ESTABLISHMENT OF AERIALLY SEEDED BIG SAGEBRUSH FOLLOWING SOUTHERN IDAHO WILDFIRES

by

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INTRODUCTION

In the western United States, big sagebrush (*Artemisia tridentata*) steppe communities dominate approximately 60 million ha (148 million acres) and comprise the largest vegetation type (Wambolt and Hoffman 2001). However, due to the invasion of exotic plants, fire has become a driving force in the ecology and management of sagebrush steppe communities.

Very little empirical analysis has examined the efficacy of aerial broadcasting big sagebrush seed following fire. At the district and field office levels, monitoring is conducted on a project by project basis, and study results are often unknown or unavailable beyond the office that conducted the project (McArthur 2004).

The objectives for this portion of the study were to investigate on seeded and unseeded post-fire communities (1) Wyoming big sagebrush (*A. t.* ssp. *wyomingensis*) establishment and persistence, and (2) the composition of big sagebrush subspecies. Additional information on other studies conducted can be found in the M.S. Thesis "Post-Fire Establishment of Vegetation Communities Following Reseeding on Southern Idaho's Snake River Plain", and is available online at <http://www.fire.blm.gov/gbri>.

Study Area

The general study area was located on the Snake River Plain of southern Idaho. Thirty-five BLM fire rehabilitation projects were selected for this study (Appendix A). Individual study sites occurred across an elevational gradient ranging from 810 to 1,640 m (2657 to 5380 ft.). Average annual precipitation ranged from about 150 to 300 mm (6 to 12 in.). Pre-fire native vegetation throughout the general area was typically dominated by Wyoming big sagebrush and a variety of perennial bunchgrasses.

Wildfires occurred between 1987 and 2000. Post-fire aerial seeding of big sagebrush occurred during the months of November through March. The number, composition, and rate of species sown per rehabilitation project varied. In addition to Wyoming big sagebrush, the most commonly seeded species were common yarrow (*Achillea millefolium*), crested wheatgrass (*Agropyron cristatum*), thickspike wheatgrass (*Elymus macrourus*), Siberian wheatgrass (*Agropyron fragile*), fourwing saltbush (*Atriplex canescens*), Russian wildrye (*Psathyrostachys juncea*), forage kochia (*Kochia prostrata*), blue flax (*Linum perenne*), and alfalfa (*Medicago sativa*).

Sampling Methods

Each of the 35 study sites (Fig. 1) contained a seeded treatment and an unseeded control. Idaho BLM Fire Rehabilitation Plans (1987-2000; USDI 2002) were used to identify prospective study sites. Sites selected had been aerially seeded with Wyoming big sagebrush and drill seeded with a variety of other native and introduced species. The chosen sites included areas within the burn perimeter that were not seeded and were representative of the vegetation and soils within the Snake River Plain. Control plots did not have an aerial or drill seeding treatment. Paired plots were located on areas with similar elevation, slope, vegetation, and soil. Vegetation sampling occurred from May through August 2002 and 2003.

At each study site, a 100-m baseline transect was randomly located within each of the seeded and control plots. A buffer zone of 30-m was established from the burn perimeter to ensure sampling of only aerially seeded sagebrush stands and not naturally regenerating stands. Five 20-m belt transects were positioned perpendicular to the 100-m baseline. Shrub canopy coverage was measured along each of the 20-m transects using line-intercept to obtain percent aerial cover (Canfield 1941). Shrub density was determined by counting the number of individuals rooted within each of the five 2 by 20-m plots.

Subspecies of sagebrush was determined using both morphological and chemical characteristics. Confirmation of big sagebrush subspecies was determined in the laboratory using a longwave ultraviolet (UV) light.

Analysis

The nonparametric Kruskal-Wallis test was used to investigate the impact of seeding on shrub density and cover (Minitab 1997). Kruskal-Wallis is a nonparametric test that looks at medians instead of means. This test was used in place of an ANOVA because the data did not meet the necessary assumptions of ANOVA (Levene's Test) possibly due to the high number of zeros present in the data. Regression analysis was used to determine whether the mass (kg ha^{-1}; lbs $acre^{-1}$) of Wyoming big sagebrush pure live seed (pls) applied during seeding influenced the density of shrubs on the seeded plots.

RESULTS

Shrub Density

The average density of sagebrush was higher on the seeded plots, but ranged from 0 to 40,300 shrubs ha^{-1} (0 to 16,309 shrubs $acre^{-1}$). One plot, Crimson Clover, had an exceptionally high number of shrubs (40,300 shrubs ha^{-1}/ 16,309 shrubs $acre^{-1}$). The data from this plot was examined and excluded from the data analyses as an outlier and also due to the possibility that portions of the project were seeded at a much higher rate than normal. Without this plot, the density of sagebrush on the seeded plots ranged from 0 to 3,800 shrubs ha^{-1} (0 to 1,538 shrubs $acre^{-1}$). Control plots had densities ranging from 0 to 1,000 shrubs ha^{-1} (0 to 405 shrubs $acre^{-1}$). Seeded plots had an average density of 530.8 shrubs ha^{-1} (215 shrubs $acre^{-1}$), whereas shrub density on control plots was 92.6 shrubs ha^{-1} (37 shrubs $acre^{-1}$; Figs. 2 and 3). The difference in sagebrush densities was not significant between aerial seeded and control plots ($P>0.05$). The establishment of aerially applied big sagebrush seeds was very low. In fact, shrubs failed to establish on

23 of the 35 fire rehabilitation projects sampled. Conversely, natural regeneration occurred on more than one-quarter of the unseeded, control plots.
By comparison, unburned big sagebrush stands in southern Idaho had densities ranging from 494 to 31,778 shrubs ha^{-1} (200 to 12,860 shrubs $acre^{-1}$), and an average shrub density of 12,538 shrubs ha^{-1} (5,074 shrubs $acre^{-1}$).

Sagebrush Cover

As with sagebrush density, average shrub canopy cover was greater on seeded plots (0.25%) compared with control plots (0.05%), but this difference was not significant (Fig. 4). Although the cover of sagebrush was greater on seeded plots, the number of plots with shrubs (12 of 35 plots) and the average cover values obtained were extremely low.

Application Rate

There was not a significant relationship between the application rate of sagebrush pure live seed (pls) and shrub density (Fig. 5). This may be due to the low number of plots sampled that had shrubs present and the lack of accurate pls data for a number of plots. The plots sampled in the present study generally had low seeding rates, ranging from 0.04 to 0.56 kg pls ha^{-1} (0.04 to 0.50 lbs $acre^{-1}$). For perspective, approximately 220,062 to 2,755,780 seeds ha^{-1} (89,056 to 1,115,226 seeds $acre^{-1}$) were broadcast seeded on plots sampled in this study. If only 1% of these sagebrush seeds had established, potential shrub densities could have ranged from approximately 2,200 to 27,558 shrubs ha^{-1} (890 to 11,152 shrubs $acre^{-1}$). Consequently, even with the application of large amounts of seed, sagebrush failed to establish on more than half of the seeded plots sampled, and established shrub densities were very low.

Sagebrush Subspecies

The results of the morphological and UV light confirmation of sagebrush indicate a mixed composition of subspecies (Fig. 6). Of the 35 seeded sites sampled, 12 sites had shrubs present. Four of these sites had only one subspecies, Wyoming big sagebrush, present in the samples collected. The samples obtained from another four sites contained Wyoming big sagebrush with a mixture of other subspecies, and an additional four sites contained basin big sagebrush (*A. t.* ssp. *tridentata*) and mountain big sagebrush (*A. t.* ssp. *vaseyana*), but did not contain any Wyoming big sagebrush.

It was a surprise to see the high occurrence of basin and mountain big sagebrush since, according to rehabilitation records, all 35 sites were seeded with Wyoming big sagebrush. One potential explanation is that these sites supported other sagebrush subspecies prior to burning and new plants established as a result of seeds present in the soil seedbank. Another, more plausible explanation is that the purchased seed contained a mixture of sagebrush subspecies, even though BLM contracted with private suppliers to purchase only Wyoming big sagebrush seed. The application of the appropriate sagebrush subspecies is essential because the long-term survival of other seeded subspecies may not be sustainable on Wyoming big sagebrush sites.

MANAGEMENT CONSIDERATIONS

Types of seeding treatments can have a strong influence on the emergence and survival of big sagebrush seedlings. On most fire rehabilitation projects in Idaho, Wyoming big sagebrush seed is aerially broadcast over the soil surface in the fall or winter. This method is used because large areas can be seeded quickly and some successful shrub establishment has occurred. However, the results from this study indicate that the aerially seeding of Wyoming big sagebrush resulted in very limited shrub establishment, at least on the sites chosen for this study.

Several alternative seeding methods should be considered in lieu of aerial seeding Wyoming big sagebrush. Seeding equipment that compacts the soil surface, such as cultipacking, chaining, and imprinting, can increase big sagebrush seedling establishment. Monsen and Meyer (1990) obtained significantly higher initial seedling emergence with the Oyer compact row seeder, a device that compacts the soil and then presses the seed onto the surface. Intermediate seedling emergence results were achieved using the Brillion cultipacker seeder (Monsen and Meyer 1990). With this device, the seed is broadcast over the surface and followed by cultipacking, which places the seed in contact with the soil and positions the seed near the soil surface (Pyke 1994). BLM's Lower Snake River District achieved successful sagebrush establishment using a seeder that incorporated a fertilizer spreader, chain or drags, and a vine-roller cultipacker (Boltz 1992). Greater sagebrush establishment has also been achieved by broadcasting big sagebrush seed onto the soil surface, followed by a land imprinter (Monsen 1988). This method produced significantly greater establishment compared with broadcast seeding, rangeland drilling, cultipack seeding, and disk chaining (Monsen 1988). Land imprinting forms a regular pattern of microdepressions on the soil surface, which aids in seed burial, seed-to-soil contact, moisture retention, seed germination, and survival (Haferkamp et al. 1987).

Another option for establishing big sagebrush is to transplant bareroot seedlings or containerized stock. These are typically transplanted only in small, critical areas due to the high cost. Planting stock between 12 to 20 cm tall are transplanted in early spring (McArthur et al. 1995). First year survival rates for transplanted stock are often 80 percent or higher (Welch et al. 1992). A similar method, the "mother plant" technique, combines transplanting and natural seed dispersal. The "mother plants" are planted as bareroot or containerized stock on key locations throughout the rehabilitation site. Within 3 to 5 years established transplanted "mother plants" mature, disperse seed, and provide an established seed source for unseeded areas (Welch et al. 1992). Although transplanting is regarded as costly, this expense could be acceptable considering the cost of broadcast seeding and the current lack of sagebrush establishment using this method. Due to the prevalence of exotic annual grasses, however, caution must be exercised and additional measures may need to be taken in order to reduce the abundance of exotic annuals and the probability of a burn following transplanting.

Another alternative is to aerial seed big sagebrush into established stands of native grasses. The success of this alternative could be explored by letting the post-fire recovery of native species occur for one year and then seeding big sagebrush into the established grass stands. Studies have shown that stands of native bunchgrasses permitted big sagebrush recruitment, but suppressed cheatgrass (Frischknecht and Bleak 1957, Booth et al. 2003). Further research could then investigate the establishment, persistence, reproduction, and rate of spread of big sagebrush in the native grass stands.

Fire rehabilitation projects where big sagebrush (and other species) are planted should be designed to include one or more unseeded controls of 2 to 4 ha (5 to 10 acres). This would promote comparisons of seeding success with natural recruitment from plants present on the site prior to the wildfire. Grazing exclusion studies are also recommended on seeded and unseeded plots to determine the effects of livestock use on natural plant recovery and seeding establishment. These studies require construction and maintenance of livestock exclosures on selected rehabilitation projects. Kaltenecker and Wicklow-Howard (1997) found that seeding competitive introduced wheatgrasses had a more adverse effect on sagebrush establishment than livestock grazing. Ultimately, the success of future wildland fire rehabilitation depends on the initiation and dedication to conduct monitoring and scientific studies, and the sharing of these findings.

This study showed some shrub recruitment on the seeded plots however, the mixed composition of big sagebrush subspecies at both the seeded and control plots requires further investigation. The application of the appropriate subspecies is essential because sagebrush seedling persistence is dependent upon initial establishment (McArthur et al. 1995), growth rate (Welch and McArthur 1984), habitat (Winward and Tisdale 1977), and moisture (Barker and McKell 1983, Kolb and Sperry 1999), temperature (Harniss and McDonough 1975), and germination requirements (Meyer 1994). Non-adapted seeds may respond differently to normal germination cues and germination may occur at an inappropriate time, resulting in seeds that fail to germinate or persist (Meyer and Monsen 1990). Locally adapted or source-identified seedlots matched to the treatment site, will increase the potential for successful shrub establishment (McArthur et al. 1995, Meyer 2003, Meyer and Monsen 1992).

CONCLUSION

In this study, the high variability in cover and density of shrubs indicates the complexity of factors influencing recruitment and establishment of sagebrush from both natural populations and from artificial seeding. The resulting low cover values combined with the low shrub densities indicates that aerially seeding big sagebrush is not a reliable, effective seeding method, at least in the sites chosen for this study. This is not to say however, that aerially seeding big sagebrush is never successful and a few sites were found where the seeding had clearly been successful. However, in order to increase big sagebrush establishment, it is imperative that other seeding methods be considered, utilized, monitored, and evaluated in comparison with the commonly used aerial seeding technique. It is also important that the appropriate big sagebrush subspecies is purchased and applied on all burned areas. In addition, the use of more local sources of big sagebrush seed is also recommended.

If current sagebrush restoration efforts do not result in a more consistent establishment and persistence of this important shrub, large areas of sagebrush-steppe may be lost, and rehabilitation may no longer be a viable option (West 2000).

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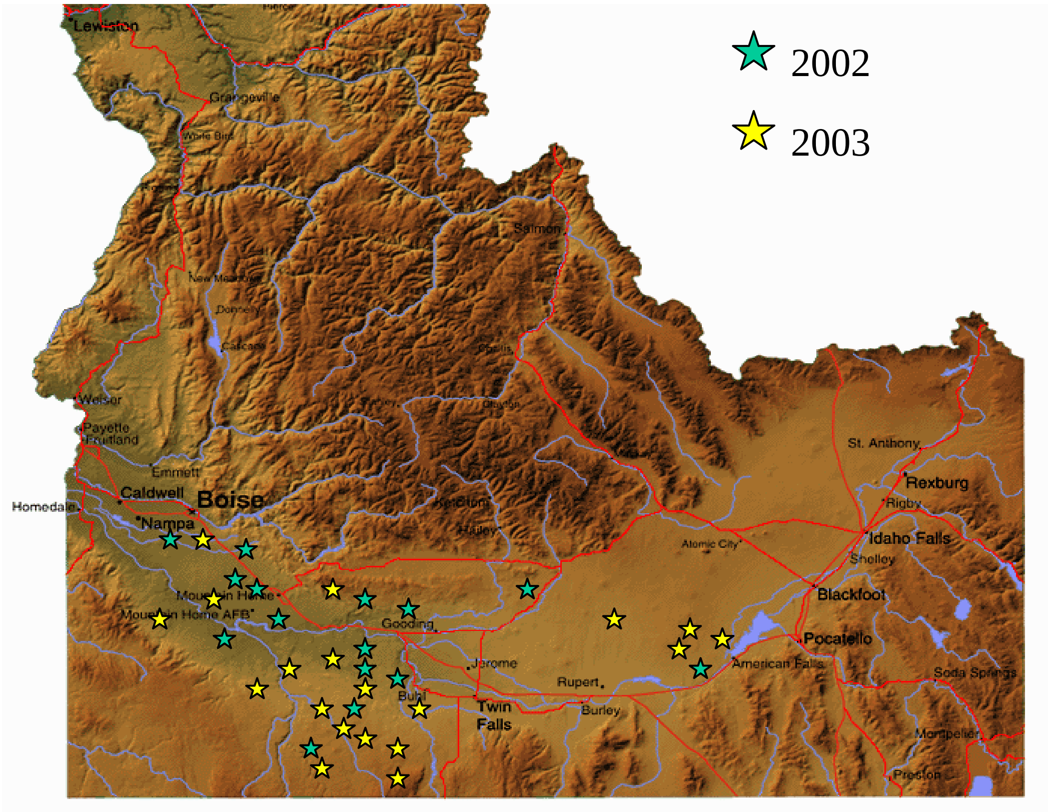

Figure 1. Map showing the distribution of individual study sites for 2002 and 2003.

Figure 2. Photograph showing the seeded site, Kinzie Butte (Shoshone Field Office). This site was seeded in 1995 and had an average big sagebrush density of 850 shrubs ha^{-1} (344 shrubs $acre^{-1}$).

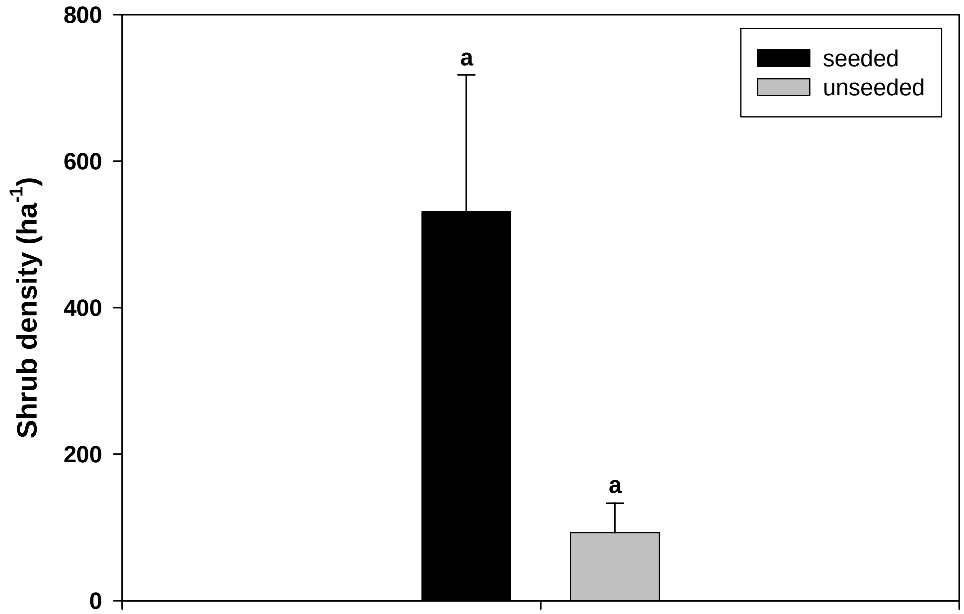

Figure 3. Mean shrub density for seeded and unseeded plots (N=34).

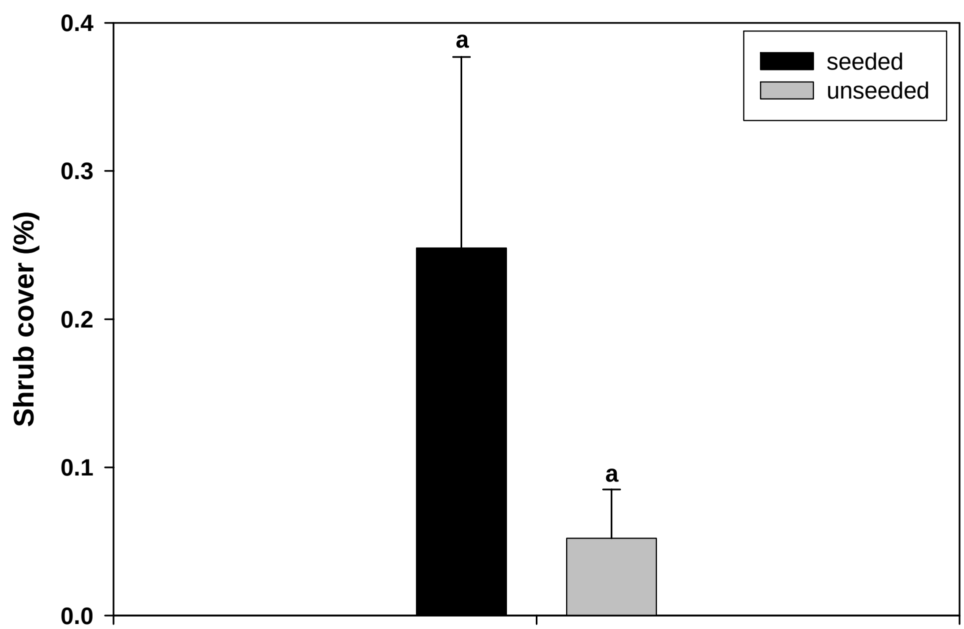

Figure 4. Mean shrub cover for seeded and unseeded plots (N=34).

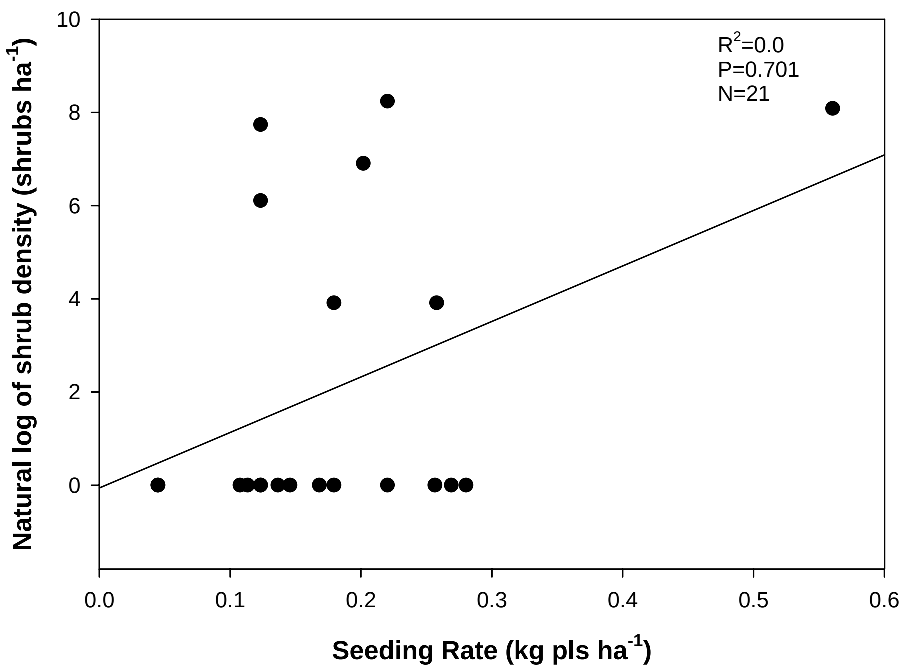

Figure 5. Seeding rate (kg pure live seed ha^{-1}) of Wyoming big sagebrush with the natural log of shrub density ha^{-1} (N=21).

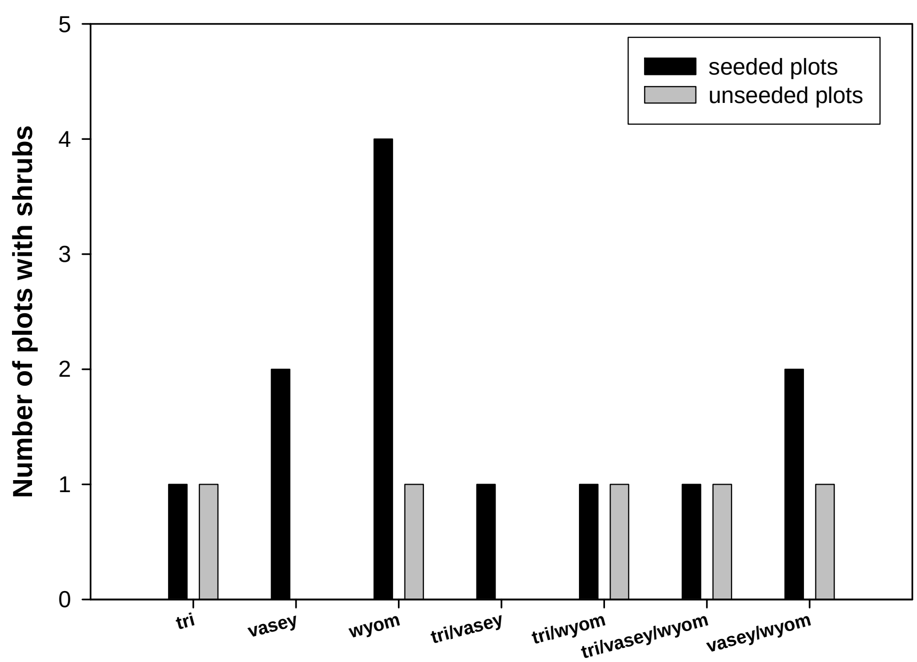

Figure 6. The distribution of big sagebrush subspecies on seeded (N=12) and unseeded (N=5) plots with shrubs. Subspecies abbreviations are tri=tridentata, vasey=vaseyana, wyom=wyomingensis. Based on belt transect UV light data.

APPENDIX A

Seeded Study Site Descriptions

Study Site	Fire Month	Fire Year	Seeding Month	Seeding Yr.	Latitude N	Longitude W	Ecol. Site (BLM)	Elev. (m)	Climate Stat.
Beet Dump	June	1986	November	1986	42º59.692'	115º38.619'	Loamy 8-10	884	Glenns Ferry
Belle Mare	July	2000	January	2002	43º02.297'	115º07.106'	Loamy 8-10	995	Mountain Home
Calf Creek	August	1997	January	1999	43º02.901'	114º57.851'	Churning clay 8-12	1041	Mountain Home
Cinder Cone	June	1987	November	1987	43º10.088'	115º58.310'	Loamy 8-10	921	Mountain Home
Clover Complex	July	1995	February	1996	42º30.565'	115º29.959'	Loamy 8-10	1296	Buhl 2
Coffee Point	July	2000	Unavailable	2000	43º13.097'	112º48.282'	Loamy 8-12	1411	Idaho Falls 46W
Cove	August	1996	February	1997	42º55.940'	115º56.136'	Sandy Loam 8-12	860	Bruneau
Crater II	June	1987	November	1987	43º11.457'	115º49.023'	Loamy 8-10	959	Mountain Home
Crimson Clover	August	2000	February	2001	42º34.035'	115º17.245'	Loamy 8-10	1282	Castleford 2N
Flat Broke	June	2000	February	2001	42º40.483'	115º47.421'	Sandy Loam 8-12	1074	Castleford 2N
Goat	August	1998	February	2000	43º01.519'	115º07.782'	Loamy 8-10	925	Mountain Home
Grass	August	2000	February	2001	42º13.616'	115º03.664'	Loamy 7-10	1638	Castleford 2N
Greys Landing	July	1989	Unavailable	1989	42º09.990'	114º43.795'	Loamy 8-12	1521	Hollister
Hawley	July	1994	February	1995	42º46.875'	113º19.365'	Loamy 8-12	1352	Minidoka Dam
Indian Allotment	July	1995	February	1996	42º55.995'	114º52.2778'	Loamy 8-12	1001	Hagerman 2SW
Indian Creek	August	1999	January	2001	43º23.791'	116º01.797'	Loamy 10-12	1012	Boise 7N
Indian Ridge	September	1997	February	1998	42º39.819'	115º01.369'	Sandy loam 8-10	1133	Castleford 2N
Initial Point 1987	June	1987	November	1987	43º20.631'	116º28.538'	Silty loam 7-10	814	Deer Flat Dam
Initial Point 1995	July	1995	January	1996	43º20.694'	116º19.312'	Loamy 8-10	857	Boise 7N
Kinyon	June	2000	March	2001	42º23.435'	115º01.038'	Loamy 8-10	1369	Castleford 2N
Kinzie Butte	July	1994	January	1995	43º05.152'	114º19.179'	Claypan 11-13	1394	Richfield
Laidlaw	August	1995	February	1996	43º02.905'	113º48.102'	Loamy 8-12	1390	Minidoka Dam
Little Big	August	1999	November	1999	42º36.861'	115º39.016'	Loamy 8-10	1155	Castleford 2N
Mule Butte	August	1999	February	2000	42º58.333'	113º24.957'	Loamy 8-12	1407	Paul 1ENE

Study Site	Fire Month	Fire Year	Seeding Month	Seeding Yr.	Latitude N	Longitude W	Ecol. Site (BLM)	Elev. (m)	Climate Stat.
Notch Butte	July	1997	February	1997	42°40.980'	115º08.935'	Loamy 8-10	1005	Hagerman 2SW
Point	July	1995	January	1998	43°25.687'	116°24.143'	Loamy 8-10	847	Deer Flat Dam
Rattlesnake Cmplx	June	1996	February	1997	43°02.948'	115°45.412'	Loamy 8-10	941	Mountain Home
RRMP416	September	1993	February	1994	43°13.585'	115°51.365'	Loamy 8-10	976	Mountain Home
Swiss Valley	July	1995	Unavailable	1996	42°55.138'	115°06.988'	Loamy 8-10	900	Hagerman 2SW
Three Creek Well	August	1995	January	1996	42°17.672'	115°22.721'	Loamy 10-13	1554	Buhl 2
Twin Butte	July	1995	February	1996	42°45.593'	115°03.481'	Loamy 8-10	1068	Bliss 4NW
Wedge Butte	July	1999	February	2000	43°15.875'	114°16.893'	Loamy 11-13	1514	Picabo
Whiskey Butte	June	1999	February	2000	42°52.320'	113°28.780'	Loamy 8-12	1341	Paul 1ENE
Wintercamp	August	1996	February	1997	42°33.004'	115°33.546'	Loamy 8-10	1225	Castleford 2N
Woodtick	August	1997	January	1999	42°55.910'	115°02.641'	Loamy 7-10	941	Hagerman 2SW