw8 Dead	Other Shrubs	Shrub Cover
Bowen	Artrw8/Agsp	8.4	7.8	2.3	0.0	0.4	18.8	2.3	60.5	13.0	2.4	1.5	14.5
Buckskin 1	Artrw8/Agsp	5.5	11.8	7.7	0.0	0.4	13.9	5.4	55.7	11.0	2.4	0.7	11.7
Buckskin 2	Artrw8/Agsp	6.9	7.8	11.7	0.0	0.3	7.7	15.7	50.1	8.1	1.6	0.0	8.1
Buzzard 2	Artrw8/Agsp	4.3	9.7	6.2	0.1	0.3	14.9	7.6	57.0	14.8	2.7	1.8	16.6
Egli 1	Artrw8/Agsp	5.3	9.1	4.2	0.1	5.6	15.9	4.7	55.3	9.63	4.58	0.0	9.63
Gap 2	Artrw8/Agsp	6.5	10.2	4.2	0.0	0.4	12.2	9.4	57.6	8.9	6.0	2.1	11.0
Glass Butte 2	Artrw8/Agsp	5.3	14.7	1.6	0.2	0.1	21.9	2.9	53.6	15.4	5.6	1.6	17.0
Glass Butte 3	Artrw8/Agsp	6.3	8.8	3.2	0.0	0.1	14.1	3.8	64.0	11.4	2.9	0.6	11.9
Moo Hill	Artrw8/Agsp	5.4	7.7	3.4	0.0	0.4	12.5	7.2	63.6	7.9	4.1	1.4	9.4
Moo Hill Exclosure	Artrw8/Agsp	5.6	13.8	6.1	0.0	0.2	17.4	4.3	52.8	14.7	8.3	1.3	16.0
Range Twelve	Artrw8/Agsp	5.9	13.5	4.4	0.1	1.0	11.3	2.1	63.6	15.8	4.0	1.0	16.7
Round Rock 1	Artrw8/Agsp	4.1	11.8	0.8	1.2	0.3	13.5	3.2	65.2	12.5	1.8	0.0	12.5
Sage Sparrow	Artrw8/Agsp	4.3	10.9	6.1	2.6	1.7	10.5	2.0	63.2	8.6	1.8	0.0	8.6
Washington	Artrw8/Agsp	4.3	9.6	6.2	0.0	0.4	6.6	11.4	61.6	7.0	5.3	0.7	7.7
Wilson 1	Artrw8/Agsp	4.0	6.0	6.8	0.1	0.7	8.7	12.6	61.2	13.3	3.3	0.0	13.3

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Appendix 1A continued. North Burns BLM District Vegetation Summaries for Wyoming Big Sagebrush Plant Associations.

Site Description		Understory Cover (%)								Shrub Cover (%)			
Site	Plant Association	POSA	Perennial Grass	Perennial Forb	Annual Grass	Annual Forb	Litter	Moss & Crust	Bare-Rock	Artrw8 Live	Artrw8 Dead	Other Shrubs	Shrub Cover
Jon Gone	Artrw8/Stth	4.9	8.5	2.4	1.4	1.3	17.3	1.8	62.6	9.0	7.6	0.0	9.0
Range Ten	Artrw8/Stth	5.8	9.5	6.8	0.0	3.0	16.8	3.8	55.8	19.8	3.9	0.7	20.5
Wilson 2	Artrw8/Stth	5.7	7.0	5.0	0.0	0.4	13.1	8.3	60.5	12.3	3.4	0.0	12.3
The Rock	Artrw8/Stco2	3.1	8.0	0.3	0.8	0.2	13.0	8.8	65.9	21.9	2.4	0.0	21.9
Gravel Pit	Artrw8/Feid	2.7	26.7	5.5	0.0	0.1	13.7	14.6	36.9	9.5	2.3	0.4	9.9
Glass Butte 1	Artrw8/Feid	3.5	20.6	2.0	0.0	0.0	11.9	4.8	57.3	13.7	0.7	0.9	14.6
Glass Butte 4	Artrw8/Feid	6.8	12.1	4.1	0.0	0.1	12.7	8.4	56.3	8.3	5.5	2.3	10.5
Glass Butte 5	Artrw8/Feid	5.1	20.8	1.2	0.0	0.1	15.4	2.6	55.1	8.0	4.8	1.4	9.4
Hiho Silver	Artrw8/Feid	3.3	17.9	4.6	0.0	0.5	11.7	3.2	58.6	6.0	4.3	2.6	8.7
Oar Butte	Artrw8/Feid	4.7	21.7	7.5	0.0	0.6	7.2	4.0	55.9	12.9	1.0	0.0	12.9
Squaw Butte	Artrw8/Feid	3.5	19.1	5.0	0.0	0.1	12.2	4.8	55.6	10.1	2.2	1.3	11.4

Appendix 1B. North Burns BLM District Site and Soil Characteristics for Wyoming Big Sagebrush Plant Associations.

	Site Descriptors					Soil Characteristics					
Site	Topo map	UTM (NAD 83)	Land form	Elevation (m)	Aspect/ Slope	Order	Suborder	Soil Depth (cm)	Surface Texture	Soil C (%)	C/N
Bowen	Harney Lake, T24S, R25E, Sec 23, SW/SW	E: 282291 N: 4816658	terrace	1400	90°, 0°	Aridisol	Xerolls	53	sandy loam	0.3	8.7
Buckskin1	Harney Lake, T27S, R26E, Sec 28, NE/NW	E: 290302 N: 4787253	footslope	1478	10°, 8°	Aridisol	Argids	65	sandy loam	0.4	12.0
Buckskin 2	Harney Lake, T27S, R26E, Sec 28, NE/NW	E: 290116 N: 4787158	sideslope	1502	320°, 11°	Mollisol	Xerolls	40	loam	0.9	12.4
Buzzard 2	Harney Lake, T29S, R28E, Sec 16, SW/SE	E: 303708 N: 4768945	shoulder	1549	320°, 6°	Aridisol	Argids	35	loam	1.1	12.6
Egli 1	Harney Lake, T25S, R25E, Sec 35, SW/SW	E: 281202 N: 4803752	terrace	1387	100°, 2°	Aridisol	Argids	53	loam	0.6	13.3
Gap 2	Harney Lake, T24S, R24E, Sec 26, NW/NW	E: 272356 N: 4816725	terrace	1403	290°, 1°	Aridisol	Argids	70	sandy loam	0.5	12.3
Glass Butte 2	Burns, T23S, R23E, Sec 16, NE/NE	E: 261144 N: 4830129	sideslope	1398	230°, 6°	Andisol	Torrands	93	sandy loam	0.8	13.0
Glass Butte 3	Burns, T23S, R23E, Sec 9, SE/SE	E: 261199 N: 4830254	summit	1409	90°, 0°	Andisol	Torrands	64	sandy loam	0.8	12.1
Moo Hill	Harney Lake, T24S, R25E, Sec 20, SW/SW	E: 277574 N: 4816855	footslope	1416	275°, 6°	N/A	N/A	68	sandy loam	0.6	9.8
Moo Hill Exclosure	Harney Lake, T24S, R25E, Sec 20, SE/NW	E: 278168 N: 4816984	sideslope	1467	270°, 9°	N/A	N/A	85	loam	1.0	10.6
Range Twelve	Harney Lake, T24S, R25E, Sec 23, NW/NW	E: 282276 N: 4817800	terrace	1410	180°, 1°	Mollisol	Xerolls	66	sandy loam	1.1	13.1
Round Rock 1	Bluejoint Lake, T30S, R26E, Sec 36, NE/NW	E: 289146 N: 4755383	sideslope	1440	90°, 21°	Aridisol	Cambids	133	sandy loam	0.6	12.2
Sage Sparrow	Harney Lake, T25S, R26E, Sec 6, NE/SE	E: 285973 N: 4812456	shoulder	1411	220°, 5°	Aridisol	Argids	45	sandy loam	0.6	11.8
Washington	Harney Lake, T28S, R26E, Sec 27, SW/SE	E: 286402 N: 4775862	footslope	1490	20°, 1°	Aridisol	Argids	68	sandy loam	0.2	10.9
Wilson 1	Harney Lake, T28S, R26E, Sec 10, SE/NW	E: 287137 N: 4780173	terrace	1480	280°, 1°	Aridisol	Argids	63	sandy loam	0.5	13.0

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Appendix 1B continued. North Burns BLM District Site and Soil Characteristics for Wyoming Big Sagebrush Plant Associations.

	Site Descriptors					Soil Characteristics					
Site	Topo map	UTM (NAD 83)	Land form	Elevation (m)	Aspect/ Slope	Order	Suborder	Soil Depth (cm)	Surface Texture	Soil C (%)	C/N
Jon Gone	Bluejoint Lake, T30S, R29½E, Sec 16, SW/SE	E: 327974 N: 4758724	sideslope	1551	160°, 7°	N/A	N/A	80	loam	0.9	10.3
Range Ten	Harney Lake, T24S, R25E, Sec 23, SW/SE	E: 282527 N: 4816649	terrace	1397	350°, 1°	Mollisol	Xerolls	53	sandy loam	0.6	12.1
Wilson 2	Harney Lake, T28S, R26E, Sec 2, NW/NW	E: 287805 N: 4783624	terrace	1478	290°, 2°	Aridisol	Argids	75	loam	0.6	12.0
The Rock	Bluejoint Lake, T30S, R27E, Sec 8, SE/NW	E: 290720 N: 4759299	footslope	1458	300°, 4°	N/A	N/A	130	loam/sandy loam	0.4	12.4
Gravel Pit	Malheur Lake, T27S, R35E, Sec 18, SW/NW	E: 381177 N: 4786641	sideslope	1284	20°, 28°	Andisol	Torrands	109	sandy loam	1.4	11.3
Glass Butte 1	Burns, T23S, R23E, Sec 16, NE/NW	E: 260718 N: 4829830	shoulder	1407	50°, 5°	Andisol	Torrands	87	loam	0.6	12.4
Glass Butte 4	Burns, T23S, R23E, Sec 9, SE/SE	E: 261493 N: 4830405	terrace	1387	60°, 1°	Mollisol	Xerolls	51	loam	0.8	10.7
Glass Butte 5	Burns, T23S, R23E, Sec 10, SW/SW	E: 261337 N: 4830336	terrace	1393	50°, 12°	Andisol	Torrands	40	sandy loam	0.5	11.6
Hiho Silver	Harney Lake, T24S, R25E, Sec 20, NE/NW	E: 277915 N: 4817857	shoulder	1497	320°, 5°	N/A	N/A	72	loam	0.8	10.6
Oar Butte	Harney Lake, T25S, R26E, Sec 6, NE/NW	E: 286424 N: 4812327	sideslope	1412	75°, 14°	Mollisol	Xerolls	94	sandy loam	1.2	12.4
Squaw Butte	Burns, T23S, R25E, Sec 34, NE/SW	E: 281201 N: 4823704	terrace	1338	350°, 5°	Andisol	Torrands	73	sandy loam	0.9	10.3

Appendix 2A. Sheephead Mountain Area Vegetation Summaries for Wyoming Big Sagebrush Plant Associations.

Site Description		Understory Cover (%)								Shrub Cover (%)			
Site	Plant Association	POSA	Perennial Grass	Perennial Forb	Annual Grass	Annual Forb	Litter	Moss & Crust	Bare-Rock	Artrw8 Live	Artrw8 Dead	Other Shrubs	Shrub Cover
Blood Hot 1	Artrw8/Agsp	4.2	12.5	1.5	0.0	0.6	8.1	11.2	62.1	8.0	6.1	0.0	8.0
Coffin Butte 2	Artrw8/Agsp	7.1	7.7	5.0	0.1	0.2	15.5	5.0	59.7	12.8	3.8	0.0	12.8
Coffin Butte 3	Artrw8/Agsp	7.8	13.3	2.3	0.3	0.3	12.6	3.9	60.5	10.6	1.9	0.0	10.6
Dead Road 1	Artrw8/Agsp	9.4	8.8	11.6	0.0	0.4	15.6	14.3	40.1	12.2	5.6	0.0	12.2
Dead Road 2	Artrw8/Agsp	6.7	11.4	10.6	0.0	0.3	18.3	10.9	42.0	7.4	3.2	0.0	7.4
Dead Road 3	Artrw8/Agsp	3.5	9.1	2.2	1.2	0.1	27.3	1.4	55.3	13.8	5.0	0.4	14.2
Folly Farm C	Artrw8/Agsp	9.0	10.7	10.6	0.0	0.2	13.2	10.5	46.6	10.2	2.3	1.2	11.4
Folly Farm D	Artrw8/Agsp	9.9	18.3	6.4	0.0	0.4	16.6	8.2	41.8	7.6	1.1	0.0	7.6
Folly Farm E	Artrw8/Agsp	7.2	10.8	2.9	0.0	0.2	14.1	2.1	63.5	12.2	4.2	0.0	12.2
Folly Farm F	Artrw8/Agsp	7.0	10.3	10.4	0.0	0.4	12.2	7.7	53.0	11.4	1.2	0.0	11.4
Folly Farm G	Artrw8/Agsp	6.3	9.5	3.1	3.5	0.2	16.7	0.5	61.4	8.8	5.2	0.0	8.8
Folly Farm Mid	Artrw8/Agsp	13..2	11.4	11.9	0.0	0.6	8.2	12.0	44.3	15.1	3.1	0.0	15.1
Bloody Hot 2	Artrw8/Stth	5.7	6.6	1.4	0.0	0.6	15.5	13.1	57.2	10.9	11.5	0.0	10.9
Folly Farm Stipa	Artrw8/Stth	7.8	7.9	2.9	0.1	0.7	13.4	5.7	62.0	19.2	3.5	0.0	19.2
Lily Hill	Artrw8/Stth	4.2	10.7	2.3	0.0	0.4	11.9	12.7	58.0	10.2	6.7	1.4	11.6
Baboon Springs	Artrw8/Stco2	0.0	10.2	0.7	1.1	0.3	13.7	0.2	73.9	3.2	5.0	1.6	4.8
Dead Road 4	Artrw8/Feid	6.8	18.1	5.9	0.0	0.4	13.9	9.0	46.0	10.8	1.6	0.2	11.0
Coffin Butte 4	Artrw8/Agsp-Stth	6.7	7.8	2.6	0.3	0.4	11.5	6.0	65.6	13.7	1.0	0.0	13.7

Appendix 2B. Sheephead Mountain Area Site and Soil Characteristics for Wyoming Big Sagebrush Plant Associations.

	Site Descriptors					Soil Characteristics					
Site	Topo map	UTM (NAD 83)	Land form	Elevation (m)	Aspect/ Slope	Order	Suborder	Soil Depth (cm)	Surface Texture	Soil C (%)	C/N
Blood Hot 1	Malheur Lake, T29S, R37E, Sec 20, NE/SE	E: 402950 N: 4765848	shoulder	1272	200°, 5°	N/A	N/A	58	loam	0.6	9.8
Coffin Butte 2	Steens Mtn., T31S, R36E, Sec 17, NW/NW	E: 392516 N: 4745847	sideslope	1356	70°, 14°	Aridisol	Argids	101	loam	0.6	13.2
Coffin Butte 3	Steens Mtn., T31S, R36E, Sec 4, NW/SW	E: 394365 N: 4749503	sideslope	1334	65°, 18°	Aridisol	Durids	126	loam	0.7	13.4
Dead Road 1	Malheur Lake, T29S, R37E, Sec 9, NW/NW	E: 403091 N: 4769254	sideslope	1352	332°, 10°	N/A	N/A	68	loam	1.0	10.3
Dead Road 2	Malheur Lake, T29S, R37E, Sec 9, NW/SW	E: 403036 N: 4769057	shoulder	1450	346°, 12°	N/A	N/A	62	loam	1.0	10.4
Dead Road 3	Malheur Lake, T29S, R37E, Sec 9, SW/NW	E: 403072 N: 4768764	shoulder	1420	170°, 12°	N/A	N/A	70	loam	0.9	10.3
Folly Farm C	Malheur Lake, T29S, R36E, Sec 36, NE/NE	E: 399866 N: 4763360	sideslope	1323	360°, 23°	Aridisol	Argids	152	silt loam	0.7	12.9
Folly Farm D	Malheur Lake, T29S, R36E, Sec 36, NE/NE	E: 399794 N: 4763095	sideslope	1386	10°, 20°	Aridisol	Argids	76	silt loam	0.8	13.0
Folly Farm E	Malheur Lake, T29S, R36E, Sec 36, NE/SE	E: 399719 N: 4762849	sideslope	1430	280°, 8°	Mollisol	Xerolls	69	loam	0.3	11.8
Folly Farm F	Malheur Lake, T29S, R36E, Sec 26, SE/SE	E: 398071 N: 4763716	sideslope	1362	270°, 14°	Mollisol	Xerolls	78	loam	0.4	12.0
Folly Farm G	Malheur Lake, T29S, R36E, Sec 25, SW/SW	E: 398254 N: 4763495	sideslope	1410	235°, 13°	Mollisol	Xerolls	91	silt loam	1.2	13.3
Folly Farm Mid	Malheur Lake, T29S, R367, Sec 31, NE/NW	E: 400940 N: 4763115	sideslope	1295	30°, 20°	Aridisol	Argids	68	silt loam	1.4	12.3
Bloody Hot 2	Malheur Lake, T29S, R37E, Sec 20, NE/NE	E: 402943 N: 4765999	shoulder	1274	360°, 5°	N/A	N/A	120	loam	0.5	9.5
Folly Farm Stipa	Malheur Lake, T29S, R30E, Sec 30, SE/SW	E: 401033 N: 4763352	footslope	1247	30°, 6°	Mollisol	Xerolls	149	loam	0.9	13.8
Lily Hill	Malheur Lake, T29S, R37E, Sec 20, NE/SE	E: 403165 N: 4766092	footslope	1251	0°, 10°	N/A	N/A	69	loam	0.7	10.7
Baboon Springs	Malheur Lake, T29S, R37E, Sec 20, SE/NE	E: 402668 N: 4765712	footslope	1250	250°, 8°	N/A	N/A	95	sandy loam	0.2	8.7
Dead Road 4	Malheur Lake, T29S, R37E, Sec 9, NW/SE	E: 403442 N: 4768769	sideslope	1430	360°, 18°	N/A	N/A	69	silt loam	1.0	10.0
Coffin Butte 4	Steens Mtn., T31S, R36E, Sec 4, NW/SW	E: 394616 N: 4749373	shoulder	1377	340°, 5°	Andisol	Torrands	63	loam	0.5	13.2

Appendix 3A. South Burns BLM District Vegetation Summaries for Wyoming Big Sagebrush Plant Associations.

Site Description		Understory Cover (%)								Shrub Cover (%)			
Site	Plant Association	POSA	Perennial Grass	Perennial Forb	Annual Grass	Annual Forb	Litter	Moss & Crust	Bare-Rock	Artrw8 Live	Artrw8 Dead	Other Shrubs	Shrub Cover
Funnel Canyon 1	Artrw8/Agsp	6.7	12.4	2.6	0.1	0.1	17.9	7.2	53.1	11.9	4.9	0.2	12.1
Trough 1	Artrw8/Agsp	8.1	12.8	2.6	0.1	0.5	17.5	10.8	47.6	12.5	3.2	3.9	16.4
Trough 2	Artrw8/Agsp	5.0	11.5	2.2	1.0	0.2	23.9	6.0	50.2	11.4	3.4	0.4	11.8
Trough 3	Artrw8/Agsp	6.0	18.0	6.3	0.2	0.2	16.4	3.2	19.8	5.7	2.6	0.3	6.0
Trough 4	Artrw8/Agsp	4.1	12.8	2.8	0.8	0.3	27.3	2.9	49.2	8.1	2.0	0.4	8.5
Lone Mountain	Artrw8/Stth	4.0	10.6	1.2	0.9	0.3	18.1	4.4	60.7	10.0	5.2	0.3	10.3
Stipa Hill	Artrw8/Stth	3.9	9.0	2.0	0.0	0.5	12.7	6.0	66.3	14.3	2.7	0.0	14.3
Exclosure Basin 1	Artrw8/Stco2	0.0	4.5	0.0	1.1	0.2	22.8	9.2	62.3	11.0	2.3	0.5	11.6
Exclosure Basin 2	Artrw8/Stco2	0.0	5.4	0.1	0.3	0.5	12.7	6.3	74.8	5.2	4.5	4.5	9.6
Funnel Canyon 2	Artrw8/Agsp-Stth	5.5	9.6	2.0	0.0	0.4	14.1	8.2	60.1	9.6	4.4	2.5	12.2

Appendix 3B. South Burns BLM District Site and Soil Characteristics for Wyoming Big Sagebrush Plant Associations.

	Site Descriptors					Soil Characteristics					
Site	Topo map	UTM (NAD 83)	Land form	Elevation (m)	Aspect/ Slope	Order	Suborder	Soil Depth (cm)	Surface Texture	Soil C (%)	C/N
Funnel Canyon 1	Adel, T39S, R31E, Sec 21, NE/NE	E: 328859 N: 4671485	sideslope	1681	5°, 17°	N/A	N/A	57	sandy loam	0.7	10.3
Trough 1	Alvord Lake, T37S, R32½E, Sec 17, NW/NW	E: 344335 N: 4689248	sideslope	1469	118°, 16°	N/A	N/A	116	loam	1.1	11.0
Trough 2	Alvord Lake, T37S, R32½E, Sec 17, NW/NE	E: 344647 N: 4689063	summit	1538	320°, 5°	N/A	N/A	51	loam	0.6	9.6
Trough 3	Alvord Lake, T37S, R32½E, Sec 17, NW/SE	E: 344658 N: 4688713	sideslope	1552	262°, 18°	N/A	N/A	132	sandy loam	0.6	9.7
Trough 4	Alvord Lake, T37S, R32½E, Sec 17, NW/SW	E: 344463 N: 4688791	shoulder	1524	216°, 9°	N/A	N/A	54	loam	0.6	10.2
Lone Mountain	Adel, T39S, R31E, Sec 36, SE/NW	E: 333033 N: 4667217	sideslope	1758	150°, 8°	N/A	N/A	63	loam	0.6	9.8
Stipa Hill	Alvord Lake, T40S. R32E, Sec 19, NE/SE	E: 335265 N: 4661308	summit	1725	222°, 1°	N/A	N/A	104	sandy loam	0.4	9.9
Exclosure Basin 1	Alvord Lake, T40S. R32E, Sec 34, SE/NE	E: 338767 N: 4657318	flood plain	1471	126°, 10°	N/A	N/A	150	loamy sand	0.2	9.5
Exclosure Basin 2	Alvord Lake, T40S. R32E, Sec 33, SW/SW	E: 338111 N: 4657650	flood plain	1485	28°, 1°	N/A	N/A	150	sandy loam	0.2	9.3
Funnel Canyon 2	Adel, T39S, R31E, Sec 21, NE/SW	E: 328571 N: 4671180	summit	1741	348°, 3°	N/A	N/A	72	silt loam	0.9	11.1

Appendix 4A. Lakeview BLM District Vegetation Summaries for Wyoming Big Sagebrush Plant Associations.

Site Description		Understory Cover (%)								Shrub Cover (%)			
Site	Plant Association	POSA	Perennial Grass	Perennial Forb	Annual Grass	Annual Forb	Litter	Moss & Crust	Bare-Rock	Artrw8 Live	Artrw8 Dead	Other Shrubs	Shrub Cover
Dry Valley Rim 1	Artrw8/Agsp	1.3	13.1	2.4	0.1	0.5	10.4	10.0	62.4	10.2	4.6	0.8	11.0
Mule Tit 1	Artrw8/Agsp	6.5	10.0	4.1	0.3	0.1	11.5	6.6	61.1	13.9	2.6	0.1	14.0
Mule Tit 2	Artrw8/Agsp	6.2	16.3	3.9	0.0	0.2	13.7	4.6	55.1	15.9	1.2	0.4	16.3
Mule Tit 4	Artrw8/Agsp	4.9	16.1	3.0	0.0	0.2	11.5	11.6	52.8	15.9	1.2	0.7	16.6
Mule Tit 5	Artrw8/Agsp	1.8	9.6	0.9	3.1	0.1	14.8	1.1	68.7	17.4	1.6	.3	17.7
Running Cow 2	Artrw8/Agsp	6.6	8.2	3.0	2.0	1.0	17.9	2.5	59.0	14.4	1.3	7.8	22.2
Dry Valley Rim 2	Artrw8/Stth	4.2	7.0	.3	0.0	.6	13.3	9.2	65.6	11.5	5.7	1.0	12.6
Indecent Exclosure	Artrw8/Stth	7.3	9.2	4.4	0.0	0.3	12.1	8.0	58.9	11.9	7.9	0.1	12.0
Mule Tit 3	Artrw8/Stth	3.1	8.9	0.5	0.1	0.4	20.2	9.2	57.7	21.4	3.6	0.8	22.3
Lone Butte	Artrw8/Stco2	3.9	16.1	0.3	1.7	0.0	21.4	3.2	53.0	10.8	7.1	0.0	10.8
Shanty	Artrw8/Stco2	4.3	15.4	0.5	0.0	0.2	17.5	1.8	60.3	7.8	1.5	8.4	16.2
Spaulding	Artrw8/Stco2	0.0	16.9	0.0	0.5	0.0	12.8	6.7	63.1	9.5	3.3	1.0	10.5
Patton 1	Artrw8/Agsp-Stth	4.5	8.0	4.2	1.2	0.4	15.1	4.3	62.7	9.4	5.7	0.4	9.8
Running Cow 1	Artrw8/Agsp-Stth	4.1	7.2	11.0	1.9	0.6	16.2	7.2	52.2	17.2	3.0	0.9	18.0

Appendix 4B. Lakeview BLM District Site and Soil Characteristics for Wyoming Big Sagebrush Plant Associations.

	Site Descriptors					Soil Characteristics					
Site	Topo map	UTM (NAD 83)	Land form	Elevation (m)	Aspect/ Slope	Order	Suborder	Soil Depth (cm)	Surface Texture	Soil C (%)	C/N
Dry Valley Rim 1	Harney Lake, T28S, R26E, Sec 18 NE/NW	E: 281908 N: 4780047	terrace	1454	90°, 0°	Aridisol	Argids	39	loam	0.3	11.0
Mule Tit 1	Bluejoint Lake, T31S, R27E, Sec 17, SW/NE	E: 289960 N: 4751303	footslope	1435	10°, 5°	Aridisol	Cambids	87	sandy loam	0.6	12.2
Mule Tit 2	Bluejoint Lake, T31S, R27E, Sec 17, SW/SE	E: 289989 N: 4750980	shoulder	1490	10°, 14°	Mollisol	Xerolls	28	loam	1.3	13.9
Mule Tit 4	Bluejoint Lake, T31S, R27E, Sec 17, SW/SE	E: 290081 N: 4750496	shoulder	1526	40°, 19°	Mollisol	Xerolls	172	loam	1.0	13.0
Mule Tit 5	Bluejoint Lake, T31S, R27E, Sec 20, NW/NW	E: 289700 N: 4750443	sideslope	1552	190°, 11°	Aridisol	Argids	42	loam	0.6	11.8
Running Cow 2	Lake Abert, T32S, R23E, Sec 20, NE/SE	E: 743133 N: 4741095	sideslope	1602	300°, 19°	Mollisol	Xerolls	204	sandy loam	0.8	13.8
Dry Valley Rim 2	Harney Lake, T28S, R26E, Sec 29, NW/SE	E: 282984 N: 4776752	footslope	1485	240°, 8°	Aridisol	Calcids	97	sandy loam	0.3	11.8
Indecent Exclosure	Adel, T37S, R28E, Sec 27, NE/NW	E: 301473 N: 4690211	terrace	1681	90°, 1°	N/A	N/A	54	loam	0.9	10.2
Mule Tit 3	Bluejoint Lake, T31S, R27E, Sec 17, SW/SE	E: 290010 N: 4750895	shoulder	1507	10°, 5°	Aridisol	Calcids	120	loam	1.3	14.2
Lone Butte	Adel, T28S, R28E, Sec 3, SE/NW	E: 301509 N: 4686090	toeslope	1678	90°, 2°	Aridisol	Cambids	85	sandy loam	0.4	11.8
Shanty	Adel, T37S, R28E, Sec 25, SW/NE	E: 304163 N: 4689106	terrace-footslope	1768	270°, 1°	N/A	N/A	175	sandy loam	0.7	10.3
Spaulding	Adel, T39S, R28E, Sec 4, NW/NE	E: 299086 N: 4677554	terrace	1612	240°, 1°	Mollisol	Xerolls	123	loam	0.3	11.1
Patton 1	Bluejoint Lake, T32S, R24E, Sec 8 SW/SE	E: 261876 N: 4742348	summit	1520	185°, 3°	Aridisol	Argids	56	loam	0.8	12.9
Running Cow 1	Lake Abert, T32S, R23E, Sec 20, NE/SW	E: 742792 N: 4741127	sideslope	1527	285°, 14°	Mollisol	Xerolls	78	sandy loam	0.5	12.6

Appendix 5A. Winnemucca BLM District Vegetation Summaries for Wyoming Big Sagebrush Plant Associations.

Site Description		Understory Cover (%)								Shrub Cover (%)			
Site	Plant Association	POSA	Perennial Grass	Perennial Forb	Annual Grass	Annual Forb	Litter	Moss & Crust	Bare-Rock	Artrw8 Live	Artrw8 Dead	Other Shrubs	Shrub Cover
Hillbilly Hill	Artrw8/Agsp	6.5	11.3	5.9	0.0	0.1	10.4	6.7	10.4	19.3	6.9	0.1	19.4
Horny Toad Hill 1	Artrw8/Agsp	6.6	8.3	5.1	0.1	0.4	13.8	8.2	57.7	15.7	9.2	1.4	17.1
Painted Gulch	Artrw8/Agsp	5.1	11.0	3.4	0.6	0.4	21.5	1.5	57.0	11.5	2.8	5.7	17.3
Horny Toad Hill 2	Artrw8/Feid	5.0	17.4	3.9	0.0	0.5	16.7	6.1	50.6	11.9	4.7	8.2	20.1
Quinn River	Artrw8/Agsp-Stth	4.2	8.7	4.9	0.1	0.3	16.7	4.4	61.0	20.8	8.6	0.2	21.0

Appendix 5B. Winnemucca BLM District Site and Soil Characteristics for Wyoming Big Sagebrush Plant Associations.

	Site Descriptors					Soil Characteristics					
Site	Topo map	UTM (NAD 83)	Land form	Elevation (m)	Aspect/ Slope	Order	Suborder	Soil Depth (cm)	Surface Texture	Soil C (%)	C/N
Hillbilly Hill	Quinn River Valley, T47N, R41E Sec 17, SW/NE	E: 468596 N: 4644866	shoulder	1799	270°, 10°	N/A	N/A	115	loam	1.0	10.4
Horny Toad Hill 1	Quinn River Valley, T47N, R41E Sec 18, NE/SE	E: 468087 N: 4645100	summit	1774	90°, 0°	N/A	N/A	53	loam	0.9	10.1
Painted Gulch	Quinn River Valley, T47N, R41E Sec 17, NW/SE	E: 468766 N: 4645103	sideslope	1772	230°, 21°	N/A	N/A	100	loam	0.7	9.9
Horny Toad Hill 2	Quinn River Valley, T47N, R41E Sec 18, NE/SE	E: 468072 N: 4645206	sideslope	1766	18°, 21°	N/A	N/A	142	loam	1.5	10.9
Quinn River	Quinn River Valley, T47N, R41E Sec 18, SE/NE	E: 468045 N: 4644888	sideslope	1723	180°, 7°	N/A	N/A	71	loam	0.4	8.3

Appendix 6A. North Vale and Owyhee Vegetation Summaries for Wyoming Big Sagebrush Plant Associations.

Site Description		Understory Cover (%)								Shrub Cover (%)			
Site	Plant Association	POSA	Perennial Grass	Perennial Forb	Annual Grass	Annual Forb	Litter	Moss & Crust	Bare-Rock	Artrw8 Live	Artrw8 Dead	Other Shrubs	Shrub Cover
OWYHEE													
Deer Park East	Artrw8/Agsp	4.7	22.9	3.2	9.8	1.2	24.7	4.1	30.9	4.6	4.1	2.1	6.7
Deer Park West	Artrw8/Agsp	4.9	16.1	4.1	7.6	1.3	16.9	3.3	46.8	6.2	3.0	6.5	12.7
Deer Park N2	Artrw8/Agsp	6.7	16.6	3.6	2.8	0.8	17.2	8.5	44.3	10.3	3.2	4.5	14.8
JC Kipuka	Artrw8/Agsp	2.3	15.2	0.4	2.8	2.4	11.7	15.8	50.5	8.6	1.4	0.1	8.7
Lizard Butte	Artrw8/Agsp	7.0	19.6	3.1	2.8	0.5	17.4	7.8	42.9	13.3	5.2	4.5	17.8
Deer Park North	Artrw8-Artrw8/Feid	6.0	28.3	3.0	0.2	1.3	20.6	7.8	33.5	16.6	0.9	1.2	17.8
NORTH VALE													
Cassidy Butte	Artrw8/Agsp	6.6	10.2	6.8	0.2	1.7	14.3	8.9	53.5	7.3	2.3	1.3	8.5
IPity	Artrw8/Agsp	7.5	15.1	5.7	0.0	0.2	14.6	5.6	51.7	9.7	4.7	0.4	10.1
Squaw Creek	Artrw8/Agsp	2.2	18.1	0.5	2.2	3.6	14.6	1.5	59.2	7.9	1.1	1.1	9.0
Windy Hill 1*	Artrw8/Agsp	4.9	8.8	5.6	0.6	0.2	9.5	4.1	66.9	12.4	4.1	0.0	12.4
Windy Hill 2*	Artrw8/Agsp	4.1	10.9	2.5	0.2	0.2	9.1	5.7	67.7	14.9	4.6	0.0	14.9
Windy Hill 3*	Artrw8/Agsp	6.4	12.1	2.7	0.2	0.2	11.9	6.4	60.3	9.3	1.5	0.0	9.3
Windy Hill 4*	Artrw8/Agsp	5.7	10.9	3.8	0.0	0.3	9.1	9.6	61.4	11.5	4.3	0.0	11.5
Clover Creek 2	Artrw8/Stth	4.6	8.9	2.6	3.7	0.3	19.3	1.4	61.2	14.9	2.1	6.5	21.4
Clover Creek	Artrw8/Stth-Agsp	7.5	13.5	3.3	0.4	0.6	16.8	4.8	53.7	15.5	1.7	0.8	16.3
Sheep Rule 1	Artrw8/Stth-Agsp	9.2	14.0	2.8	0.1	0.3	14.0	2.4	58.0	18.7	1.1	0.9	19.5
Sheep Rule 2	Artrw8/Agsp-Stth	12.8	10.5	7.4	0.1	0.3	12.4	6.5	51.7	22.3	0.8	2.3	24.6
Sheep Rule 3	Artrw8/Agsp-Stth	12.8	23.5	9.7	0.0	0.5	14.2	7.5	35.7	25.5	0.6	0.0	25.5

Appendix 6B. North Vale and Owyhee Soil Characteristics for Wyoming Big Sagebrush Plant Associations.

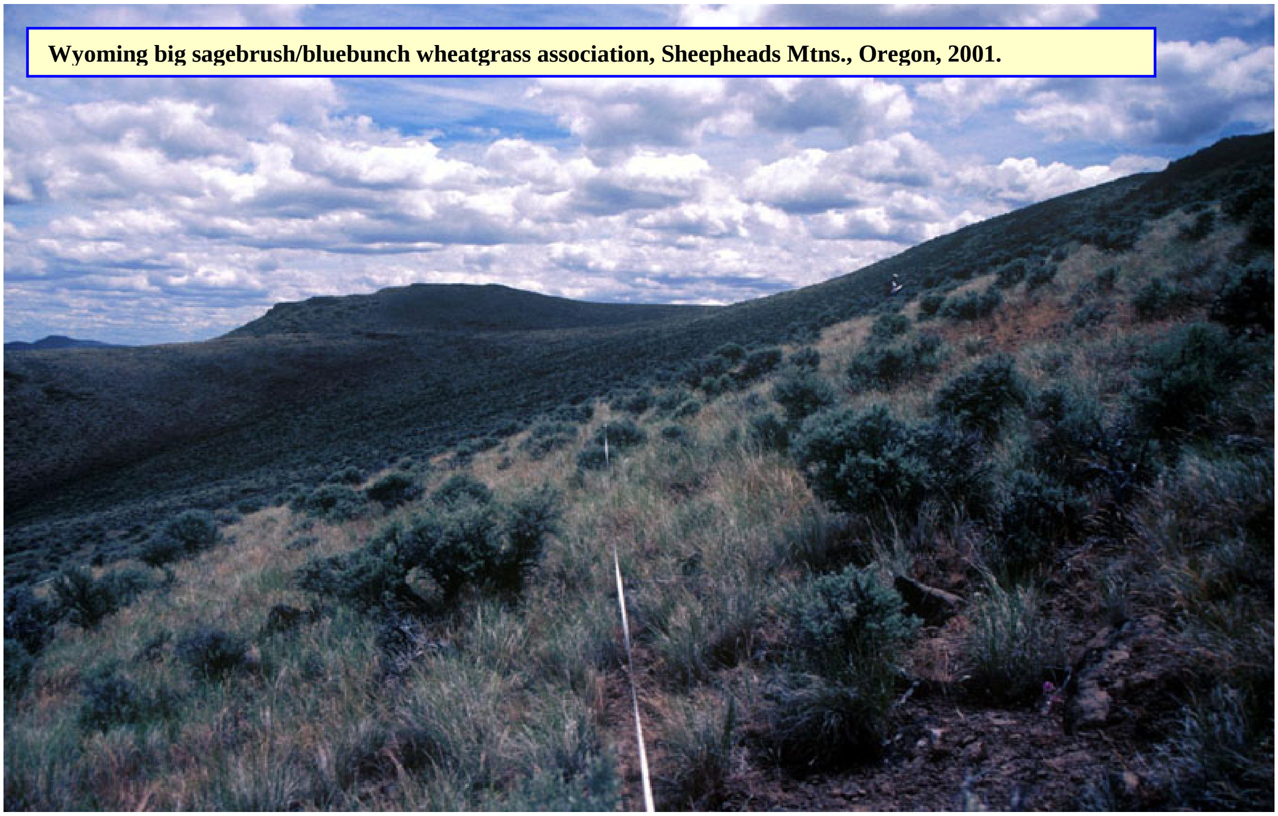
	Site Descriptors					Soil Characteristics					
Site	Topo map	UTM (NAD 83)	Land form	Elevation (m)	Aspect/ Slope	Order	Suborder	Soil Depth (cm)	Surface Texture	Soil C (%)	C/N
OWYHEE Deer Park East	Hole-in-the-Ground T27S R43E, Sec 30 SW	E: 456921.429 N: 4781146.728	upland sideslope	1290	93 º, 12º	Mollisol	Petrocalcidic Palexeroll	145	loam	0.72	13.2
Deer Park West	Hole-in-the-Ground T27S R42E, Sec 36 NE/NE	E: 457749.328 N: 4781091.852	upland sideslope	1292	290 º, 16º	Aridisol	Xeric Haploargid	215	loam	0.96	12.9
Deer Park N2	Hole-in-the-Ground T27S R42E, Sec 36 SE	E: 457332.613 N: 4780983.685	upland footslope	1265	360 º, 5º	Aridisol	Xeric Calciargid	158	silt loam	0.88	13.5
Jordan Crater Kipuka West	Jordan Craters South T28S R43E, Sec 33 NE	E: 462757.716 N: 4776535.662	kipuka	1336	250 º, 5º	Aridisol	Lithic Xeric Haploargid	37	silt loam	0.38	11.9
Lizard Butte	Hole-in-the-Ground T27S R42E, Sec 30 NW/NE	E: 456861.437 N: 4781703.227	upland shoulder	1313	260 º, 3º	Aridisol	Vitrixerandic Calciargid	93	loam	0.69	12.3
Deer Park North	Hole-in-the-Ground T27S R42E, Sec 36	E: 456895.166 N: 4780855.965	upland sideslope	1304	310 º, 18º	Mollisol	Aridic Argixeroll	74	silt loam	1.67	13.2
NORTH VALE Cassidy Butte	Avery Creek, T22S R41E Sec 3 SW/E	E: 445282 N: 4835283	upland sideslope	1236	280 º, 10º	Aridisol	Xeric Haploargid	210	sandy loam	0.47	12.4
IPity	Steens Mtn, T30S, R37E, Sec 13, SE/SW	E: 409103 N: 4756594	foot slop	1523	12 º, 8º	Aridisol	N.A.	70	loam	1.48	10.7
Squaw Creek	Avery Creek, T21S R41E, Sec 20 SW/NE	E: 442507 N: 4841940	upland sideslope	986	300 º, 8º	Aridisol	Xeric Haplocambid	89	loam	0.94	10.2
Windy Hill 1	Skull Springs	E: 437830 N: 4814930	shoulder	1323	180 º, 5º	Aridisol	N.A.	71	loam	1.12	10.8
Windy Hill 2	Skull Springs	E: 437979 N: 4814729	ridge summit	1344	--, 0-1º	Aridisol	N.A.	60	loam	0.99	9.9
Windy Hill 3	Skull Springs	E: 438143 N: 4814732	upland sideslope	1335	90º, 12º	Aridisol	N.A.	80	silt loam	1.06	9.5
Windy Hill 4	Skull Springs	E: 437822 N: 4814879	upland sideslope	1321	270 º, 5º	Aridisol	N.A.	70	loam	0.78	9.8
Clover Creek 2	Log Creek T17S R40E, Sec 27 NW/NW	E: 436155 N: 4879542	plateau	1161	205 º, 3º	Aridisol	Xeric Arigidurid	85+	silt loam	0.46	9.1
Clover Creek	Log Creek T17S R40E, Sec 27 NW/NW	E: 436169 N: 4879671	plateau	1164	260 º, 3º	Aridisol	Xeric Arigidurid	85+	loam	0.75	9.3
Sheep Rule 1	Log Creek T17S R40E, Sec 21 SE/NW	E: 434600.54 N: 4880312	upland sideslope	1207	90 º, 3º	Aridisol	Xeric Calciargid	66	loam	0.57	11.3
Sheep Rule 2	Log Creek T17S R40E, Sec 21 SE/NW	E: 434403.628 N: 4880500.068	upland sideslope	1217	310 º, 7º	Aridisol	Xeric Petrocalgid	115	loam	0.95	12.4
Sheep Rule 3	Log Creek T17S R40E, Sec 21 NE/SE	E: 434658.692 N: 4880613.539	upland sideslope	1278	40 º, 8º	Mollisol	Aridic Calcixeroll	117	silt loam	0.98	12.6

Appendix 7A. Louse Canyon Vegetation Summaries for Wyoming Big Sagebrush Plant Associations.

Site Description		Understory Cover (%)								Shrub Cover (%)			
Site	Plant Association	POSA	Perennial Grass	Perennial Forb	Annual Grass	Annual Forb	Litter	Moss & Crust	Bare-Rock	Artrw8 Live	Artrw8 Dead	Other Shrubs	Shrub Cover
Airplane Reservoir	Artrw8/Agsp	4.2	8.7	2.7	0.0	0.6	11.9	4.4	68.4	11.2	7.6	0.3	11.5
Antelope Creek	Artrw8/Agsp	4.8	9.6	1.5	0.6	0.3	17.8	5.5	60.7	15.9	6.9	1.3	17.2
Black Butte	Artrw8/Agsp	4.3	11.7	6.5	0.1	1.0	17.9	6.2	53.4	17.8	5.4	0.3	18.1
LCLC 4	Artrw8/Agsp	5.1	9.1	7.3	0.0	1.0	20.3	4.9	52.2	12.9	6.6	0.5	13.3
Lucky Seven (CHH5)	Artrw8/Agsp	6.8	10.1	3.7	0.1	0.5	15.1	8.5	54.8	13.6	6.4	0.8	14.3
Tent Creek	Artrw8/Agsp	4.3	10.3	2.8	0.0	0.9	16.4	4.4	60.4	15.9	7.5	0.0	15.9
TGIF	Artrw8/Agsp	8.1	8.6	7.1	0.4	1.3	15.5	5.2	45.2	14.7	3.0	0.0	14.7
Toppin Butte 5	Artrw8/Agsp	5.9	9.8	6.3	0.2	0.5	13.1	7.0	57.7	10.4	4.2	0.0	10.4
Poached Egg Hill	Artrw8/Agsp-Stth	8.5	9.9	7.3	0.02	0.9	21.4	3.4	52.7	9.9	2.3	1.2	11.2
Star Valley	Artrw8/Agsp-Stth	3.4	7.4	7.8	0.0	1.2	16.7	4.0	60.6	19.0	5.1	1.7	20.7
Toppin Butte 1	Artrw8/Feid	2.3	12.0	6.1	0.0	0.9	10.5	3.3	65.4	15.6	3.2	0.0	15.6
Toppin Butte 2	Artrw8/Feid	5.0	17.3	4.9	0.0	0.3	9.8	2.7	60.5	3.3	3.1	0.5	3.8
Toppin Butte 3	Artrw8/Feid-Agsp	3.4	20.3	3.6	0.0	0.3	14.4	2.6	56.0	14.3	4.7	0.0	14.3
Toppin Butte 4	Artrw8/Feid-Agsp	5.4	19.4	4.0	0.03	0.5	13.0	5.9	52.6	12.6	6.2	0.0	12.6
Sage Rage 1	Artrw8/Stth	3.6	5.3	2.2	0.03	1.0	12.4	9.1	65.0	12.3	4.9	0.0	12.3
Sage Rage 2	Artrw8/Stth	3.1	5.7	3.0	0.0	0.5	18.5	16.2	50.4	13.9	6.9	0.2	14.0
Sage Rage 3	Artrw8/Stth-Agsp	6.4	9.1	1.1	0.0	0.3	13.5	13.5	56.5	11.9	7.0	0.3	12.2
Sage Rage 4	Artrw8/Stth-Agsp	3.2	11.7	2.0	0.2	1.6	17.5	11.0	54.2	12.2	8.2	0.0	12.2

Appendix 7B. Louse Canyon Site and Soil Characteristics for Wyoming Big Sagebrush Plant Associations.

	Site Descriptors					Soil Characteristics					
Site	Topo map	UTM (NAD 83)	Land form	Elevation (m)	Aspect/ Slope	Order	Suborder	Soil Depth (cm)	Surface Texture	Soil C (%)	C/N
Airplane Reservoir	Lookout Lake, T40S, R47E, Sec 7 NE	E: 479645 N: 4662415	plateau	1750	70 °, 2°	Aridisol	N.A.	57	silt loam	1.12	9.7
Antelope Creek	Grasshopper Flat North, T38S R44E Sec23 E	E: 457539 N: 4678324	upland sideslope	1687	120 °, 3°	Aridisol	N.A.	112	loam	0.61	8.9
Black Butte	Stoney Corral T39S R47E sec 20 SW/SW	E: 480096 N: 4667763	hilltop	1796	74 °, 1.5°	Aridisol	N.A.	66	loam	1.04	10.1
LCLC 4	Guadalupe Meadows T39S R47E Sec 27	E: 474625 N: 4666224	plateau	1804	72 °, 1.5°	Aridisol	N.A.	60	loam	1.02	9.7
Lucky Seven (CHH5)	Starvation Springs T38S R45E Sec 20	E: 460620 N: 4678024	plateau	1722	265 °, 1°	Mollisol	N.A.	74	loam	0.94	9.9
Tent Creek	Lookout Lake T40S R39E Sec 20 SW	E: 480700 N: 4658146	plateau	1740	160 °, 1°	Aridisol	N.A.	78	silt loam	1.20	9.7
TGIF	Guadalupe Mead. T39S R47E Sec 34 NE/ NE	E: 473806 N: 4665755	plateau	1780	212 °, 1°	Aridisol	N.A.	70	loam	1.20	10.3
Toppin Butte 5	Rawhide Pocket T37S R47E, Sec 24 SW/NE	E: 487161 N: 4687475	upland sideslope	1577	180 °, 2°	Aridisol	N.A.	51	silt loam	0.83	9.4
Poached Egg Hill	Oregon Butte, T40S, R46E, Sec 3 SW/SE	E: 474367 N: 4663257	plateau	1761	30 °, 1°	Aridisol	N.A.	50	silt loam	0.88	9.7
Star Valley	Oregon Butte, T40S, R46E, Sec 2 SW	E: 475632 N:4663040	upland sideslope	1769	238 °, 5°	Aridisol	N.A.	53	loam	0.63	9.7
Toppin Butte 1	Beaver Charlie, T37S R48E, Sec 21 NE/NE	E: 492412.9 N: 4688050	plateau	1566	0 °, 0-1°	Aridisol	N.A.	68	loam	0.84	9.4
Toppin Butte 2	Rawhide Pocket, T37S, R47E, Sec 7 SW	E: 488794 N: 4690394	upland sideslope	1598	10 °, 2-3°	Aridisol	N.A.	63	loam	0.79	9.7
Toppin Butte 3	Rawhide Pocket, T37S, R47E, Sec 7 SW/SE	E: 488655 N: 4690270	upland sideslope	1599	325 °, 1°	Aridisol	N.A.	63	loam	0.91	9.9
Toppin Butte 4	Rawhide Pocket, T37S, R47E, Sec 13 NE/SE	E: 488178 N: 4689574	upland sideslope	1600	296 °, 3°	Aridisol	N.A.	60	loam	0.87	9.7
Sage Rage 1	Rawhide Pocket, T38S, R47E, Sec 13 N	E: 487276 N: 4680681	plateau	1601	284 °, 1°	Aridisol.	N.A.	73	silt loam	0.80	9.9
Sage Rage 2	Rawhide Pocket, T38S, R47E, Sec 24 S	E: 487440 N: 4677472	plateau	1612	30 °, 2°	Aridisol	N.A.	85	loam	1.01	9.7
Sage Rage 3	Stony Corral, T39S, R47E, Sec 25 SW/SW	E: 486792 N: 4675467	plateau	1645	28 °, 1°	Aridisol	N.A.	85	loam	0.77	9.0
Sage Rage 4	Stony Corral T39S R47E, Sec 1 NW/NE	E: 486858 N: 4673912	plateau	1643	182 °, 1°	Aridisol	N.A.	56	loam	0.69	8.5



Wyoming big sagebrush/bluebunch wheatgrass association, Sheepheads Mtns., Oregon, 2001.

After wildfire. Wyoming big sagebrush/bluebunch wheatgrass association, Sheepheads Mtns., Oregon, 2003.

III. Response of Wyoming Big Sagebrush Communities to Wildfire

Jon Bates, Kirk Davies, and Rick Miller

Summary

First and second year post-wildfire vegetation recovery in the Wyoming big sagebrush (*Artemisia tridentata* spp. *wyomingensis* (Beetle & A. Young) S.L. Welsh) alliance was assessed in the Sheepshead Mountains in southeastern Oregon. A wildfire burned over 16,000 ha across the northern portion of the Sheepshead range in August 2001. Prior to the fire, seven plots had been established and measured in the area in June 2001 as part of another study. Plots were sampled in 2002 and 2003 to assess early successional response to severe wildfire conditions. Plant communities affected by the wildfire were represented by Wyoming big sagebrush/bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Smith), and Wyoming big sagebrush/Thurber's needlegrass (*Stipa thurberiana* Piper) associations. The study plots were in mid to high seral ecological condition.

The Sheepshead burn was an intense wildfire, characterized by the elimination of sagebrush on all study plots. On all plots bareground increased significantly and cover of herbaceous vegetation, litter, moss, and crust declined significantly after fire. The Wyoming big sagebrush/Thurber's needlegrass association was the most severely impacted by the wildfire. Perennial grasses (Sandberg's bluegrass (*Poa sandbergii* Vasey) and Thurber's needlegrass) cover and density were significantly reduced by the wildfire. Consequently, these grass species have been slow to respond the first two years after wildfire. Cheatgrass (*Bromus tectorum* L.) has increased slowly in cover but because of the reduction in the perennial grass component much of the area in this association remains open to further annual grass colonization.

Understory response to the fire in the Wyoming big sagebrush/bluebunch wheatgrass association varied depending on site. Recovery of perennial grasses in this association has been more rapid when compared to perennial grass recovery in the Wyoming big sagebrush/Thurber's needlegrass association. Bluebunch wheatgrass was less affected by fire and tended to recover more quickly than other native bunchgrasses. Cheatgrass has remained a minor to nonexistent component of these communities after fire.

Vegetation response to the fire varied by species. Mat forming forbs and basally dense bunchgrasses (Thurber's needlegrass, Idaho fescue (*Festuca idahoensis* Elmer), Cusick's bluegrass (*Poa cusickii* Vasey)) were the most severely impacted. Bluebunch wheatgrass and bottlebrush squirreltail were only slightly damaged and recovered rapidly by the second growing season post fire. Perennial forbs with growth points protected belowground and most annual forbs were either unaffected or increased in cover following the wildfire.

The high mortality of perennial grasses and presence of cheatgrass in the Thurber's needlegrass association suggests there is a substantial risk for annual grass replacement of this sagebrush steppe association after wildfire. The wildfire did not severely impact the mid and high seral Wyoming big sagebrush/bluebunch wheatgrass association. However bluebunch wheatgrass and Thurber's needlegrass associations are often found in a mosaic on the landscape. Thus, efforts should be made to limit wildfire disturbance in these plant associations in eastern Oregon and elsewhere. If burning is prescribed in these associations, prescriptions should be limited to periods when fuel moisture is higher and fire conditions less severe.

Introduction

The purpose of this study has been to evaluate the effects of wildfire to Wyoming big sagebrush (*Artemisia tridentata* spp. *wyomingensis* (Beetle & A. Young) S.L. Welsh) plant associations. The big sagebrush complex is delineated into three alliances: the Wyoming big sagebrush alliance; basin big sagebrush (*Artemisia tridentata* spp. *tridentata* Nutt.) alliance; and mountain big sagebrush (*Artemisia tridentata* spp. *vaseyana* (Rydb.) B. Boivin) alliance. The Wyoming big sagebrush alliance is considered to have been the most extensive of the big sagebrush complex in the Intermountain West (Miller and Eddleman 2000, Tisdale 1994). This alliance is more arid than the other big sagebrush alliances (Miller and Eddleman 2000). Thus, productivity and vegetative cover are lower, and levels of bare ground are higher.

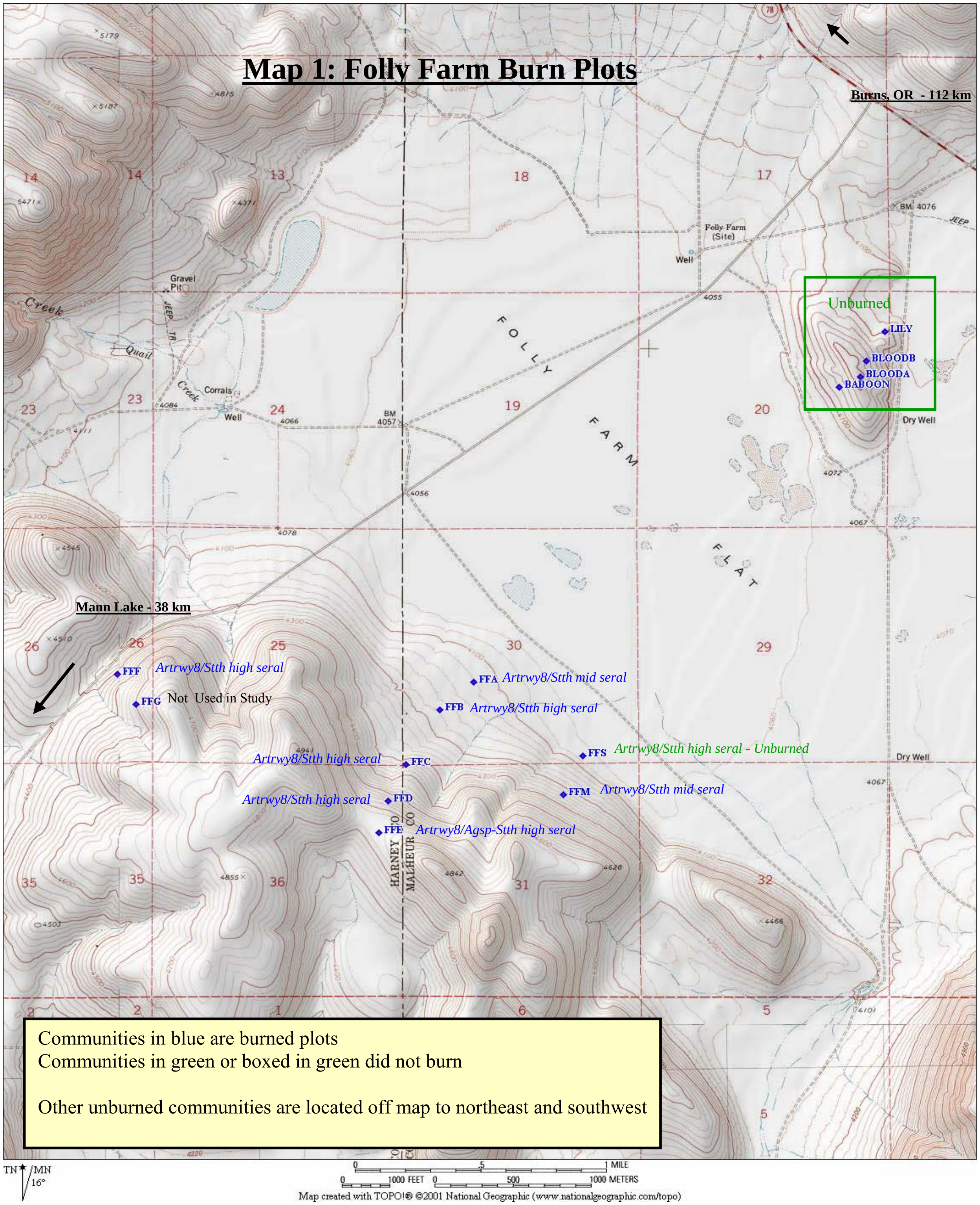
Large areas of the Wyoming big sagebrush alliance are rated in low seral condition or have converted to annual grasslands (West 1984, Miller and Eddleman 2000). The invasion by cheatgrass has resulted in dramatic increases in both size and frequency of fire in Idaho's Snake River Plains and Nevada (Young and Evans 1973, Whisenant 1990, West 2000). Whisenant (1990) estimated mean fire return intervals in Wyoming big sagebrush plants communities have been reduced from 50-100 years to < 10 years as a result of cheatgrass (*Bromus tectorum* L.) invasion. The increased fire frequency has permitted cheatgrass and other introduced annuals to replace the native shrub and herb layers. This community conversion from native to exotic dominance is a major factor for loss of wildlife habitat and reduced populations of sagebrush obligate and facultative wildlife species.

However, extensive areas in southeastern Oregon, northern Nevada, and southwestern Idaho contain Wyoming big sagebrush communities in mid- to late seral ecological stages (USDI-BLM, 2001). These areas are co-dominated by sagebrush and perennial bunchgrasses with limited presence of cheatgrass (EOARC file data). However, cheatgrass presence, even in limited amounts has the potential to alter these intact systems after fire disturbance. There is limited information on the effects of wildfire in the Wyoming big sagebrush alliance in this region. This information is needed to; (1) evaluate post-burn secondary successional dynamics; and (2) to develop a risk assessment of community susceptibility to cheatgrass or other weed invasion after fire disturbance. In this study, first and second year post-wildfire vegetation responses in two Wyoming big sagebrush associations were assessed in the Sheepshead Mountains in southeastern Oregon.

Methods

Study Site

Wildfire impacts to the Wyoming big sagebrush alliance has been monitored in two plant associations in the Sheepshead Mountains in southeast Oregon. Fifteen study sites were set up in spring 2001 (Map 1). Initial vegetation measurements were made in June 2001 as part of another study assessing plant cover potentials in Wyoming big sagebrush associations. Nine of the plots burned in an intense wildfire in August 2001. Sagebrush was largely removed across an extensive and ecologically diverse 16,000-ha area. Few unburned patches remained within the fire perimeter.


Map 1: Folly Farm Burn Plots
Burns, OR - 112 km
Unburned
LILY
BLOODB
BLOODA
BABOON
Folly Farm (Site)
FOLLY FARM FLAT
Mann Lake - 38 km
FFF Artrwy8/Stth high seral
FFG Not Used in Study
FFA Artrwy8/Stth mid seral
FFB Artrwy8/Stth high seral
FFS Artrwy8/Stth high seral - Unburned
FFC Artrwy8/Stth high seral
FFD Artrwy8/Stth high seral
FFM Artrwy8/Stth mid seral
FFE Artrwy8/Agsp-Stth high seral
HARNEY CO
MALHEUR CO
Communities in blue are burned plots
Communities in green or boxed in green did not burn
Other unburned communities are located off map to northeast and southwest
Map created with TOPO!® ©2001 National Geographic (www.nationalgeographic.com/topo)

Plant Communities

Plant communities monitored in the study included two of the five vegetation Wyoming big sagebrush associations described by Davies et al. (2004); Wyoming big sagebrush/bluebunch wheatgrass and Wyoming big sagebrush/Thurber's needlegrass. The Wyoming big sagebrush/bluebunch wheatgrass association consisted of five sites; prior to the wildfire four were rated in high-seral ecological condition (Folly Farm C, D, E & F) and one was rated as mid-seral (Folly Farm Mid) (Map 1). The Wyoming big sagebrush/ Thurber's needlegrass association included one site rated in mid-seral ecological condition (Folly Farm A) and one site rated in high ecological condition (Folly Farm B). Wyoming big sagebrush was the dominant shrub in all associations measured. Green rabbitbrush (Chrysothamnus viscidflorus) was present in limited densities on all plots. In the Wyoming big sagebrush/Thurber's needlegrass association spiny hopsage (*Atriplex confertifolia* (Torr. & Frem.) Wats.) and gray horsebrush (*Tetradymia canescens* DC.) were present in low densities. Paired unburned plant associations were located nearby (within 2-3 miles) to provide comparison with burned plots.

Vegetation Measurements

Plots were about 0.4 ha in size (50x80 m). Five, 50-meter transects were permanently established in each plot. Transects were placed every 20 m off of an 80 m main line (Fig 1). Transects were set up perpendicular to the hillslope. The location of transects were recorded by the global positioning system.

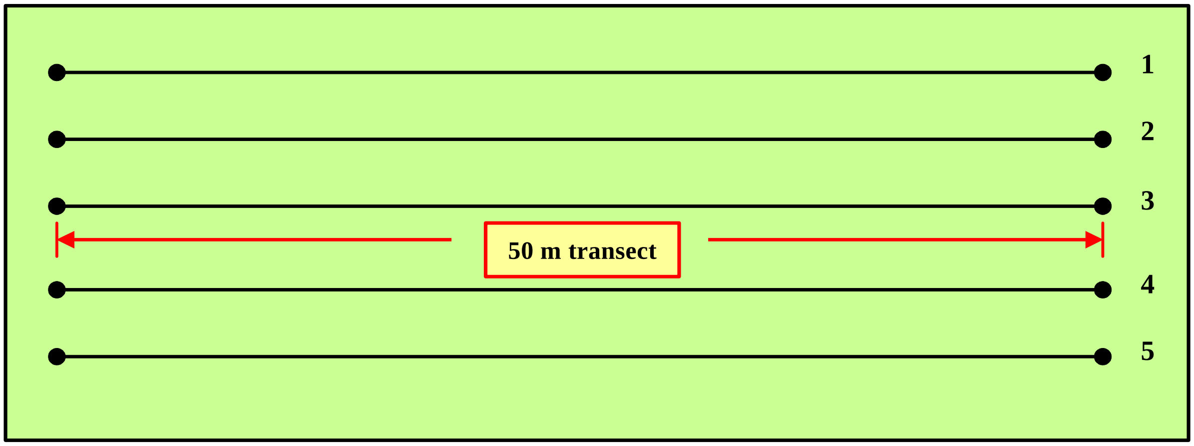
Shrubs

Shrub cover (by species) was determined using the line-intercept method (Canfield 1949) (Fig 2). Shrub cover was separated into live and dead cover. Canopy gaps were included in shrub cover estimates if less than 15 cm. Shrub density (by species) was determined by counting the numbers of shrubs rooted within 2x50 m belt transects. Shrub cover and density was separated into three categories by species: seedlings, juveniles, and mature. Juvenile shrubs were identified by their smaller size relative to other shrubs in community and lack of reproductive development (current or past year reproductive structures were lacking).

Herbaceous

Herbaceous species cover, bare ground, rock, litter, moss, and crust were estimated using 0.2 m^2 frames each spring in 2001, 2002, and 2003. Plant density of perennial species was estimated in 2002 and 2003 by counting individuals rooted inside the 0.2 m^2 frames. Starting at the 3-m point on each transect, frames were located every 3 meters on the transect lines (15 frames per transect – a total of 75 frames per plot) (Fig 2). Plant species richness was estimated by recording all species present within the 80x50 m plot.

Figure 1. Plot Layout for Wyoming Big Sagebrush Sites

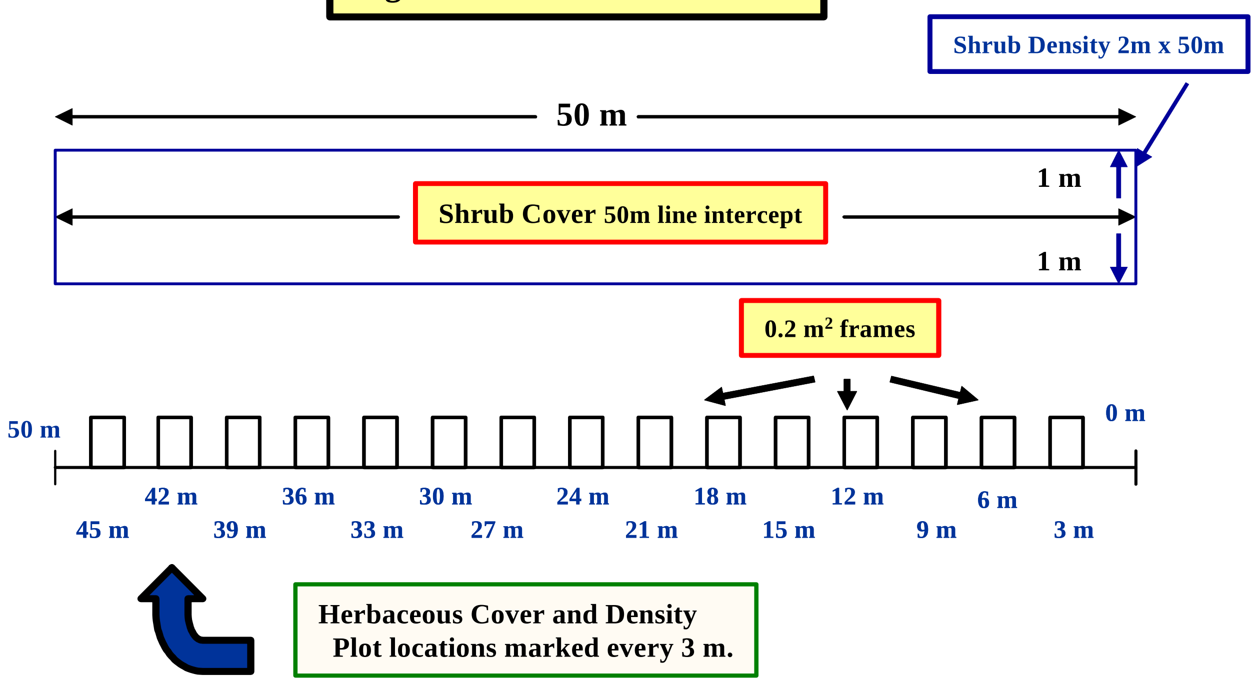


Transects:
- length, 50 m
- separation between transects 20 m

Shrubs:
- Cover, 50 m line intercept
- Density, 50m x 2m belt transects

Herbaceous:
- canopy cover and density estimated inside 0.2 m^2 frames every 3 m on transect. Start at 3 m.
- canopy cover and density measured by species
- Species richness estimated by listing all species inside 50m x 80m plot.

Figure 2. TRANSECT SETUP



Soil characteristics

Soils were described in 2001 (EOARC file data) but are not included in this manuscript. To see soils data, refer to Appendix 10 in section 1 of the report. Soils are described Folly Farm plots A-F. Effects of fire to micro-topography were recorded in 2002 and 2003 by comparing burned areas with nearby unburned sites (EOARC file data).

Data Presentation and Analysis

This report presents pre-burn and post-burn vegetation cover data. Data from paired unburned plots are not presented. Fire impacts were summarized by association and seral stage. Data shown for each burned plot will focus on the major herbaceous functional groups and the dominant perennial grass describing each association. Functional groups include Sandberg's bluegrass (*Poa sandbergii* Vasey), late seral perennial bunchgrasses, cheatgrass, perennial forbs, and annual forbs. Sagebrush cover is reported as live cover only. Individual species responses are briefly mentioned when appropriate. Data was analyzed within each site between years using t-tests to test for significant changes in cover of herbaceous plants, litter, moss, and crust.

Results and Discussion

Shrubs

The Sheepshead burn was an intense wildfire, which was characterized by the elimination of Wyoming big sagebrush on all study plots. Sagebrush has not reestablished on any plots the first two years after fire. Green rabbitbrush re-sprouted the first year after fire but its density is extremely low across the plots (< 20 plants/ha). Spiny hopsage and gray horsebrush were present in the Wyoming big sagebrush/ Thurber's needlegrass associations appear to have been eliminated by the fire. Resprouting of horsebrush has not been observed.

Herbaceous

Herbaceous response has varied greatly by association and to a lesser degree within association. In all plots, bare ground increased significantly, and cover of litter, moss, and crust declined significantly. For specific responses for each plot refer to the Appendix I beginning on page .

Wyoming big sagebrush/Thurber's needlegrass association

The Wyoming big sagebrush/Thurber's needlegrass association was the most severely impacted by the wildfire. Perennial grasses (Sandberg's bluegrass, bluebunch wheatgrass, and Thurber's needlegrass) were significantly reduced in cover. Recovery of these grasses has been slow the first two years after fire. Perennial and annual forbs increased in cover by the 2nd year post-fire. Mat forming perennial herbs, such as oval leaf buckwheat (*Eriogonum ovalfolium* Nutt.) and Hoods phlox (*Phlox hoodii*) were significantly reduced in cover and density.

Hawksbeard species (*Crepis* spp.) and long-leaf phlox (*Phlox longifolia* Nutt.) however increased significantly in cover. Cheatgrass has increased slowly but because of the reduction in the perennial grass component much of the area in this association remains open to further colonization.

Wyoming big sagebrush/bluebunch wheatgrass association

The response to the fire in the Wyoming big sagebrush/bluebunch wheatgrass association has varied depending on site. However, recovery of perennial grasses has tended to be more rapid than the Wyoming big sagebrush/Thurber's needlegrass association. Bluebunch wheatgrass is less affected by fire and tends to recover more quickly than other native bunchgrasses (Wright et al. 1979). Thurber's needlegrass, Idaho fescue (*Festuca idahoensis* Elmer) and Cusick's bluegrass (*Poa cusickii* Vasey) were all severely impacted by fire in this association. Cheatgrass was either not present or did not increase after the fire. Perennial forb response has varied by individual site. Sites with a high percentage of Hood's phlox were slow to recover compared to plots with a higher percentage of hawksbeard species or velvet lupine (*Lupinus leucophyllus* Dougl.). Annual forbs in this association tended to respond rapidly and thus far were primarily composed of blue-eyed Mary (*Collinsia parviflora* Lindl.).

Species Response

The initial responses of specific species to the fire have generally agreed with those reported by Wright et al. (1979). Mat forming forbs and the denser bunchgrasses (Thurber's needlegrass, Idaho fescue, and Cusick's bluegrass) were the most severely impacted species. Table 1 provides an estimate of herbaceous species response to the effects of the wildfire in the Sheepshead Mountains.

Conclusions and Management Implications

A limited number of studies have produced mixed results on the impacts of wildfire to the Wyoming big sagebrush alliance. The impact that fire has on plant communities is dependent on a number of factors, including site potential and characteristics, plant composition, the severity of wildfire, and pre- and post-fire weather (Wright et al. 1979). In this study, the impact of wildfire to the two Wyoming big sagebrush associations monitored and their subsequent recovery have differed significantly.

The results indicated the Wyoming big sagebrush/Thurber's needlegrass association was severely impacted by wildfire. Though these sites were rated in mid to late seral stages, recovery has been slow and the presence of cheatgrass suggests an enhanced likelihood for these sites to be converted to annual grass dominated systems.

The Wyoming big sagebrush/bluebunch wheatgrass association, in mid to late seral stages, were less impacted by wildfire than the Wyoming big sagebrush/Thurber's needlegrass association. Recovery has been more rapid and lack of cheatgrass response indicates that these sites will recover with native perennial bunchgrasses and forbs dominating the herbaceous layer.

Table 1. Wildfire effects to plant species in Wyoming big sagebrush/Thurber's needlegrass and Wyoming big sagebrush/bluebunch wheatgrass associations, Sheepshead Mountains, Oregon.

Severely impacted	Slightly impacted	No impact or enhanced
<u>Grasses</u>	<u>Grasses</u>	<u>Grasses</u>
Thurber's needlegrass	bluebunch wheatgrass	cheatgrass
Idaho fescue	bottlebrush squirreltail	six weeks fescue
Cusick's bluegrass	Sandberg's bluegrass	
Sandberg's bluegrass		
<u>Perennial Forbs</u>	<u>Perennial Forbs</u>	<u>Perennial Forbs</u>
low pussytoes	velvet lupine	speckle pod milkvetch
Hood's phlox	daggerpod	Brunea mariposa lily
obscure milkvetch	lava aster	basalt milkvetch
dwarf yellow fleabane	wooly-pod milkvetch	low hawksbeard
scabland fleabane	morning milkvetch	taper-tip hawksbeard
desert yellow fleabane		western hawksbeard
oval-lvd. eriogonum		big seed lomatium
Hook's daisy		broadsheath lomatium
		Nevada lomatium
		taper-tip onion
		long-lvd. phlox
		one-stemmed groundsel
		Bolander's yampah
	<u>Annual forbs</u>	<u>Annual forbs</u>
	white daisy tidytips	desert alyssum
		little blue-eyed Mary
		cushion cyrptantha
		autumn willow-weed
		groundsmoke spp
		sinuate gilia
		white-stemmed blazing star
		thread-stem linanthus
		pink microsteris
		thread-leaf phacelia
		burr buttercup
		Jim Hill tumble mustard
		pinnate tansy mustard
		yellow salsify

Severely impacted – species cover reduced by more than 80% with no change in cover in years following fire.

Slightly impacted – species cover between 50% -90% of pre burn levels the first 2 years after fire.

No impact or enhanced – Cover not affected or increased above pre-burn levels.

Wyoming big sagebrush has not reestablished after fire and recovery is likely to be a slow process. Lack of sagebrush recruitment indicates that there was a limited seed pool and/or poor establishment conditions. There have been no studies investigating reestablishment of Wyoming big sagebrush after wildfire. Results from the mountain big sagebrush alliance indicate that reoccupancy of a site by sagebrush is linked to many factors including seed bank, pre and post fire weather, and fire size and severity (Ziegenhagen 2004).

The Wyoming big sagebrush alliance evolved with fire, however, the recent spread of exotic weeds, particularly cheatgrass, and alteration of the fire cycles has removed sagebrush communities from large areas in Nevada, Idaho and Utah (Whisenant 1990). In remaining areas of the northern Great Basin containing relatively intact Wyoming big sagebrush communities, management of both wild and prescribed fires must be carefully considered. The high mortality of perennial grasses and presence of cheatgrass in the Thurber's needlegrass association suggests there is a substantial risk for annual grass replacement of this steppe association after wildfire. Though the wildfire did not severely impact the mid and high seral Wyoming big sagebrush/bluebunch wheatgrass association, bluebunch wheatgrass and Thurber's needlegrass associations are often found in a mosaic on the landscape. Thus, efforts should be made to limit wildfire disturbance in remaining intact Wyoming big sagebrush plant associations of eastern Oregon northern Nevada, and southwest Idaho. Large wildfires in the Wyoming big sagebrush alliance could cause further reductions in populations of sagebrush obligate species, such as sage grouse.

Prescribed fire should still remain an option in the Wyoming big sagebrush alliance. Forbs are critical in the diet of sage grouse during pre-laying and brood-rearing periods (Barnett and Crawford 1994, Drut et al. 1994, Crawford et al. 2004). Evidence suggests that chick survival is positively associated with forbs and invertebrate availability (Drut et al. 1994). Wrobleski and Kauffman (2003) found that forbs, important in sage grouse diets, increased in abundance and productivity and had lengthened growing seasons following fire and suggested that properly applied, fire may benefit sage grouse. If burning is prescribed in these associations, prescriptions should be limited to periods with higher fuel moisture and less severe fire conditions, such as during early and mid fall. In our studies at EOARC, fall burning when conditions are less severe and fuel moisture is higher there were limited negative impacts to herbaceous plants (EOARC file data). The understory, which included Thurber's needlegrass and Idaho fescue, made rapid recoveries within the first two years after prescribed fall fires. If forbs are limiting for sage grouse, patch burning in the fall in mid to high seral Wyoming big sagebrush communities may be a management alternative to increase forb availability in sage-grouse rearing habitat.

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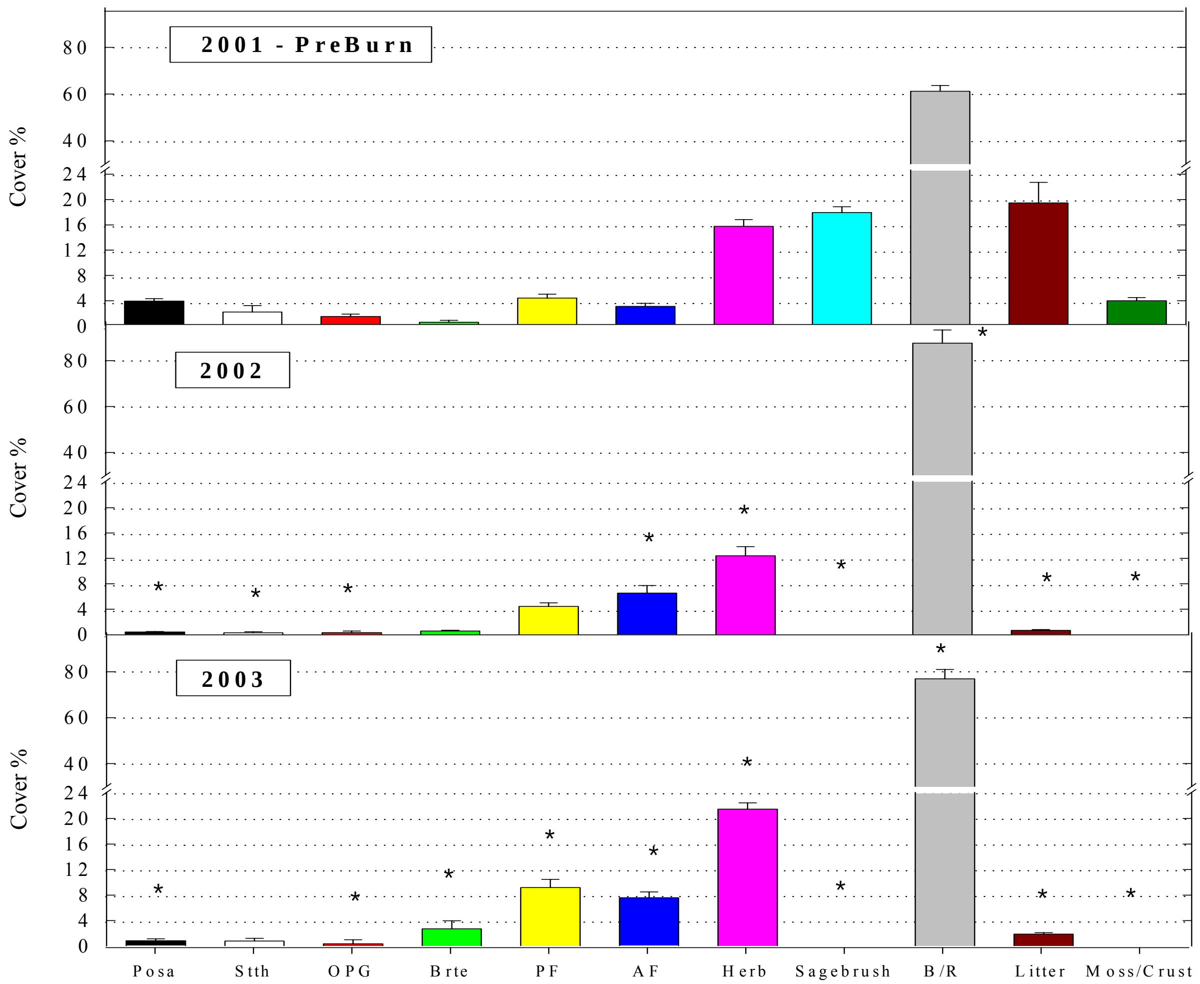
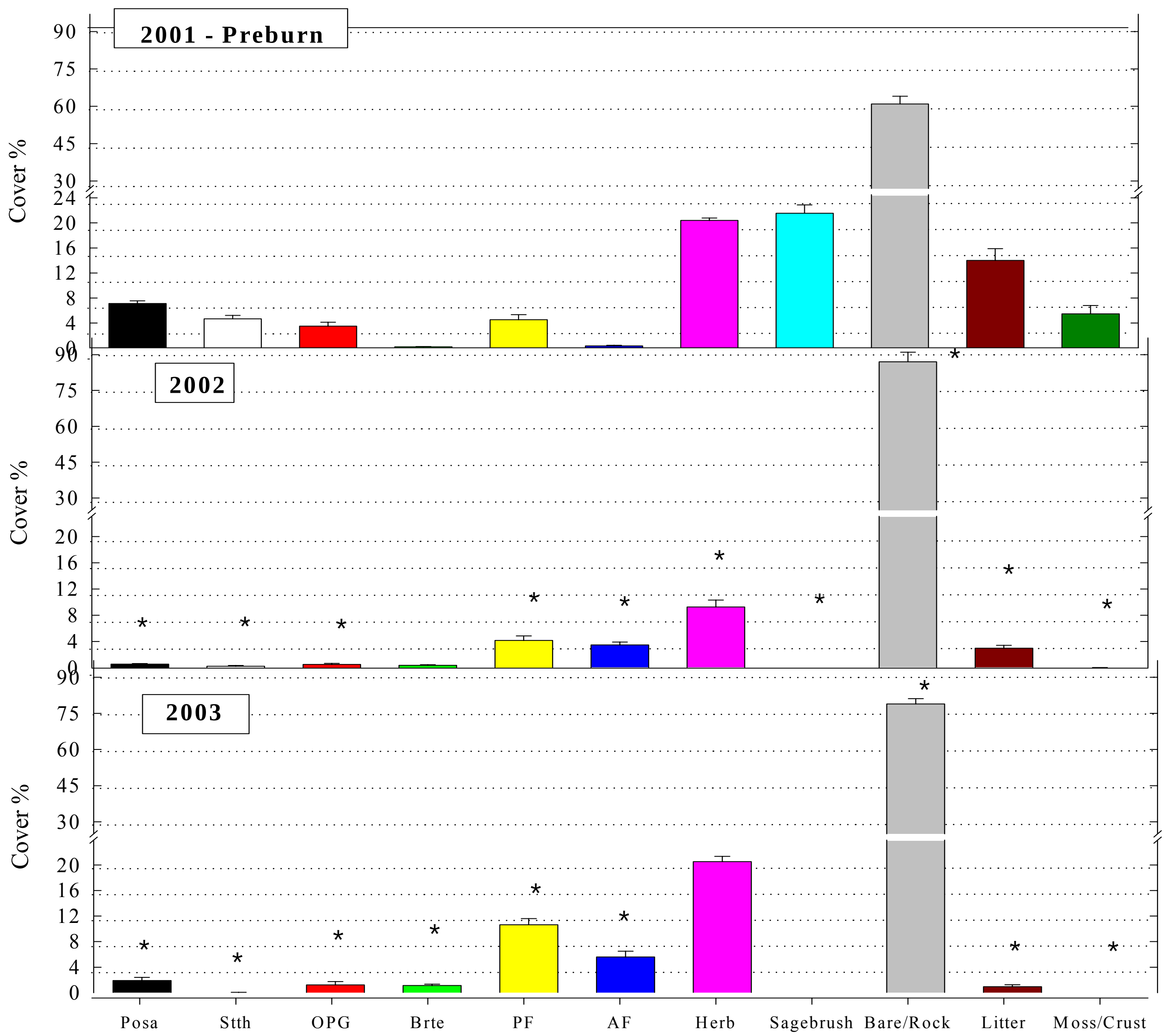
APPENDIX I: Vegetation response of Wyoming big sagebrush associations to wildfire.



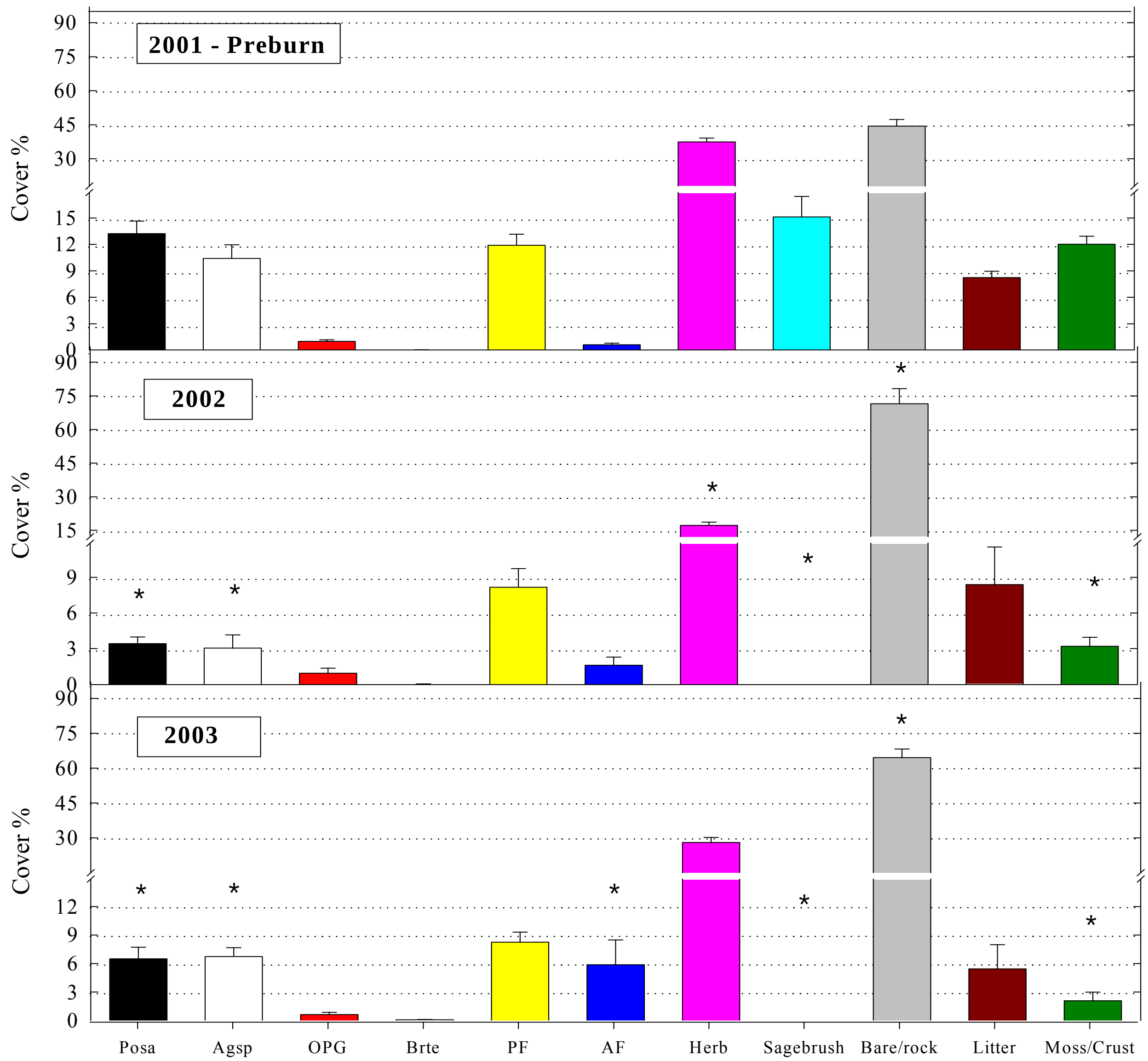
A. *Folly Farm A: Mid-seral Thurber's needlegrass*

As a result of burning there was a significant decline in cover of Sandberg's bluegrass (Posa), Thurber's needlegrass (Stth), and other perennial grasses (OPG), litter, and moss/crust. Sandberg's bluegrass and perennial grasses have been slow to respond as the fire killed many plants. Sagebrush was removed as well as all moss and crust. Moss and crust were primarily located under sagebrush plants. Perennial forbs (PF), annual forbs (AF) and Cheatgrass (Brte) all increased by the second year after fire (2003). The perennial forb group was mainly comprised of longleaf phlox (mean = 8.6 $\pm$ 1.4 %). Mat forming perennial forbs were eliminated or substantially reduced in cover (e.g. (oval-leaved buck-wheat (*Eriogonum ovalifolium* Nutt.), lava aster (*Aster scopulorum* Gray). Annual forbs that increased substantially were fireweed (*Gayophytum* spp.) and desert alyssum (*Alyssum desertorum* Stapf.). Cheatgrass (Brte) increased slightly however this site remains open to substantial expansion of this species especially as the perennial grass component has been much reduced. Herbaceous species richness declined after fire. Total number of species was 26 in 2001, 19 in 2002, and 23 in 2003. The decrease was due to a reduction in the number of perennial forb species from 12 to 6. Annual forbs increased by 4 species (from 8 at the pre-burn level). Asterisks (*) indicate significant differences (p=0.5) between pre-burn and post burn values for each functional group or species.



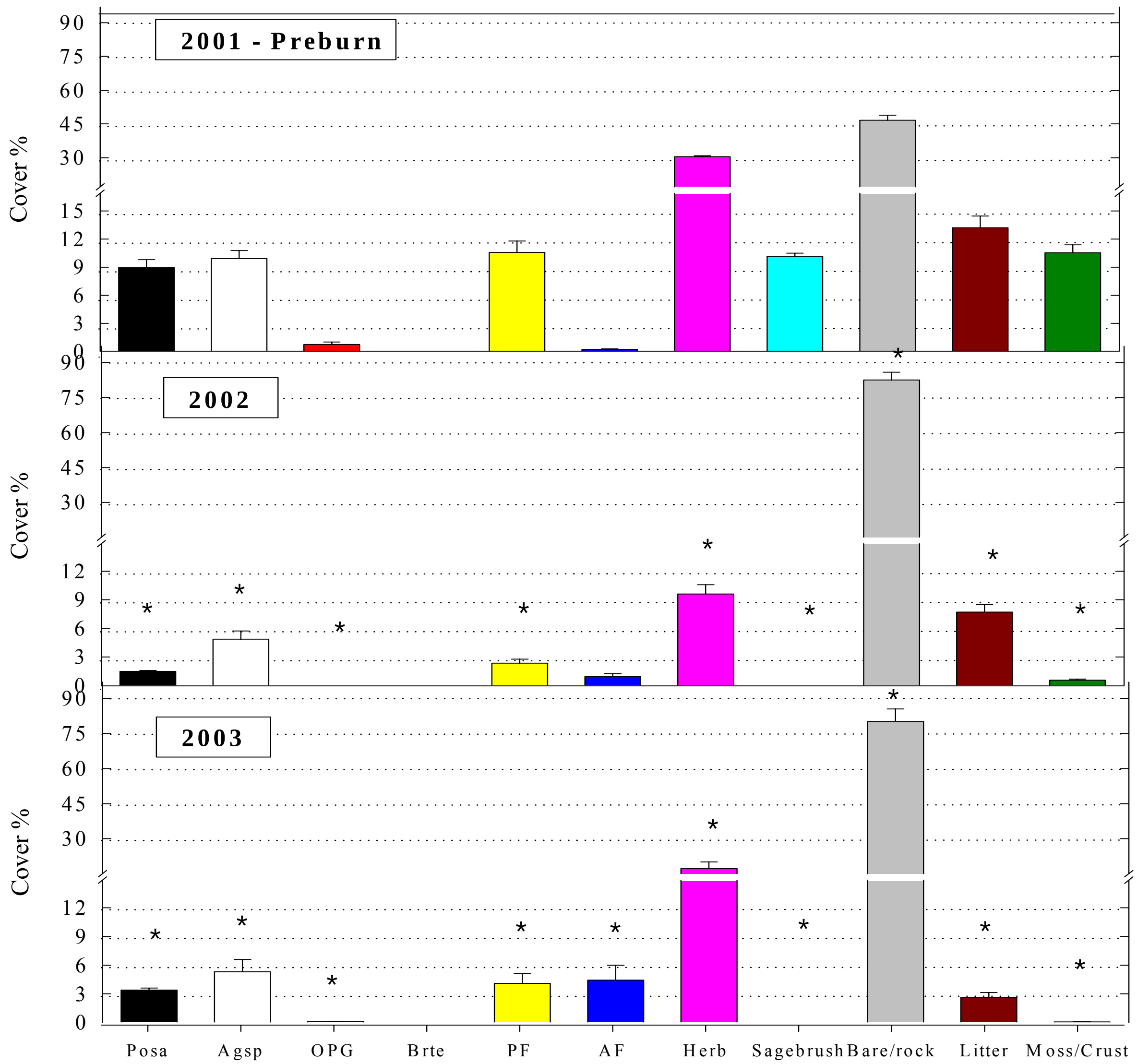
B. *Folly Farm B: High-seral Thurber's needlegrass*

There was a significant decline in cover of Sandberg's bluegrass (Posa), Thurber's needlegrass (Stth), and other perennial grasses (OPG). Thurber's needlegrass declined almost 100% and there are very few plants left on site. In 2003, other perennial grass cover was only about 15% of pre-burn levels. Sagebrush was removed as well as all moss and crust. Moss and crust were primarily located under sagebrush plants. Perennial forbs (PF), annual forbs (AF) and Cheatgrass (Brte) all increased by the second year after fire (2003). The perennial forb group was mainly comprised of longleaf phlox (mean = 7.6 $\pm$ 1.0 %) and western and low hawksbeard (*Crepis occidentalis* Nutt. And *Crepis modocensis* Greene, cover mean = 1.53 + 0.2 %). Annual forbs that increased substantially were fireweed, desert alyssum, blue-eyed Mary, and shy gilia (*Gilia intermedia* Dougl.). Cheatgrass increased slightly, however as in the previous site there remains a great deal of open space available for this species to expand. Herbaceous species richness increased slightly after fire. Total number of species was 25 in 2001, 30 in 2002, and 29 in 2003. The increase is mainly due to more annual forb species appearing. Asterisks (*) indicate significant differences (p=0.5) between pre-burn and post burn values for each functional group or species.



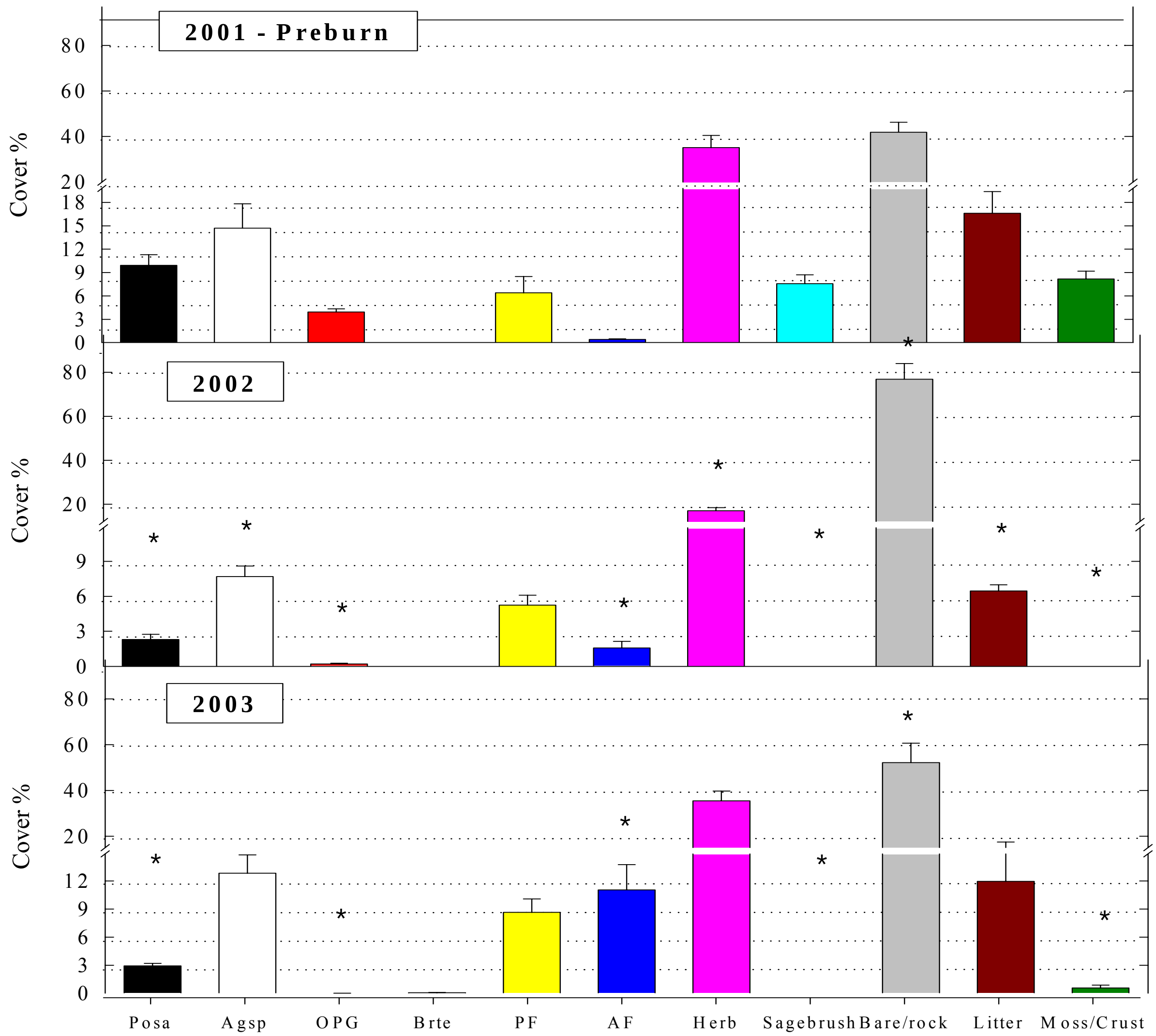
C. *Folly Farm Mid: Mid-seral bluebunch wheatgrass (north aspect)*

There was a significant decline in cover of Sandberg's bluegrass (Posa) and bluebunch wheatgrass (Agsp) the first year after fire. In 2003, bluebunch wheatgrass was about 60% of the pre-burn level. Perennial forbs (PF) have not returned to pre-burn levels. The perennial forb group in 2003 was mainly comprised of velvet lupine (mean = 4.4 $\pm$ 1.4 %) and western hawksbeard (mean = 2.25 + 0.1 %). Velvet lupine cover was half of pre-burn levels but western hawksbeard cover increased 4-fold after fire. Annual forbs (AF) increased significantly by the second year after fire (2003). Annual forbs were mainly composed of blue-eyed Mary (mean = 5.7 $\pm$ 2.6 %). Cheatgrass cover (<0.1%)has not changed since fire. Herbaceous species richness has not changed significantly after fire. Total number of species was 23 in 2001, 22 in 2002, and 21 in 2003. Asterisks (*) indicate significant differences (p=0.5) between pre-burn and post burn values for each functional group or species.



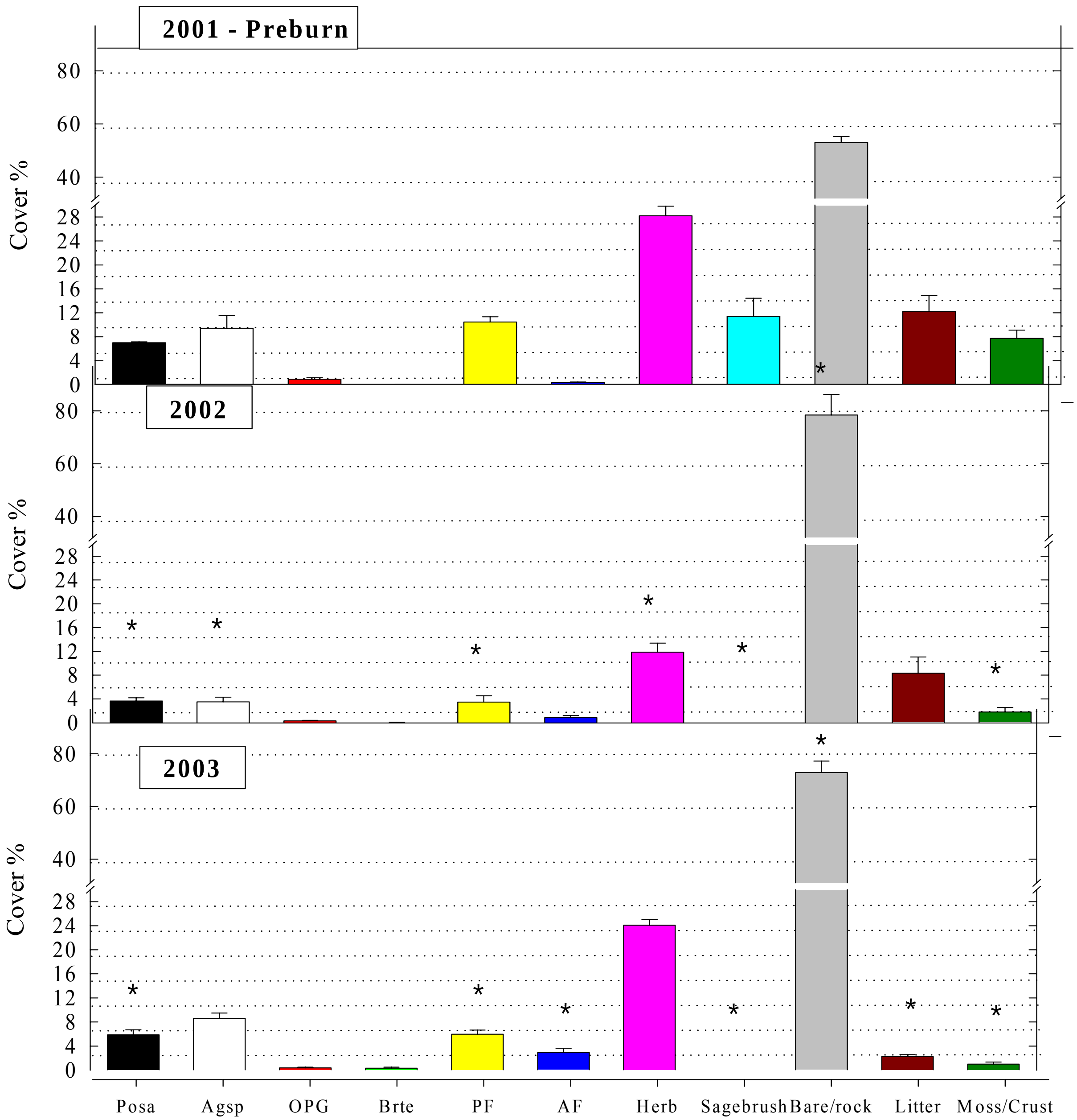
D. *Folly Farm C: High-seral bluebunch wheatgrass (north aspect)*

There was a significant decline in cover of Sandberg's bluegrass (Posa) and other perennial grasses (OPG) the first year after fire. In 2003, bluebunch wheatgrass (Agsp) was about 60% of the pre-burn level but remains significantly below pre-burn levels. Moss and crust were largely eliminated after fire. Perennial forbs (PF) cover has not returned to pre-burn levels. The perennial forb group in 2003 was dominated by taper-tip (*Crepis acuminata* Nutt.) and western hawksbeard (western and taper-tip hwksbeard, mean cover = 2.2 + 0.5 %). The decline in perennial forbs cover resulted from significant declines in mat-forming forbs, particularly Hood's phlox (*Phlox hoodii*). Cover of Hood's phlox declined from 6.5% to 0.5% after fire. Annual forb (AF) cover increased significantly by the second year after fire (2003). Annual forbs were mainly composed of blue-eyed Mary (mean = 3.4 $\pm$ 1.6 %). Cheatgrass cover (<0.1%) did not change in response to fire. Herbaceous species richness did not changed significantly after fire. Total number of species was 23 in 2001, 24 in 2002, and 24 in 2003. Asterisks (*) indicate significant differences (p=0.5) between pre-burn and post burn values for each functional group or species.



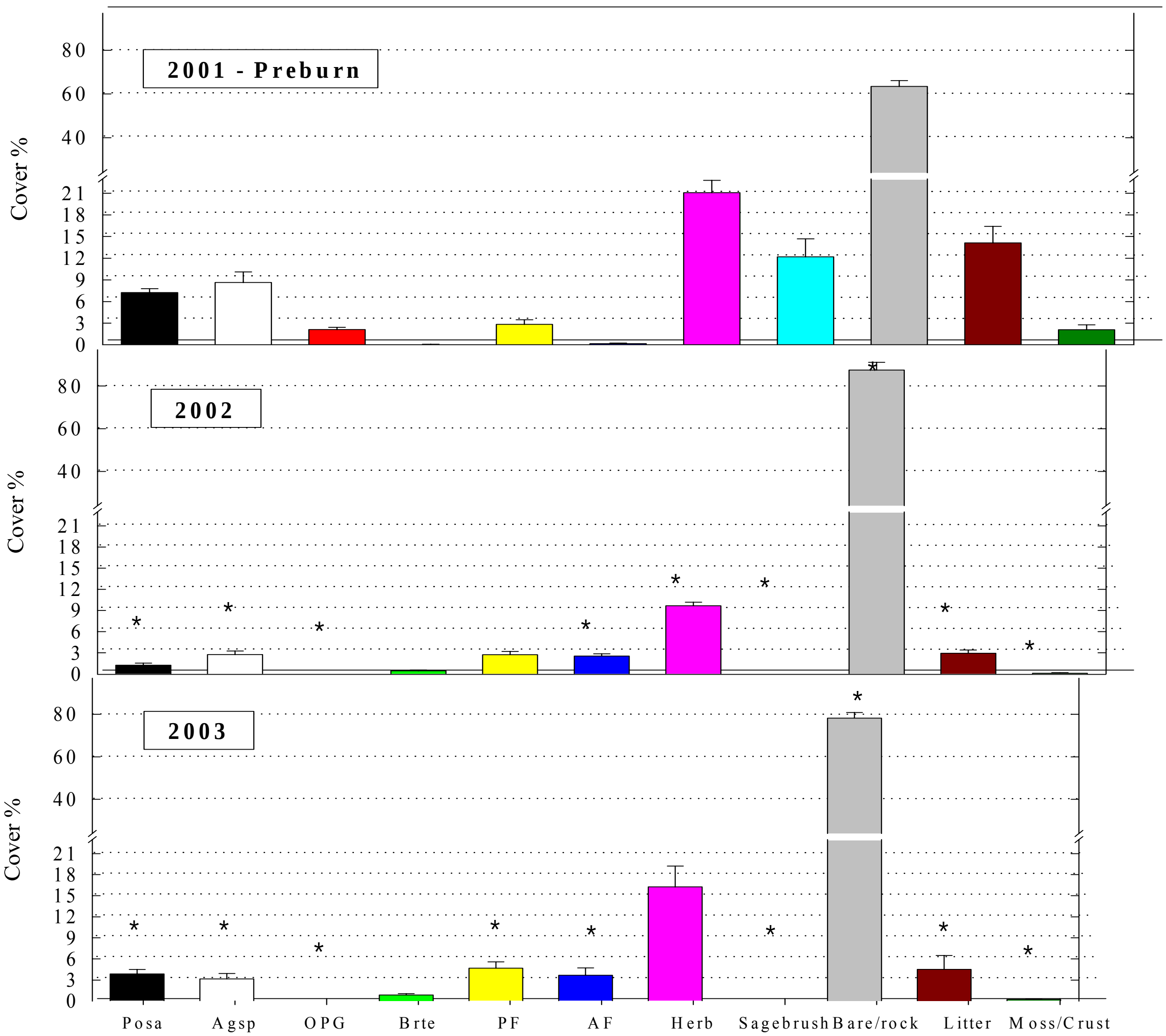
E. *Folly Farm D: High-seral bluebunch wheatgrass (north aspect)*

There was a significant decline in cover of Sandberg's bluegrass (Posa) and other perennial grasses (OPG) the first year after fire. By 2003, bluebunch wheatgrass (Agsp) was about 80% of the pre-burn level. Idaho fescue and Cusick's bluegrass were severely reduced by fire and have not recovered (pre-burn cover was about 3.8%). Moss and crust were largely eliminated after fire. Perennial forbs (PF) cover was greater than pre-burn levels after fire in 2003. Velvet lupine, western hawksbeard, low hawksbeard, long-lvd. hawksbeard, and taper-tip onion (*Allium acuminata* Hook.) increased significantly after fire. Annual forbs (AF) increased significantly by the second year after fire (2003). Annual forbs were mainly composed of blue-eyed Mary (mean = 9.9 $\pm$ 2.6 %). Cheatgrass cover (<0.1%)has not changed since fire. Herbaceous species richness initially increased the first year after fire as a result of greater annual forb diversity. Annual forb diversity fell in 2003 perhaps due to drought conditions. Total number of species was 24 in 2001, 29 in 2002, and 23 in 2003. Asterisks (*) indicate significant differences (p=0.5) between pre-burn and post burn values for each functional group or species.



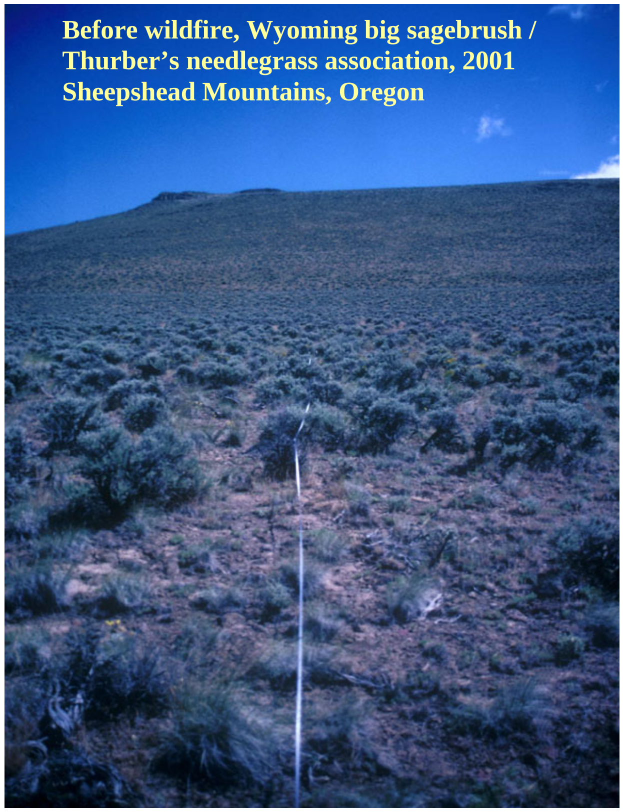
F. *Folly Farm F: High-seral bluebunch wheatgrass (west aspect)*

There were significant decline in cover of Sandberg's bluegrass (Posa) and bluebunch wheatgrass (Agsp) the first year after fire. By 2003, bluebunch wheatgrass was about 90% of the pre-burn level. Squirreltail has increased slightly after fire. Moss and crust were largely eliminated after fire. Perennial forbs (PF) cover was about half of pre-burn levels in 2003. The decline in perennial forbs cover resulted from significant loss of Hood's phlox. Cover of Hoods phlox declined from 5.9% to 0.3% after fire. There were slight increases in the cover of taper-tip hawksbeard and ba salt milkvetch (*Astragulus filipes* Torr.). Annual forb (AF) cover increased only slightly the second year after fire (2003) and included a variety of species. Cheatgrass cover (<0.1%) did not change in response to fire. Herbaceous species richn ess decreased significantly the first year after fire as a result of a decline in perennial and annual forb diversity. However, perennial and annual forb species increased back to pre-burn levels fell in 2003. Total number of species was 33 in 2001, 23 in 2002, and 32 in 2003. Asterisks (*) indicate significant differences (p=0.5) between pre-burn and post bu rn values for each functional group or species.

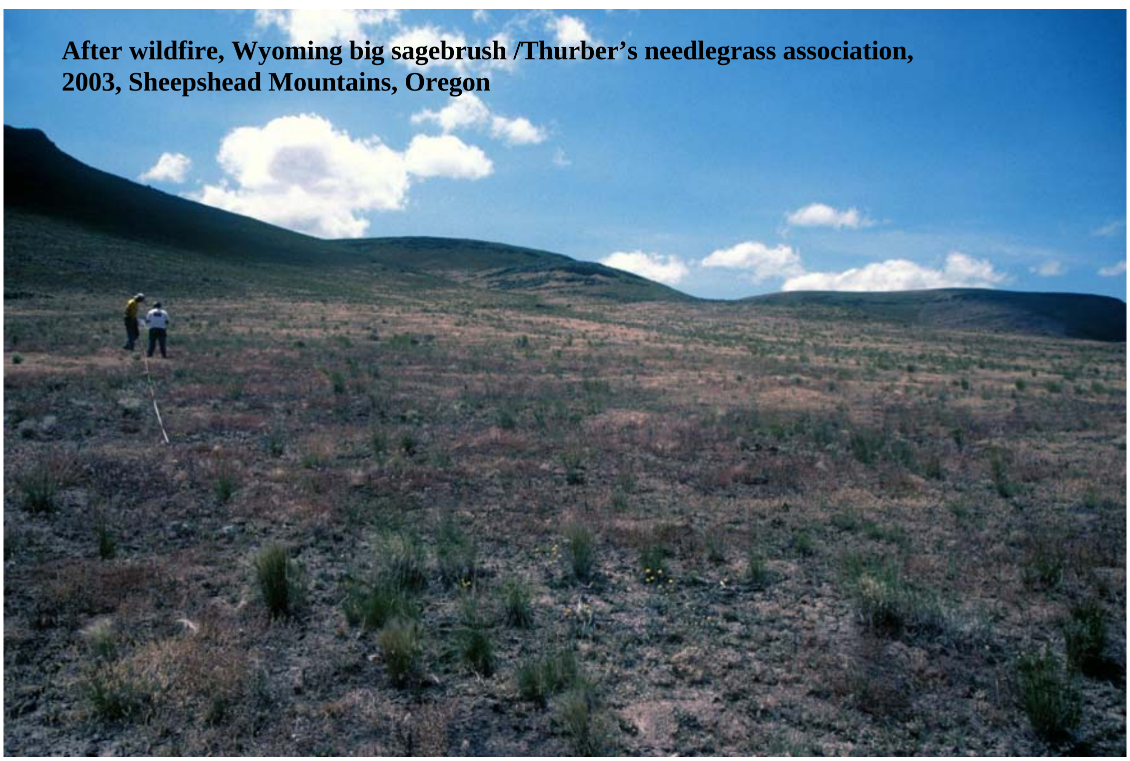


G. *Folly Farm E: High-seral bluebunch wheatgrass (south aspect)*

There were significant declines in cover of Sandberg's bluegrass (Posa), bluebunch wheatgrass (Agsp) and other perennial grasses (OPG) the first year after fire. Bluebunch wheatgrass cover was about 30% of pre-burn levels in 2002 and 2003. Both Thurber's needlegrass and bluebunch wheatgrass cover declined significantly. Needlegrass is present but cover declined 10-fold after fire. Moss and crust were largely eliminated after fire. Perennial forbs (PF) cover increased slightly after fire in 2003. This increase has been primarily due to higher cover values for western hawksbeard and low hawksbeard and long-leaf phlox. Annual forb (AF) cover increased the first year fire. Thread leaf phacelia (*Phacelia linearus* (Pursh) Holz.) was the dominant annual forb in 2002 and blue-eyed Mary was the dominant annual forb in 2003. Cheatgrass cover increased but was less than 1% in 2003. Herbaceous species richness decreased slightly the first year after fire as a result of a decline in perennial forb diversity. However, perennial forb species increased back to pre-burn levels fell in 2003. Total number of species was 33 in 2001, 29 in 2002, and 32 in 2003. Asterisks (*) indicate significant differences (p=0.5) between pre-burn and post burn values for each functional group or species.



Before wildfire, Wyoming big sagebrush / Thurber's needlegrass association, 2001 Sheepshead Mountains, Oregon



After wildfire, Wyoming big sagebrush /Thurber's needlegrass association, 2003, Sheepshead Mountains, Oregon

IV. Ongoing ecological research in the Wyoming big sagebrush alliance

Fire & Grazing in Wyoming Big Sagebrush Steppe, (Bates)

The purpose of this study is to assess grazing impacts to vegetation recovery after burning sagebrush grassland. Current management generally requires a minimum of two years of grazing rest after fire on sagebrush bunchgrass range. There is limited information regarding fire and grazing in the sagebrush steppe. We are investigating several grazing scenarios following fire to assess timing of grazing and effects to vegetation recovery. There will be five treatments applied; 1) no grazing and no fire; 2) fall grazing the 1st growing season after fire; 3) Spring grazing the 2nd growing season after fire; 4) Fall grazing the 2nd growing season after fire; and 5) spring grazing the 3nd growing season after fire . We hypothesize that; 1) dormant (late -summer/fall) grazing first two years after fire the will have little detrimental impact to understory plant recovery; and 2) spring grazing (May-June) within the first two years after fire will arrest or delay understory recovery. Plots were burned in September 2002. Grazing trials began in summer 2003.

Long–term Climate Effects to Vegetation Dynamics in the Wyoming Big Sagebrush Alliance (Bates, Miller, and Davies)

Land managers also face a significant challenge in separating the effects of management from that of climate variability. This becomes particularly important in making ecological assessments and detecting trends in rangeland condition. We are evaluating effects of long term interannual weather variability on Wyoming big sagebrush community composition, cover, production, and structure. A total of 35 sites scattered across eastern Oregon are being revisited over a 10-year period (2003-2012). We are cataloging perennial and annual forb dynamics (production, density, and cover by species and production of perennial and annual forbs) as affected by annual weather patterns. In the first two years of the study we have documented substantial variation in productivity and composition across all sites, particularly forb production, cover, and density (EOARC file data). The timing of precipitation appears to have a major influence on forb abundance.

Functional Role of Wyoming Big Sagebrush (Davies, Bates, and Miller)

We are currently investigating the functional role of Wyoming big sagebrush within a plant community. Of particular interest is whether Wyoming big sagebrush is facilitating or competing with associated plant species and how these interactions vary spatially and temporally. Wyoming big sagebrush has been viewed as an undesirable plant because it was viewed as a direct competitor with forage plant species. We are comparing vegetation and environmental characteristics under sagebrush canopies (subcanopy) to those of the area between sagebrush plants (interspaces). We are also comparing some of the characteristics of these areas to those of former subcanopy and interspace areas in a recent burn (fall 2002) and an older burn (fall 1993).

Preliminary results suggest on harsher (hotter and drier) sites environmental modification under sagebrush plants may benefit associated plant species. On these sites, perennial grass and forb cover was greater under sagebrush plants than between them. On more mesic Wyoming big sagebrush sites, there appears to be little or no difference in perennial grass and forb cover between the two areas. In 2003, relative humidity was higher, temperatures were mediated, solar radiation was less, total soil carbon and nitrogen were higher, and soil moisture (at least early in the growing season) was greater under sagebrush plants than between them. Further analysis will investigate if vegetation and soil differences in subcanopy and interspace areas remain after sagebrush is removed with fire. Further data collection and analysis will also validate or refute preliminary results. Community vegetation and resource capture differences will also be investigated between the burned and unburned sagebrush stands.

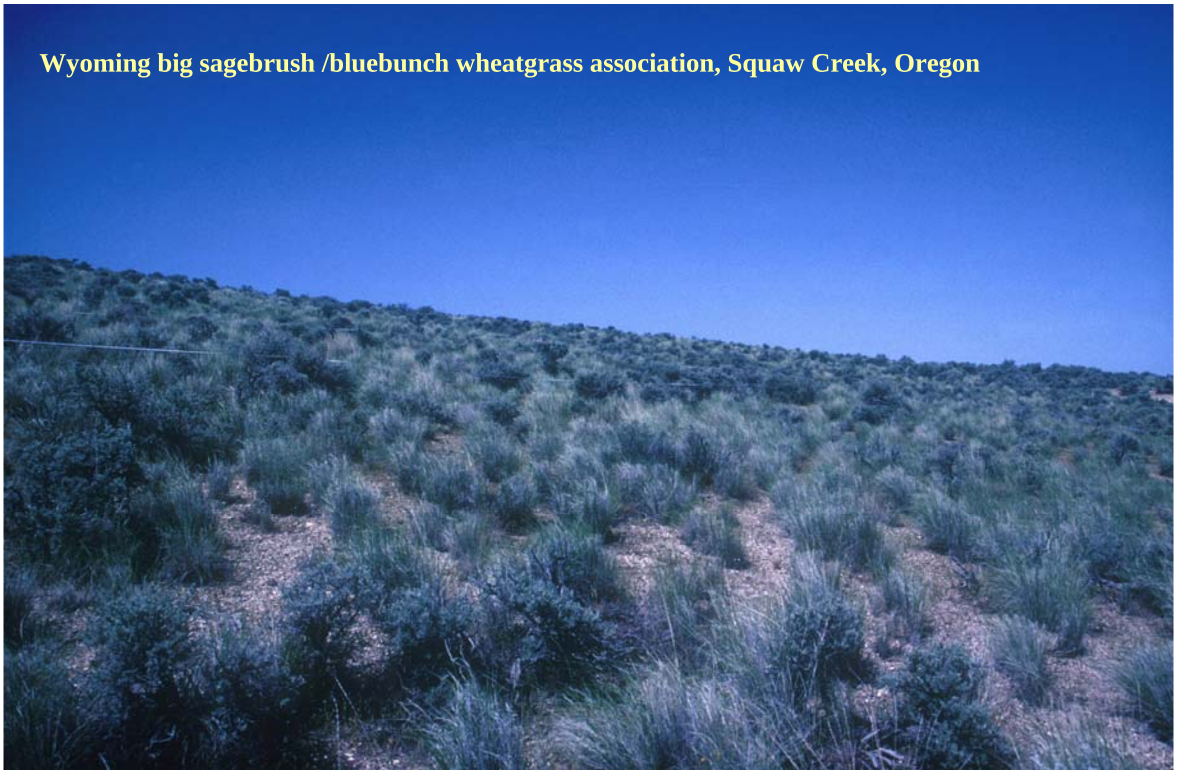
Fire Impacts to Productivity in Wyoming Big Sagebrush Steppe (Bates, Svejcar)

We are evaluating the effects of fire to sagebrush steppe productivity. For 6 years we have monitored production of the main plant functional groups every 2 weeks during the growing season on burned and unburned sagebrush steppe. By clipping frequently we have been able to track current year's production trends and develop a better understanding of how peak production fluctuates at the community and functional group (e.g. perennial grasses, perennial forbs) level. The burn increased herbaceous production when compared to the unburned treatment and there was a flush of forb production (EOARC file data). The results indicate that disturbance is important at temporarily increasing availability of forbs in the sagebrush steppe.

Fire Effects to Plant and Arthropod Diversity (Rhodes, Bates)

Fire historically had an important role in development of sagebrush steppe communities by reducing the abundance of woody plants and increasing productivity and abundance of herbaceous species. In the Wyoming big sagebrush alliance fire return intervals are estimated to have been between 50 to 100 years. A species of major concern in this alliance is the status of the sage grouse. Burning of Wyoming big sagebrush communities is of major concern to wildlife biologists because of potential negative effects to sage grouse populations. There has been increased research focus on the effects of fire and management in remaining intact Wyoming big sagebrush communities. Much of the recent research in Wyoming big sagebrush has tended to focus on sage grouse habitat or dietary requirements. However, there is conflicting evidence as to the importance of fire in Wyoming big sagebrush communities for increasing forb production important in sage grouse diets. A deficiency of many studies assessing fire in Wyoming big sagebrush is that they have tended to focus on select response variables such as specific forbs used in sage grouse diets. There has been little information provided on overall community dynamics especially with regards to plant species diversity. Investigations of disturbance affects to dietary invertebrates have also been limited in sage grouse studies with regards to their spatial abundance. Sagebrush plant communities are structurally complex which likely influences diversity and abundance of invertebrates. The purpose of this study was to assess effects of burning to plant diversity, cover, productivity and density, and insect abundance in a Wyoming big sagebrush plant community. In addition, results elsewhere suggest that traditional range inventory methods, such as Daubenmire transects, underestimate species diversity and may miss exotic species that pose a threat to community integrity following disturbance. They have consequently recommended adoption of a Modified-Whitaker plot to improve diversity assessments and improve monitoring of rare species. In this study plant diversity will be assessed by comparing Daubenmire transects and Modified-Whitaker plots.

Wyoming big sagebrush /bluebunch wheatgrass association, Mule Tit, Oregon



Wyoming big sagebrush /bluebunch wheatgrass association, Squaw Creek, Oregon