AN ABSTRACT OF THE THESIS OF

Ted O. McArthur for the degree of Master of Science in Rangeland Resources presented on February 20, 2004.
Title: Emergency Fire Rehabilitation of BLM Lands in the Great Basin: Revegetation & Monitoring.

Abstract approved:

David A. Pyke

The Bureau of Land Managements (BLM) Emergency Fire Rehabilitation (EFR) policy was developed in 1985 to encourage protection of sites from soil erosion and to minimize potential changes in vegetation communities that may result from the dominance of weedy species. To achieve the goals of EFR policy, managers often used introduced perennial grasses that established quicker and competed better with introduced annuals than did native plants. However, the change of sagebrush-grass communities to communities dominated by introduced forage grasses has led to concerns for wildlife habitat. This concern contributed to a policy change encouraging the use of native species, when available, for rehabilitation projects.

This study attempts to assess the effectiveness of BLM EFR projects in meeting the stated goals of the BLM EFR policy in the Great Basin. To do this, two field offices per state were randomly selected from an inclusive list of all Great Basin field offices. In 2001, we randomly selected three EFR projects per field office from those projects that used native species. On each project site, we used a common monitoring technique in association with monitoring techniques implemented by the BLM to assess if national EFR objectives were being met.

A semi-structured survey was developed to determine the potential reasons why native and introduced plants were either used or not used, why monitoring was and was not proposed, and whether monitoring was implemented in rehabilitation projects.

BLM monitoring techniques did not adequately evaluate EFR goal achievement. The time it took to implement any of the BLM methods did not differ significantly from the time needed to implement the common protocol on the two projects where BLM had implemented monitoring and used native plants ($F_{3,12} = 1.63$, $P = 0.23$). Cost to implement the common monitoring technique was minimal and it directly measured aspects of stated EFR policy goals.

Vegetative cover of all natives, seeded and volunteers, contributed half of the overall cover on EFR projects and was significantly higher than sown introduced species. Invasive species were intermediate and did not differ significantly from either the natives or the introduced. The seeded species were a subset of the native or introduced classes. Composition by cover between sown native, sown introduced, and invasive species did not differ significantly. Vegetation cover increased the surface soil stability 39% of the time and subsurface stability 56% beneath the vegetation.

Respondents of the survey stated that they generally use more natives and more complex seed mixtures than they did historically. Many also stated that they prefer to use native over introduced species. However, most felt that introduced species are more effective in meeting EFR goals on the degraded sites than native species. All respondents would like to access a summarized report of other rehabilitation projects. The respondents were split between accessing it through the

World Wide Web or through a written report. We believe that a common database could be created and maintained on the World Wide Web if a common sampling protocol was implemented.

Emergency Fire Rehabilitation of BLM Lands in the Great Basin: Revegetation & Monitoring

by

Ted O. McArthur

A THESIS

Submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Presented February 20, 2004
Commencement June 2004

Master of Science thesis of Ted O. McArthur presented on February 20, 2004.

APPROVED:

Major Professor, representing Rangeland Resources

Head of Rangeland Resources Department

Dean of Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Ted O. McArthur, Author

ACKNOWLEDGEMENTS

I would like to thank Dr. David A. Pyke for taking the chance and giving me the opportunity to work on this project. Dr. Pyke has encouraged and mentored me through this entire process and I am grateful for it. I would also like to thank my committee members. Dr. Bruce Shindler was very helpful in developing the survey aspect of this study, and also has been a great asset when writing about the survey and our conclusions. I am grateful for Dr. Lee Eddleman and his input into this research and for his expert tutelage in the field of Rangeland Ecology. I learned a great deal in his classes.

The project was made possible through the support of the BLM. I would like to specifically thank Mike Pellant and Tom Roberts for their interest and input into this research. The field managers that I interviewed and worked with on getting site-specific information were professional and courteous. Without their cooperation it would have been difficult to accomplish this work.

I am also grateful for the assistance of Eric Toman, Rob Williams, and Kirsten Edwards for their assistance in development of the survey instrument. I have had a lot of support and assistance from many of my friends in the Rangeland Resources Department at Oregon State University.

I was fortunate to have two outstanding field technicians Kara Hempy and Michelle Parde.

My parents have been a great influence on me throughout the years. Gardening with my Mother, and tagging along with my Father on many of his research projects has led me to my interest and desire to work in the field of ecology. My father is the person who taught me that by doing things you love you can accomplish great things.

And finally I would like to thank my wife Cindy and my son Kai. With their support and encouragement I was able to accomplish this work. Cindy made an excellent pinch field technician. She has been my inspiration and guiding light in this research and in our life together.

CONTRIBUTION OF AUTHORS

Dr. David A. Pyke and Dr. Bruce Schindler were involved with the design and analysis of this research as well as the writing of this manuscript.

TABLE OF CONTENTS

LIST OF FIGURES

Figure | Page

LIST OF TABLES

INTRODUCTION

Fire is a natural phenomenon of many arid and semi-arid ecosystems within the western United States. More frequent fires favor the dominance of herbaceous plants, whereas less frequent fires favor woody plants (Wright et al. 1979; Wright 1980). The historic fire return interval for sagebrush grasslands of the Great Basin is between 30 to 70 years (Kilgore 1978; Wright et al. 1979). This interval is often shorter for more mesic communities (e.g., mountain big sagebrush, *Artemisia tridentata* ssp. *vaseyana*), and longer in more xeric communities (e.g., Wyoming big sagebrush, *Artemisia tridentata* ssp. *wyomingensis*).

Fire-return intervals have changed since Euro-Americans settled these areas. Humans suppressed fires while large numbers of livestock consumed fine-fuels thus reinforcing fire suppression. Woody species increased dominance due in part to the absence of fire and to the competitive advantage woody plants gained over herbaceous plants by preferential livestock grazing (West 1988).

The introduction and spread of invasive annual grasses, such as cheatgrass (*Bromus tectorum),* occurred concomitantly with excessive livestock grazing of herbaceous plants (West 1988). After the 1930's, the Taylor Grazing Act (43 USCS § 315) brought reductions in livestock numbers and adjustments in grazing seasons (Heady 1975; Holechek et al. 1989). These changes in grazing management allowed herbaceous species to increase. As fine fuels increased, so also did fire frequency. As early as 1932, many historically sagebrush-dominated sites were becoming cheatgrass-dominated sites after fires (Whisenant 1990, Billings 1994). With cheatgrass dominance, the fire-return interval was reduced drastically and threatened the existence of sagebrush and other native fire-sensitive plants (West 1988).

The shift of these ecosystems from diverse shrub-grass communities to near monocultures of annual grasses severely modified their structure and function. The ecosystem's hydrologic function declined when fire removed vegetation that protected soil from raindrop impacts and winds, thus increasing the probability of soil erosion. Erosion may also threaten water quality, human dwellings, and roads (BLM 1999). If wildfire-annual grass cycles are left unchecked more damaging species may establish and the ability of a site to maintain its former vegetation state may be lost entirely (Billings 1994; Brooks and Pyke 2002).

Fire rehabilitation programs have existed within the U.S. Department of the Interior, Bureau of Land Management (BLM) since the early 1960's. However, a formal policy, Emergency Fire Rehabilitation (EFR, currently referred to as Emergency Stabilization and Rehabilitation), was not established until 1985 (M. Pellant, personal communication). The main goals of the policy were to protect sites from soil erosion and to minimize potential changes in vegetation communities that may result from the dominance of weedy species (BLM 1985).

When the EFR program began in the Great Basin, managers often used introduced perennial grasses that established quicker and competed better with introduced annuals than did native plants (Heady and Bartolome 1977; Pellant and Monsen 1993; Roundy et al. 1997). These introduced perennial grasses provided equal or greater livestock forage and tolerated livestock grazing better than native grasses. The change of sagebrush-grass communities to communities dominated by monocultures of introduced forage grasses or weeds led to concerns for wildlife habitat (Reynolds and Trost 1980; Call and Maser 1985; Bock et al. 1986; Miller and Eddleman 2000).

Wildlife habitat concerns contributed to a policy shift toward rehabilitation with native species, when native species are available (Shaw and Roundy 1997: Richards et al. 1998; McArthur and Young 1999). More recently, Presidential Executive Order 1312 (02/03/99) on Invasive Species mandates that federal agencies should use native species when possible to protect ecosystems from introduced invasive species. However, the use of native plants depends on the availability of seed and funds to purchase those seeds. Native seed often cost much more than introduced species (Richards et al. 1998; McArthur and Young 1999). In the Great Basin, natives species are generally thought to establish and survive poorer than introduced species when they must compete with invasive plants (Asay et al. 2001, but see Thompson 2002 for success with native species). Although the BLM cannot use EFR funds to restore all species in a native plant community, the Draft Emergency Fire Rehabilitation Handbook H-1742-1 (BLM Instruction Memo No. 98-148 July, 1998) strongly encouraged the use of native plants when reseeding any EFR project. The only study to examine native plant use before these EFR policy shifts reported that an average of three or fewer native species were sown in four Nevada BLM districts (Richards et al. 1998).

The increase in native plant use on EFR projects provides a unique opportunity to examine their establishment success in a variety of ecosystems. Currently, BLM EFR policy encourages and funds monitoring on EFR treatments, but information on establishment of native species is often unknown or unavailable beyond the office that conducted the project.

Recently, the BLM initiated the Great Basin Restoration Initiative (GBRI) to restore diverse plant communities on BLM lands in the Great Basin and similar adjacent areas (Fig. 1) in the hope of restoring land health, stopping invasive annual grass-wildfire cycle, and restoring wildlife habitat in the region. GBRI supports the review and synthesis of monitoring data on native species revegetation projects into a regional report that may assist the BLM's restoration efforts (BLM 1999). Therefore, the BLM requested an evaluation of their Emergency Fire Rehabilitation program in the Great Basin.

This study addresses several critical questions regarding emergency fire rehabilitation policy and project implementation. The intent was to determine if these questions could be answered, and if so what were the answers. Did species seeded on EFR projects, regardless of their origins (native vs. introduced vs. invasive, seeded vs. non-seeded), establish equivalent cover? Were seeded species adapted to the environment of the site where they were sown? Was two years of monitoring (the length of time funded in the current policy) adequate to assess native plant establishment on a site and did implemented monitoring address goals of EFR policy? Did EFR projects protect sites from soil erosion and minimize the dominance of weedy species? If monitoring implemented by the BLM did not address goals of EFR policy, what would be the cost of implementing monitoring that does? What criteria did BLM land managers use when choosing native and introduced species for an EFR seed mixture? Lastly, what factors influenced BLM land managers to monitor or not monitor EFR projects? To address these questions we conducted a study that incorporated data collection and analysis as well as a survey of BLM managers.

MATERIALS AND METHODS

Both data collection and analysis and survey portions of the study were conducted over the same geographical area. The data collection and analysis portion of the study included establishment success of seeded species, suitability of seeded species, and achievement of EFR goals. The survey portion of the study was an analysis of how BLM managers make decisions on rehabilitation plantings.

STUDY AREA

BLM maintains 20 field offices that cover 33.5 million hectares (82.9 million acres) throughout the four states in the Great Basin: Idaho, Nevada, Oregon, and Utah (Fig. 1). Each field office has large, continuous blocks of land with similar plant communities (e.g., *Atriplex confertifolia* (shadscale), *Artemisia tridentata* (big sagebrush), and *Juniperus sp.* (juniper) communities). All field offices are located in semiarid settings with similar continental climates. Nevada and Utah offices are located in the hydrologic Great Basin and most of the pertinent Idaho and Oregon field offices are in the Columbia Plateau and Snake River Plains hydrologic systems. The invasion and dominance of invasive annual grasses such as cheatgrass or medusahead, affects ecosystems in all four states (McArthur et al. 1990; Monsen and Kitchen 1994). Density and biomass of introduced annual grasses relates directly to wildfire fuel loads, fire frequency and size, and rehabilitation needs.

To provide adequate dispersion of sample data, two field offices per state were randomly selected from the total list of Great Basin field offices. The selected field offices represent approximately 51 % (17.2 million hectares or 42.6 million acres) of the BLM land area in the Great Basin study area.

ESTABLISHMENT SUCCESS

We recognize that terms such as *native* and *introduced* species may differ depending on the observer's landscape viewpoint and scale, but for the purposes of this paper we elected to take a course scale approach to these definitions.

Native Species: a species of North American origin that is indigenous in the Great Basin study area.

Introduced Species: a species whose origin is from outside of North America that is growing in the Great Basin study area.

Invasive Species: Nonnative, alien, or exotic to the ecosystem, and one whose introduction causes, or is likely to cause, economic or environmental harm or harm to human health.

Establishment: A measured presence of a plant species sown on an EFR project site during our site visit five or more years after project initiation.

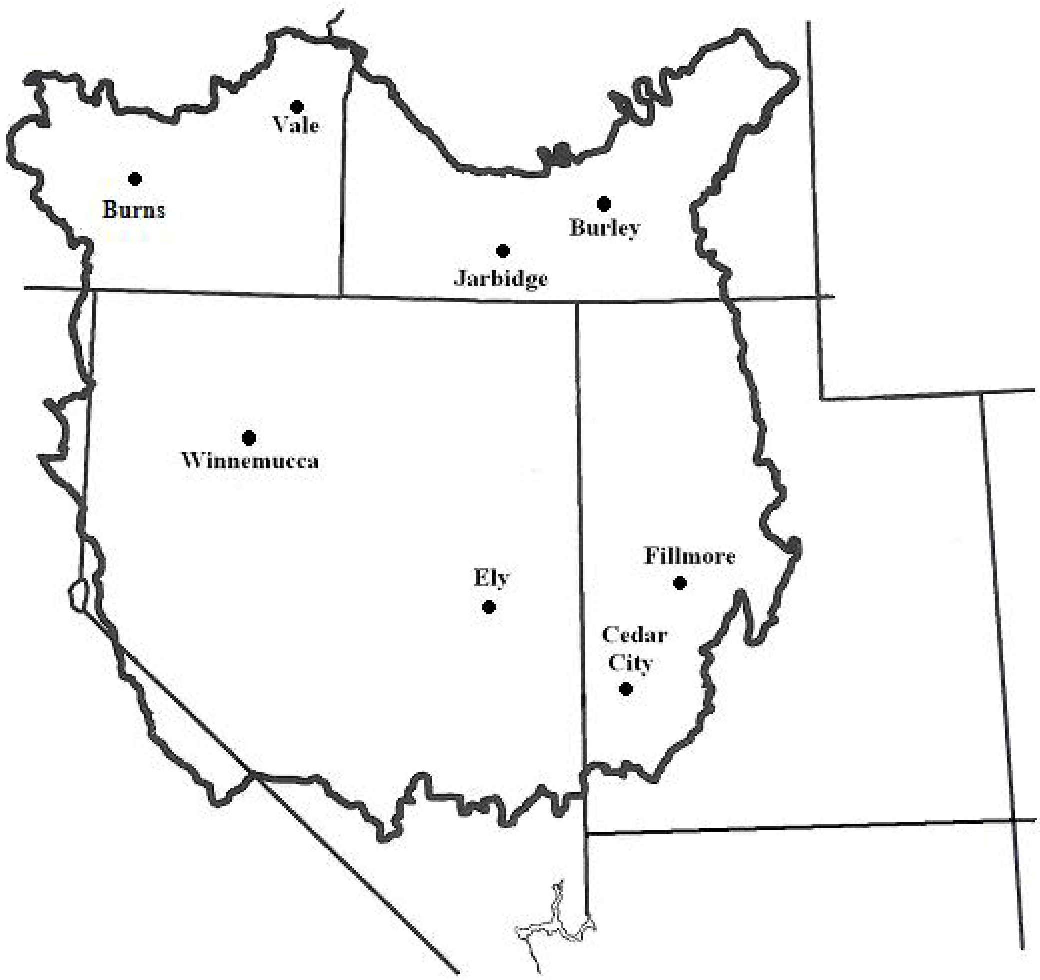

Figure 1. Great Basin (Holmgren 1972), with the BLM Field Offices that were visited labeled.

To examine the establishment success of seeded species, we selected randomly three EFR projects per field office for conducting additional field monitoring. Potential projects had to meet the following selection criteria: (1) monitoring was implemented in 1995 or earlier; and (2) projects had three or more native species in the seed mixture. When fewer than three projects met our criteria, we used all projects with monitoring and three native plants, then we selected randomly from a prioritized list of projects with: three native species and no monitoring; two native species with monitoring; two native species without monitoring (Table 1).

Establishment success of individual seeded species was difficult to evaluate because of the large variation in species sown on projects. Therefore, instead of analyzing by species, we grouped species by origin (i.e., native vs. introduced) for analysis. In 2001, we used the line-point intercept technique (see description below) to measure and compare the proportional cover of native species, introduced and invasive species. If plants established from seed that existed in the seed bank or if plants existed before the fire and survived the fire and seeding, we were not able to distinguish these volunteers from those sown at the site. Significant differences among percentage cover of species groups was tested using an analysis of variance. Data were arcsin square-root transformed to normalize the data before analysis, but all comparisons were back-transformed before presentation (Proc GLM, SAS 1999). Within group differences were tested using the LSMEANS option (SAS 1999).

SPECIES SUITABILITY

To objectively evaluate the suitability of the species selected by BLM for each site on an EFR project, the list of seeded species was compared with the list of species recommended by VegSpec Version 3.1, a revegetation expert system (Pyke et al. 1998; *http://plants.usda.gov* 5/20/2002). The VegSpec list was generated using the soil map unit of the site gathered from the local county soil surveys and from the climate of the closest long-term weather station at or near the same elevation of the site. Only plant species that occurred in VegSpec's database (2500 plants nationwide) were used in comparisons. For those species seeded but not recommended by VegSpec, we determined the reason why VegSpec did not recommend the species and categorized these reasons (e.g., Major Land Resource Area, soil texture, soil pH, rooting depth, precipitation, and minimum temperature). Agreement, Kappa (K), between VegSpec recommendations and establishment, was tested using 2 x 2 χ^2 exact test categorical analysis (Proc FREQ, SAS 1999). Kappa is the test of agreement between two observations (BLM seed list vs. VegSpec); +1 would mean total agreement, 0 would mean independence, and -1 would mean exact disagreement between the two groups.

EFR GOAL ACHIEVEMENT

EFR projects were evaluated for their ability to achieve EFR policy goals, that include soil stability and minimize invasive species spread, at two moments in time: 1) three years after the fire (the end of the EFR-funded monitoring); and 2) in 2001when we resampled projects. We intended to use the BLM file data and analyses to access goal achievement during the initial 3-year project period and then repeat their procedure to test for changes over time. Unfortunately, we were unable to determine if EFR projects achieved these two policy goals because data on post-treatment invasive plant cover and soil stability or any other soil movement measure was not collected from these sites, and because clear measurable objectives for these goals were not stated in field office EFR plans. In an attempt to collect data that would relate to the two EFR goals, we established a common monitoring procedure at all selected projects using protocols from Herrick et al. (2002). If BLM had existing monitoring locations, we established our common procedure in that location. If no BLM plots existed, we located our plots by developing a grid within the predominant ecological site on the EFR project area, and assigning a number to each grid point then used a random number generator to select the grid coordinate where the monitoring plot would be located. We determined how many plots per project based on the size of the fire, and the diversity of the vegetative community within the project area.

Techniques used to assess EFR goal attainment should relate to either invasive species dominance or soil stability. Cover and composition of invasive (mainly introduced annual grasses and forbs, e.g. cheatgrass or Russian thistle [*Salsola kali*]) and non-invasive vegetation is also an estimate of dominance and potential competitors on a site (Tilman et al. 1997). Soil cover plays an important role in erosion control especially related to raindrop impact (Morgan 1986). Soils with greater aggregate stability are better able to resist erosion (Morgan 1986, Morgan et al. 1987). Connectivity of a vegetative community also plays an important role in understanding erosion potential of a site. Large interspaces between plants provide less resistance to surface flow and lead to a greater potential for erosion on a site (Branson et al. 1981).

Our common monitoring procedure consisted of three techniques, line-point intercept, canopy and basal gap, and soil aggregate stability method, taken along three 50-m transects (Herrick et al. 2001, 2002). We measured canopy and ground cover using a line-point intercept technique (Herrick et al. 2002). Each object contacted by the rod (2 mm diameter) lowered at 1 m intervals along a single 50-m line was identified and counted. Potential hits included live and dead (standing dead or litter not in contact with the soil) vegetation, litter (dead vegetation in contact with the soil surface), gravel/rock (> 2 mm), and biological soil crusts. Cover of live vegetation was subdivided into invasive, native, and introduced plants.

To gain a better understanding of the interplant connectivity, we measured the gap distance between plant canopy and basal gaps. Canopy gaps were distances along a line with less than 50% cover for at least a 20-cm length. Basal gaps were distances with at least 20 cm without intersecting a live plant base. These gaps were measured and classified into percentages of the line's distance with canopy or basal gaps >25 cm, >50 cm, >100 cm, and >200 cm.

A field soil aggregate stability test measures the ability of soil particles to remain aggregated when they become wet, relating to the erodability of the soil (Herrick et al. 2001). Nine soil samples were taken at random intervals along each of 3, 50-m transects. Each sample was categorized whether it came from under live vegetation or from bare soil. One sample (approximately 5 mm diameter) was taken from the surface and one from 2.5 cm deep at each location to compare subsurface to surface stability. This provides a measure of the resilience of the subsurface soil should the surface soil erode.

DATA COLLECTION TIME

The amount of time taken to complete each technique was recorded to assess cost between implemented monitoring techniques currently used by the BLM and the common technique that we applied. Only two field offices repeated the same quantitative techniques at multiple projects within their field offices. Each field office used a different technique. Winnemucca field office used a combination of plant density within a 0.9 by 30.5 m (3 by 100 ft) belt transect and plant cover taken from a 30.5 m (100 ft) line intercept method (Interagency Technical Reference 1996). Burns field office used the pace 180 technique. This technique measures cover with 50 points taken using a step-point technique (Interagency Technical Reference 1996) and when plants were not contacted at the point they would identify the species of the closest plant to the point within an 180^{o} arc in front of the observer.

For comparing sampling times, we standardized all time measurements for a technique to time per m or time per point and adjusted these values to time per 150 m or time per 150 points, which was the number of meters/point collected in the common protocol. When more than one technique was used, the total time for all techniques (BLM Winnemucca – density and line-intercept; common technique – soil stability, canopy and basal gap, and line-point intercept) was calculated. The time to conduct the BLM technique was compared to the common technique using an analysis of variance with technique nested within field office (Proc GLM, SAS 1999).

Table 1. Randomly selected sites for field visits to repeat monitoring methods, and implement a common monitoring protocol.

Fire Code	Field Office	Fire Location	Date of Fire	Acreage that was seeded	Type of Monitoring	Status of Monitoring
F-367	Burley	T. 11 S. R. 18 E. Sec. Various	8/7/90	3200	Browse	Implemented
F-550	Burley	T. 7-8 S. R. 26-27 E. Sec. Various	7/27/94	3886	Density	Implemented
F-445	Burley	T. 7 S. R. 26 E. Sec. Various	6/24/92	1504	Frequency	Implemented
M-379	Burns	T. 27-28 R. 31-32 Sec. Various	7/30/96	4310	Cover	Implemented
M-352	Burns	T. 21-23 S. R. 27-29 E. Sec. Various	8/6/90	10000	Photo Point	Implemented
M-380	Burns	T. 27 S. R. 27-28 E. Sec. Various	7/30/96	3850	None	None proposed
R-349	Cedar City	T. 29 S. R. 16 W. Sec. 8-11,14-17	7/24/89	300	Trend	Proposed
R-372	Cedar City	T. 27-29 S. R. 9-10 W. Sec. Various	7/30/94	7825	Trend	Proposed
R-384	Cedar City	T. 31-32 S. R. 17 W. Sec. Various	8/5/90	300	Trend	Proposed
K-392	Ely	T. 6-8 N. R. 64-65 E. Sec. Various	6/7/96	3560	Photo Point	Implemented
Y-020	Ely	T. 3-4 N. R. 71 E.(NV)/T.30-31 S. R. 20 W.(UT)	7/15/93	1377	Community Structure Analysis	Proposed
K-032	Ely	T.5-6 N. R. 66 E. Sec. Various	6/7/96	5600	Photo Point	Implemented
R-465	Fillmore	T. 11-13 S. R. 4 W. Sec. Various	8/2/96	6000	Cover	Implemented

Table 1 Continued

Fire Code	Field Office	Fire Location	Date of Fire	Acreage that was seeded	Type of Monitoring	Status of Monitoring
R-521	Fillmore	T. 24-25 S. R. 11 W. Sec. Various	6/28/94	4050	Photo Point	Implemented
R-566	Fillmore	T. 23-26 S. R. 7-8 W. Sec. Various	7/5/96	25500	Cover	Implemented
F-113	Jarbidge	T. 15 S. R. 10 E. Sec. Various	7/18/94	2408	Photo Point	Implemented
F-190	Jarbidge	T. 8. S. R. 11 E. Sec. 4,5,9,32	7/3/96	2760	Photo Point	Implemented
F-277	Jarbidge	T. 13 S. R. 9 E. Sec. Various	8/20/96	13470	Photo Point	Implemented
N-113	Vale	T. 26 S. R. 44 E. Sec. 10	7/16/94	40	Photo Point	Implemented
M-726	Vale	T. 29-31 S. R. 41-42 E. Sec. Various	7/30/96	11200	Photo Point	Implemented
I-111	Vale	T. 29 S. R. 41 E. Sec. 8,17-20	7/20/95	480	Photo Point	Implemented
X-393	Winnemucca	T. 30 N. R. 40-41 E. Sec. Various	7/30/95	1420	Cover	Implemented
J-485	Winnemucca	T. 39-41 N. R. 41-43 E. Sec. Various	8/26/96	11600	Line Intercept	Implemented
J-484	Winnemucca	T. 46-47 N. R. 41-42 E. Sec. Various	8/26/96	5485	Line Intercept	Implemented

DECISION PROCESS SURVEY

A semi-structured survey was developed to determine the potential reasons why native and introduced plants were either used or not used and why monitoring was proposed and not implemented in the rehabilitation projects (**Appendix 1)**. The survey was administered to BLM personnel who were involved in EFR projects during 1988-1999 and employed at the selected field offices. Originally, fifty people met requirements to participate in the survey, however, we were unable to administer the survey to people that had retired, or no longer worked for the agency. This reduced the population to those that currently work for the BLM. This new potential sample population equaled thirty-six people. Of this sample population, we were able to contact 78% or 28 people. All contacted people agreed to participate in the study.

Surveys were administered over the telephone or in person using open and close ended questions (**Appendix 1**) protocol was developed using techniques discussed by Dillman (1978). Participants were biologists and field office managers. Survey results were confidential and summarized for the entire region. Participant's responses were recorded on audiotapes to accurately capture responses given during the survey. Content from responses to the open-ended questions were grouped into themes and expressed in the percentage of respondents with similar themed responses. Responses from the questions with pre-designated options are also reported in percentage of responses for each option (**Appendix 2**). Information regarding any individual's response or responses from any state or field office are confidential and will not be released.

RESULTS

ESTABLISHMENT SUCCESS

Introduced species that established from seed, or recovered after the fire, most consistently were crested or desert wheatgrass (*Agropyron cristatum* or *A. desertorum*) and intermediate wheatgrass (*Agropyron intermedium*), whereas native species were bluebunch wheatgrass (*Pseudoroegneria spicata*), big sagebrush (*Artemesia tridentata*), and Indian ricegrass (*Achnatherum hymenoides*). A complete list of seeded species and their percent cover by site is provided in Appendix 3.

Cover significantly differed among plant groups ($F_{2,60} = 4.05$, $P < 0.02$) when volunteer and sown species were combined in each origin group. Cover of all natives (Native, Figure 2), seeded and volunteers, contributed half of the overall cover (Native + Introduced + Invasive) on EFR projects and was significantly higher than the introduced group, but did not differ significantly from invasives ($P = 0.06$). The seeded species were a subset of the native or introduced classes. Composition by cover between sown (native or introduced) and invasive species did not differ statistically ($F_{2, 60} = 1.87$ $P = 0.16$; Figure 2).

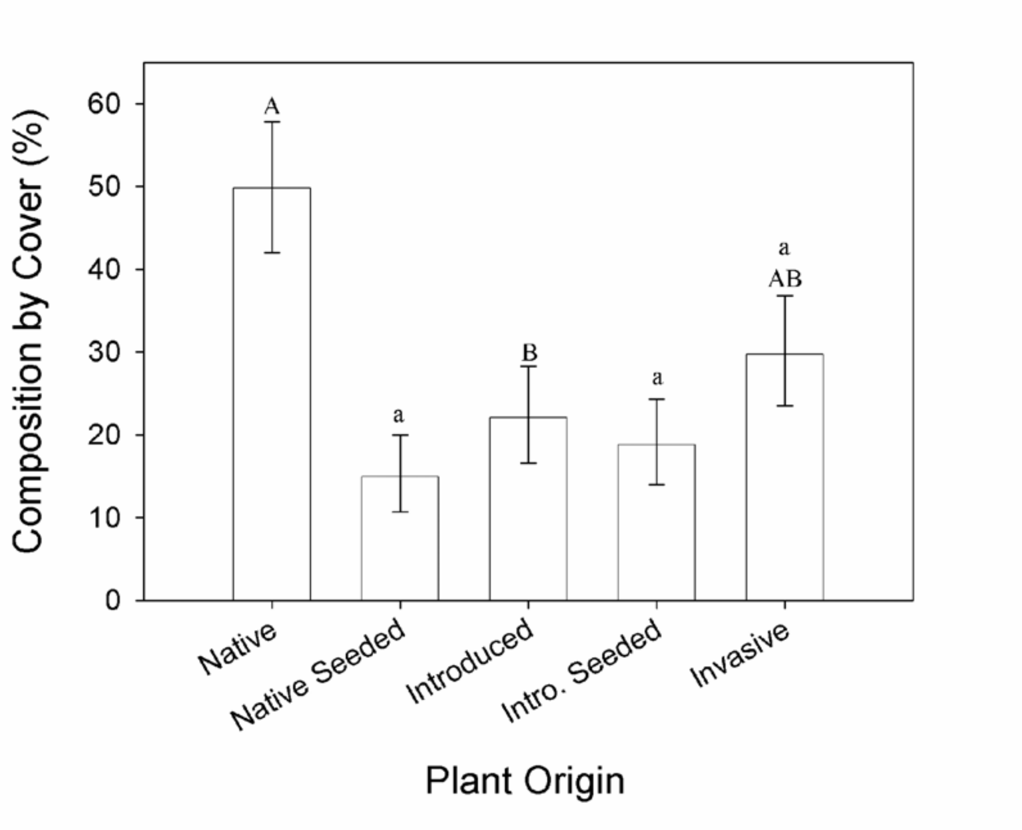

Figure 2. Mean (± 1 SE) (N = 21) plant cover of five plant categories from Bureau of Land Management rehabilitation projects in four states (Idaho, Nevada, Oregon, Utah) in the Great Basin. Bars with different letters are significantly different ($P \leq 0.05$).

SPECIES SUITABILITY

Our results show a strong agreement between the recommendation of VegSpec, and species establishment. Seventy-five percent of the species sown on rehabilitation projects fell on the agreement diagonal of the exact test table (Table 2; $K=0.5$; $P<0.05$).

Table 2. Number of seeded species (% of overall total), categorized based on whether they established (defined as presence on site at 5 or more years after seeding) or did not establish and whether VegSpec recommended the species for the site.

	Number of Species Recommended By VegSpec	Number of Species ***Not*** Recommended by VegSpec	Total
Number of Species that Established	**36 (41%)**	**7 (8%)**	**43 (49%)**
Number of Species that did *Not* establish	**15 (17%)**	**30 (34%)**	**45 (51%)**
Total	**51 (58%)**	**37 (42%)**	**88 (100%)**

VegSpec did not recommend 42 % of the species sown on EFR projects for their specific site. Of these species, one was a native species, while the remainder were introduced species. Seven species were not recommended by VegSpec, but were able to establish. Insufficient precipitation was the reason VegSpec did not recommend these species, but precipitation at these sites were within 4% of the recommended precipitation for those seven species. Of the 30 species that were not recommended by VegSpec and did not establish, 28 were not recommended because precipitation at the site was below the recommended amount for establishment. For those 28 species, average precipitation for a site was from 8 to 62% less than VegSpec's listed requirement for the species. VegSpec did not recommend the remaining two species because the site's growing season was too short.

For 7 of the 15 species that did not establish, but VegSpec recommended, the site's mean precipitation was the minimum acceptable level for recommending the species. The other eight species had no obvious reasons related to site characteristics or species requirements that might aid in the explanation for their inability to establish.

EFR GOAL ASSESSMENT

Determining success of rehabilitation projects is a key factor in assessing the performance of the program. The two main goals in EFR policy are soil stability and the ability of a site to suppress exotic weed expansion and encroachment. Our original intention was to compare monitoring data taken over time to assess the relative success of the projects we visited. None of the sites collected data on any measure of soil stability. Only five projects had quantifiable vegetation monitoring data available for comparison. Three of these five projects monitored perennial plants only, so comparisons of the exotic annual grasses on these sites were impossible. Although the other two projects collected density and cover for all species, there was insufficient data to compare invasive and seeded species.

We implemented a field aggregate stability test between unvegetated and vegetated and between surface and subsurface soil samples at each project as a potential method for collecting soil stability data. Most projects (78%) did not differ significantly (< > 1.0 units; Herrick et al. 2001) between surface and subsurface samples regardless of whether samples came from under vegetation or in bare soil locations (Table 3). Vegetation cover increased the surface and subsurface stability of soil beneath the vegetation on 39 and 56% of the projects.

Table 3. Average (+SE) soil stability class of Bare and Covered segments of soil along the monitoring transects for the listed EFR sites. The soil stability scale ranged from 0 to 6, lowest to highest soil stability rating. Surface minus sub-surface (2.5cm) codes rate soil stability difference (+ equals greater than 1.0; 0 equals 1.0 to -1.0; - equals less than -1.0)

	BARE			COVERED			SURFACE	SUBSURFACE
Fire Code	**Surface**	**Surface-2.5cm**	**2.5cm**	**Surface**	**Surface-2.5cm**	**2.5cm**	**Covered-Bare**	**Covered-Bare**
F-113	2.60+.36	0	2.11+.36	3.33+.31	0	2.93+.31	0	0
F-190	1.71+.24	0	2.07+.25	3.58+.26	0	2.96+.26	+	0
F-277	2.39+.24	0	2.22+.24	3.51+.31	0	3.14+.28	+	0
F-367	2.43+.26	0	2.46+.25	4.19+.22	0	3.61+.26	+	+
F-550	4.88+.33	+	1.44+.22	5.11+.17	+	3.99+.20	0	+
J-484	1.27+.11	0	1.23+.12	2.09+.32	0	1.80+.23	0	0
J-485	1.91+.20	0	1.51+.11	2.67+.41	0	2.70+.29	0	+
K-392	2.73+.30	0	3.03+.44	3.25+.32	0	3.70+.43	0	0
M-352	3.93+.49	0	3.86+.38	4.98+.28	+	3.97+.23	+	0
M-379	2.73+.41	0	2.29+.28	4.63+34	+	3.38+.25	+	+
M-380	2.82+.29	+	1.81+.21	3.74+.26	0	3.24+.29	0	+
M-726	3.43+.31	+	2.00+.22	4.22+.24	0	3.42+.27	0	+
R-329	4.00+1.00	+	3.00+.55	3.43+.30	0	4.13+.48	0	+
R-384	2.18+.46	0	1.45+.21	2.29+.47	0	2.29+.57	0	0
R-521	2.11+.17	0	1.76+.25	2.20+.36	0	3.08+.49	0	+
R-566	2.41+.26	0	2.10+.31	3.59+.50	0	2.86+.52	+	0
X-393	2.07+.34	0	2.19+.35	2.25+.95	-	4.00+.87	0	+
Y-020	2.00+.32	0	2.00+.37	3.13+.35	0	3.38+.43	+	+

Another important factor related to potential soil erosion is the amount of area exposed by gaps in the canopy of the vegetation or by gaps between plant bases (Table 4). For example the first column indicates that 93.7% of a transect' s length is uncovered by plant bases and that these gaps between bases are greater than 0.25 m and 50.9% of a transect's length is uncovered by overhanging plant cover or bases and that these gaps between canopies are greater than 0.25 m.

Table 4. Mean (±SE) proportion of transect lengths (m) in canopy and basal gap interspaces class for all EFR projects (N = 24).

	Gap Sizes			
	> .25 m	**>.5 m**	**> 1 m**	**>2 m**
Basal Gap	93.7±1.3%	91.1±1.4%	84.7±1.9%	69.1±2.9%
Canopy Gap	50.9±2.5%	42.5±2.8%	30.2±2.9%	16.5±2.9%

DATA COLLECTION TIME

The time it took to implement any of the BLM methods did not differ significantly from the time needed to implement the common protocol on the two projects where data for both techniques was collected ($F_{3,12} = 1.63$, $P = 0.23$; Table 5). Although we have limited data for the time to collect data for each BLM technique, we did collect data on the time-to-sample using the common protocol at all projects. The average time necessary to collect all four techniques was 133 ± 8 minutes (mean ± SE). The time for the individual techniques were 54 ± 3, 28 ± 1, 19 ± 1, and 32 ± 2 minutes for soil aggregate stability, canopy gap, basal gap, and line-point intercept (N = 24 except soil stability N = 20). The maximum time to collect data for all four techniques was 210 minutes, which was an extreme and was located on a relatively steep slope with burnt remains of dead oak shrubs.

Table 5. Time (mean ± SE), in minutes, to complete monitoring methods (using a two-person team). The common techniques were all implemented for each site visited. The BLM techniques of density and line intercept were done on a 100 ft transect, for comparison the time per foot measurements were correlated for time to measure 150 meters. The BLM technique of step 180 collected 50 points, for comparison the time per point was correlated to collecting 150 points.

Fire Code	Field Office	BLM Technique Time per 150 meters				Common Technique Time per 150 meters				
		Density[1]	Line intercept[1]	Step 180[2]	**Total**	Soil Stability[3]	Canopy Gap[4]	Basal Gap[4]	Line Point Intercept[4]	**Total**
J-484a	Winnemmucca	74	25	na	**98**	45	18	11	15	**89**
J-484b	Winnemmucca	74	25	na	**98**	43	30	18	16	**107**
J-485a	Winnemmucca	64	49	na	**113**	38	13	7	10	**68**
J-485b	Winnemmucca	74	39	na	**113**	39	26	15	24	**104**
	MEAN±SE	**71±3**	**34±6**	**na**	**106±4**	**41±2**	**22±4**	**13±2**	**16±3**	**92±9**
M-379a	Burns	Na	Na	45	**45**	58	19	na	33	**110**
M-379b	Burns	Na	Na	60	**60**	52	18	na	15	**85**
M-352	Burns	Na	Na	135	**135**	54	17	na	49	**120**
M-380	Burns	Na	Na	30	**30**	33	35	na	21	**89**
	MEAN±SE	**Na**	**Na**	**68±23**	**68±23**	**49±6**	**22±4**	**na**	**30±8**	**101±8**

[1]Interagency Technical Reference 1996

[2]The step 180 method is similar to the step-point method (Interagency Technical Reference 1996), however, it only measures perennial plants and ground-level or basal hits, and when a perennial is not hit the next closest perennial plant in a 180 degree arc is listed

[3]Herrick et al. 2001

[4]Herrick et al. 2002

DECISION PROCESS SURVEY

When managers prepared seed mixtures for EFR projects, only 8 of the 28 respondents considered a species' origin as a primary or secondary consideration. Respondents were consistent in their definition of native species. A strong majority felt native plants were those that were indigenous (or had evolved in) to specific ecosystems whereas the remainder felt natives were those species that occurred naturally in the area before Euro-American settlement. Most respondents defined introduced species as those that did not occur naturally in the area before Euro-American settlement. The remainder was split evenly among species that originated outside North America and species that did not evolve in the specific ecosystem (Table 6).

Table 6. Survey response definition of native and introduced species. Data displayed in number of respondents and proportion of total responses.

	Number of Respondents	Proportion of Respondents
Definition of native species		
Species that occurred in an area naturally	8	29%
Species indigenous to a specific local ecosystem	20	71%
Definition of introduced species		
Species that do not occur naturally	12	43%
Species that originated outside of North America	8	29%
Species that did not evolve in a specific ecosystem	8	29%

Respondents gave several reasons why they used native species in seed mixtures. The primary reason was because they wanted to return the site to its historical vegetation, or to its natural state. The next three most common responses had similar numbers of respondents. One group felt that using native species tended not to disrupt ecological processes, stating that we still do not understand the processes that occur on sites and they wished to insure the maintenance of these processes. Another group used native species because they believed it was a requirement of the BLM standards and guidelines for Rangeland Health, while a third group used native species in EFR projects to help meet needs for wildlife habitat (Table 7).

Table 7. Survey response regarding native species use and benefit perception. Data displayed in number of respondents and proportion of total responses.

	Number of Respondents	Proportion of Respondents
Reasons for using native species in EFR projects		
Return the species historically present at the site	8	29%
Wildlife habitat concerns	7	25%
Well adapted species for maintaining ecological processes	7	25%
BLM standards and guidelines for rangeland health	6	21%
Are native plants beneficial in EFR projects		
No	2	7%
Yes and No	18	64%
Yes	8	29%
Why are native species not beneficial in EFR projects		
Difficult to establish	15	54%
Too expensive	3	11%
Disagree with statement	10	36%

Respondents were generally non-committal in their views of the benefits of native plants in projects. The majority felt that native plants were not beneficial for EFR projects were because they were difficult to establish when site conditions have changed or deteriorated. Another group felt their expense out-weighed their benefits in EFR projects (Table 7).

When asked why respondents would not use native species on EFR projects three main reasons were given: seed is not available (21%); native seed is too expensive (21%); and native species are not competitive with weeds (21%). When respondents were asked if they would use more native species if more seed was available, 86% of the respondents stated yes. Also, when asked if they would use more native species if they were less expensive 75% responded yes.

All respondents felt that non-native perennials were beneficial for EFR projects at least on some occasions. A wide majority felt that non-native perennials were always beneficial in EFR projects. Many related reasons were given on why respondents felt non-natives were beneficial to EFR projects. These included the following: non-native perennials can successfully compete and establish on sites dominated by invasive species; they stabilize the soils; they were easy to establish; they had good vigor; they have been successful at giving desired results; they can establish on tough sites; and they were inexpensive (Table 8).

Table 8. Survey responses regarding non-native species benefit perceptions. Data displayed in number of respondents and proportion of total responses.

	Number of Respondents	Proportion of Respondents
Are non-native plants beneficial to EFR projects		
Yes	24	86%
Yes and No	4	14%
No	0	0%
Why are non-native species beneficial in EFR projects		
Compete with invasive species	7	25%
Stabilize soils	4	14%
Establish on tough sites and prepare for late seral stages	3	11%
Easy to establish	4	14%
Good vigor	4	14%
Inexpensive	3	11%
Successful at achieving desired results	3	11%

Three-quarters of the respondents said their perceptions toward non-native plant use in EFR projects have changed over time in several key ways. Managers now use more complex seed mixtures, combinations of grasses, forbs, and shrubs that now include native species, than in the past (21%). They are less likely to use just non-natives in seed mixtures (18%) while others (18%) stated they already use fewer non-natives than in the past. They are more likely to use native species first before they consider non-native perennials than they did in the past (18%). Those whose perceptions have not changed (25%) either used or would consider using a combination of natives and non-natives in a seed mixture, stating that they looked at what species would meet the EFR goals of reducing soil erosion and invasive species spread on the site.

When questioned about monitoring, nearly two-thirds of respondents stated they generally implemented monitoring programs as part of their EFR projects, whereas nearly a third stated that they did not or sometimes they did not implement monitoring. Nearly half of respondents completed data collection for monitoring, yet about one third of the respondents (32%) did not complete data collection for some or all projects. Of those that did not finish their established monitoring programs, the majority listed the main reasons for not completing monitoring as time constraints, and changes in work priorities. A dominant comment was that monitoring was the first item sacrificed when their workload increased past their monetary or staffing capacity (Table 9).

Table 9. Survey responses regarding monitoring implementation and perceptions of monitoring process. Data displayed in number of respondents and proportion of total responses.

	Number of Respondents	**Proportion of Respondents**
Are monitoring plans generally implemented?		
Yes	18	64%
Yes and No	4	14%
No	5	18%
No response	1	4%
Is the data collection completed?		
Yes	13	46%
Yes and No	6	21%
No	3	11%
No response	6	21%
Why was data collection not completed?		
Not enough time or staffing	4	14%
Change in priorities	4	14%
Unfamiliar with techniques	1	4%
No response	19	68%
How has your perception changed regarding monitoring over time?		
Has not changed	9	32%
It is more important now	10	36%
Changed from using qualitative to quantitative techniques	4	14%
We should be doing more than we are currently doing	4	14%
No Response	1	4%

Respondents clearly felt that monitoring was useful (65%) for assessing EFR objectives and of those who felt it was useful and goals, one-third felt it was useful in assessing only species establishment success. A small proportion of respondents (12%) felt that monitoring was not useful at times because inappropriate methods were used to evaluate EFR objectives or species success (e.g. ocular estimates or photo plots).

Table 10. Survey responses regarding availability of EFR project information and format preferences. Data displayed in number of respondents and proportion of total responses.

	Number of Respondents	Proportion of Respondents
If information was readily available from past EFR projects, would you use it as a resource		
Yes	28	100%
No	0	0%
Primary format you would like to see it in?		
Written report	13	46%
Searchable database on Word Wide Web	13	46%
Searchable database on CD	2	7%
Secondary format you would like to see it in?		
Searchable database on World Wide Web	5	18%
Searchable database on CD	10	36%
Written report	6	21%
Would not look at a secondary source	7	25%

All respondents stated they would use information from other EFR projects if the information was available. Opinions on how this information should be disseminated were not clear. Respondents were split between a primary preference for disseminating written reports and having a searchable database on the World Wide Web. The dissemination of a searchable CD was rarely seen as a primary source but it was the respondent's principal secondary choice (Table 10).

DISCUSSION

One of the critical questions this study addressed was whether species seeded on EFR projects, regardless of their origins (native vs. introduced), establish equivalent cover. On average, introduced species represent a greater proportion of the seeds in wildfire rehabilitation seed mixtures in the Great Basin (Richards et al. 1998, D.A. Pyke and T.O. McArthur unpublished data). The belief that introduced plants are better adapted to the Great Basin than natives because introduced species establish quicker and compete better with invasive plants than native plants is common in the literature (Heady and Bartolome 1977, Pellant and Monsen 1993, Roundy et al. 1997, Asay et al. 2001). These reasons were given by nearly half of the survey respondents as reasons why introduced plants are beneficial in EFR projects. Given these beliefs and results from others that introduced plants may ultimately dominate sites where mixtures of native and introduced species are planted (Harris and Dobrowolski 1986), we anticipated that introduced species would dominate the plant composition on EFR projects. Unexpectedly, composition by cover did not differ between sown native and sown introduced species and when volunteer natives were included, natives (sown and volunteer) dominated the site. We recognize that our results only provide a moment-in-time estimate of this relationship and we cannot imply any long-term trends for native or introduced plant composition. Only repeated monitoring data, which was largely nonexistent, can provide information on these trends. Several confounding variables would also need to be addressed in future studies, such as timing and extent of cattle grazing after a project is sown, seeded vs. volunteer native response, and location of monitoring plots (i.e. potentially placed in convenient locations or sites that looked good).

Our next critical question dealt with suitability of species seeded in EFR projects. Our measure of establishment success, presence of seeded species on an EFR project five or more years after sowing, was most often related to the plant's suitability for the specific project's environment. To our knowledge, no other study has attempted to statistically evaluate a land manager's ability to sow species that match the plant's environmental requirements with those of the site on multiple revegetation projects. Species selection for EFR projects is an important endeavor, and can be difficult because of limited information on the autecology of Great Basin species (Roundy and Call 1988). Although managers responding to our survey listed a species' ability to establish and survive on the project location (species suitable for the site) as the primary reason for sowing a species, we found that incorrect species choices for specific projects were more likely to occur with introduced cultivars, even though the environmental requirements of these cultivars are published with the cultivar release and are widely available in fact sheets for the species (NRCS USDA 2002, http://plants.usda.gov and follow links to Plant Materials and Fact Sheets). In addition, VegSpec (USDA NRCS 2001, Pyke et al. 1999), a Web-based revegetation expert system, provides an initial tool for checking a species' suitability to a location since it uses long-term climate and soil data to recommend species that will grow under the location's environmental limitations. This decision support tool incorporates the planting requirements for all published cultivars released by federal agencies.

As we anticipated, some species that VegSpec recommended were not detected on projects and likely did not establish where they were sown. The vagaries of weather or seed predators can lead to failures (Whisenant 1999) and some species may be more susceptible to these vagaries than others. Improper seeding techniques are cited as seeding failures elsewhere (Barnett and Baker 1991) and are not uncommon in the Great Basin since the standard rangeland drill does not accommodate multiple seeding depths that are often required for sowing multiple species that vary in seed size (Call and Roundy 1991). In three cases, fourwing saltbush (*Atriplex canescens*) was not able to establish, even though it was recommended for the site. Of the four sites where fourwing saltbush was listed as suitable for the site and was sown, only one had any measurable establishment. This is an example of the type of failure that may occur even though a species is known to establish well in many other locations in the Great Basin area (e.g., McArthur and Sanderson 1995; Ott et al. 2003).

The use of native species in revegetation projects, especially EFR projects, is restricted by three main perceptions of managers, seed availability, seed expense and lack of competitiveness with invasive species. If seed were more available or less expensive, these managers clearly favored using more native seeds on EFR projects. Research and development on seed growth and storage will aid in making native seeds more available (Roundy et al. 1997), but continued studies on native plant selections for competing with invasive plants is needed to break the bottleneck caused by invasive plant competition that manager's recognized and currently exists to using native plants on EFR projects in the region.

The lack of monitoring data associated with projects that used native species made it impossible to answer our question associated with the adequacy of the current policy to fund monitoring of EFR projects only from EFR funds for two years post treatment. Although the majority of land managers perceived that monitoring data is usually completed, only half of all EFR projects even implemented monitoring, data were summarized rarely and no evidence for distribution was ever found (D.A. Pyke and T.O. McArthur unpubl. data). This is a difficult situation to address. Why, when most respondents felt that monitoring was beneficial, is there such a lack of quantifiable data. Part of the answer may be that even though the total body of available monitoring is disjointed and minimal, the managers may feel that it is sufficient for their needs. Only 14% of respondents felt that the monitoring that has been done to this point needs to improve.

Nearly half of the managers perceived that reports are being prepared that summarize data, but this contradicted our ability to find these reports at most locations. Without these data, the BLM is unable to determine the effectiveness of their treatments in addressing the two major goals for EFR, to prevent soil erosion and invasive species spread; one of the reasons given for the usefulness of such reports. Although we implemented a common monitoring design to gather this type of data, we were unable to compare BLM data collected two years after a treatment to data collected during our sampling to develop any sense of a trend.

The BLM has shifted from using qualitative monitoring, such as photo points, to using quantitative techniques, such as line intercept and density (D.A. Pyke and T.O. McArthur unpubl. data). However, the determination of the effectiveness of an

EFR project to meet EFR goals requires collections of data relating not just to the plant species that were seeded, but also to the soil protection, soil movement and to species that were being prevented (i.e. the invasive plants).

The line-point intercept and the basal and canopy gap measurements are two techniques that have been proposed as quantitative monitoring tools that address indicators that relate to soil stability and hydrologic function attributes of rangeland health (Pyke et al. 2002). In addition, the soil aggregate stability (Herrick et al. 2002), one of the indicators of rangeland health (Pyke et al. 2002), is a direct soil measurement related to the potential for soils particles to be displaced by water. In addition, Robichaud and Brown (2002) have designed a sediment capture technique that could be used on hill slopes to measure soil movement directly. If an interagency standardized protocol for rehabilitation is developed (General Accounting Office 2003), techniques like these that have direct relationships to the major goal of EFR should be considered.

The time to implement the common technique was similar to those of techniques currently used in the BLM. With the exception of density, which could be added, the common technique measured the same parameters as the BLM techniques, but provided additional information such as litter cover and sizes of unvegetated gaps that relate to erosion potential (Pyke et al. 2002) and at similar costs. Considering that the major labor cost for implementing either technique was often the cost associated with driving to these remote projects (up to two hours one-way), the cost of spending additional time collecting data to determine effectiveness would seem beneficial. Using techniques that provide the additional benefits of monitoring all EFR goals at the same cost may justify the current expenses, however, it will not address work priorities that can only be addressed by the managers themselves. For monitoring to receive the necessary priority to insure data are collected and reported, we suggest that agencies report the number and percentage of EFR projects where effectiveness monitoring and reporting is completed.

The General Accounting Office (GAO) (2003) report to Congress on federal EFR treatments strongly recommended developing an interagency standardized method for collecting, storing, and analyzing data to better assess the effectiveness of wildfire rehabilitation projects. Labor costs are the major consideration for monitoring, but information gained from certain techniques can provide greater benefits than other techniques. Density provides excellent information on seedling emergence and establishment, but as plants die through natural thinning (Pyke and Archer 1991) cover might provide better information on soil protection and on plant composition and dominance.

Another GAO (2003) recommendation included retaining untreated checks or controls within EFR projects to determine the need for and effectiveness of treatments. Our results indicated that volunteer native plants that were not seeded contributed the majority of the cover in the Great Basin. These data could be an indication that EFR treatments might have been unnecessary, but without control plots we cannot know. The lack of control plots to determine the effectiveness and need of treatments is a common problem in the U.S. Forest Service fire rehabilitation monitoring as well (Robichaud et al. 2000).

We endorse the recommendation by the General Accounting Office (2003) that common monitoring techniques be developed that assess the effectiveness of EFR projects at meeting EFR goals. Robichaud et al. (2000) recommended an Internet-based BAER reporting and retrieval system. We support this recommendation and believe the system should contain basic information on the fire, site, rehabilitation objectives, rehabilitation project, and monitoring information regarding the success of the project to meet objectives. Over half of the respondents in the survey stated that they would utilize such a system. All of the participants, however, stated that they would like to use this type of information although some of them would prefer it in a written format, or on a CD. Those that chose the written format may be unaware that they would be required to summarize data for this written report, and with their already full schedules this may be impractical.

CONCLUSIONS

Rehabilitation is an important aspect of recovering degraded rangelands. Emergency Fire Rehabilitation provides an opportunity to decrease fire frequency by reducing the dominance and spread of annual grasses that fuel fires in Great Basin shrub steppe ecosystems. However, the effectiveness of this program needs to be validated through a more comprehensive monitoring program. We believe the additional cost is minimal, while the benefit is crucial to determine success or progress of rehabilitation projects in meeting EFR goals.

In our study we found no evidence to support introduced species superiority in establishment over native species (sown and with residual plants). It appears that perception is the key factor in the dominant use of introduced species in EFR projects. However, our study was not designed to compare the reported greater competitive ability of introduced than native species in reducing exotic annual grass dominance. We advise the development of a standardized monitoring protocol for similar ecosystems such as semi-arid shrub grasslands. Combining this standardized monitoring procedure with an accessible database for EFR effectiveness, managers will be able to easily evaluate species and habitats where successful establishment and EFR goals have been achieved. Research will not be able to test all possible species and techniques for revegetation on all environments, therefore scientists and managers will need appropriate effectiveness monitoring to guide adaptive management in the EFR projects.

LITERATURE CITED

Asay, K. H., W. H. Horton, K. B. Jensen, and A. J. Palazzo. 2001. Merits of native and introduced *Triticeae* grasses. Canadian Journal of Plant Science 81: 45-52.

Ashcroft, G. L., D. T. Jensen, and J. L. Brown. 1992. Utah climate. Utah Climate Center, Utah State University. Logan, UT. 127 p.

Barnett, J.P. and J.B. Baker. 1991. Regeneration methods. Pages 35-50 IN: Duryea, M.L. and P.M. Dougherty (eds), Forest regeneration manual. Kluwer Academic, Boston, MA.

Billings, W.D. 1994. Ecological Impacts of Cheatgrass and Resultant Fire on Ecosystems in the Western Great Basin. p. 22-30. In: S.B. Monson, S.G. Kitchen (eds). Proceedings-Ecology and Management of Annual Rangelands. United States Department of Agriculture. Forest Service. Intermountain Research Station. Gen. Tech. Ref. INT-GTR-313. Ogden, UT.

Bock, C.E., J.H. Bock, K.L. Jepson, and J.C. Ortega. 1986. Ecological effects of planting African Lovegrass in Arizona. National Geographic Research 2:456-463

Brady, N. C., and R. R. Weil. 1996. The nature and properties of soils. Prentice Hall. Upper Saddle River, NJ. 740 p.

Branson, F.A., G.F. Gifford, K.G. Renard, and R.F. Hadly. 1981. Rangeland Hydrology, 2nd Ed. Denver: Society for Range Management.

Brooks, M., and D.A. Pyke. 2002. Invasive plants and fire in the deserts of North America. In: Brooks, M., and S. Coloff (eds.), Proceedings of the invasive species and fire workshop, 1st National Fire Congress, San Diego CA November 2000. Tall Timbers Publishing, Tallahassee, FL.

Bureau of Land Management. 1985. Emergency Fire Rehabilitation Handbook. U.S.Department of the Interior, Bureau of Land Management Manual Handbook H-1742, Washington D.C.

Bureau of Land Management. 1999. Emergency Fire Rehabilitation Handbook. U.S. Department of the Interior, Bureau of Land Management Manual Handbook H-1742-1, Washington D.C.

Bureau of Land Management. 1999. The Great Basin Initiative: Out of ashes, opportunity.U.S. Department of the Interior, Bureau of Land Management, National Office of Fire and Aviation, Boise ID. http://www.nv.blm.gov/crisis/pdf/pub2b2.pdf

Call, C.A. and B.A. Roundy. 1991. Perspectives and processes in revegetation of arid and semiarid rangelands. J. Range Manage. 44:543-549.

Call, M.W. and C. Maser. 1985. Wildlife Habitats in Managed Rangelands-The Great Basis of Southeastern Oregon: Sage Grouse. United States Department of Agriculture, Forest Service, PNW Forest and Range Experiment Station. Gen. Tech. Rep. PNW-187. Portland, OR.

General Accounting Office. 2003. Wildland fires: better information needed on effectiveness of emergency stabilization and rehabilitation treatments. Report to Congressional Requesters, U.S. General Accounting Office, GAO-03-430, Washington DC. http://www.gao.gov/new.items/d03430.pdf October 24, 2003.

Harris, G.A. and J.P. Dobrowolski. 1986. Population dynamics of seeded species on northeast Washington semiarid sites, 1948 – 1983. J. Range Manage. 34:46-51.

Heady, H.F. 1975. Rangeland Management. New York: MacGraw-Hill.;

Heady, H.F. and J. Bartolome. 1977. The Vale rangeland rehabilitation program: The desert repaired in southeastern Oregon. USDA For. Serv. Resour. Bull. PNW-70. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Herrick, J.E., W.G. Whitford, A.G. de Soyza, J.W. Van Zee, K.M. Havstad, C.A. Seybold, and M. Walton. 2001. Field soil aggregate stability kit for soil quality and rangeland health evaluations. Catena 44:27-35.

Herrick, J.E., J.R. Brown, A.J. Tugel, P.L. Shaver, and K.M. Havstad. 2002. Application of soil quality to monitoring and management: paradigms from rangeland ecology. Agron. J. 94, no 1: 3-11.

Holechek, J. L. , R.D. Pieper & C.H. Herberl 1989.Range Management: Principles and Practices, Englewood Cliffs, New Jersey: Prentice-Hall Inc.

Holmgren, N.H. 1972. Plant Geography of the Intermountain Region. P.77-161 *In:* A. Cronquist, A.H.Holmgren, N.H. Holmgren, and J.L. Reveal. Intermountain Flora: Vascular Plants of the Intermountain West, U.S.A.. Hafner Publishing Company, Inc., New York and London.

Jones, M. M., N. C. Turner, and C. B. Osmond. 1981. Mechanisms of drought resistance. P. 15-17 *In:* L. G. Paleg, and D. Aspinall (eds.). The physiology and biochemistry of drought resistance in Plants. Academic Press, New York.

Kilgore, B.M. 1978. Fire in Ecosystem Distribution and Structure: Western Forest and Scrublands. *In:* H.A. Mooney, T.M. Bonnicksen, N.L. Christensen, J.E. Lotan, W.A. Reiners. Proceedings: Fire Regimes and Ecosystem Properties; 1978 December 11-15; Honolulu, Hawaii. Gen. Tech. Rep. WO-26. U.S. Department of Agriculture, Forest Service.

McArthur, E. D., E. M. Romney, S. D. Smith, and P. T. Tueller (compilers). 1990. Proceedings—symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management. USDA Forest Service General Technical Report INT-276. Intermountain Forest and Range Experiment Station, Ogden, UT. 351 p.

McArthur, E. D., and S. C. Sanderson. 1995. Twist Hollow: a Mojave Desert Restoration Project. p.350-351 *in* N. E. West (ed..). Proceedings of the Fifth International Rangeland Congress. Society for Range Management, Denver, CO.

McArthur, E.D. and S.A. Young. 1999. Development of Native Seed Supplies to Support Restoration of Pinyon-Juniper Sites. *In*: S.B. Monson and R. Stevens, comps. 1999. Proceedings: Ecology and Management of Pinyon-Juniper Communities within the Interior West; 1997 September 15-18; Provo, UT. Proc. RMRS-P-9. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Miller, R.F. and L.L. Eddleman. 2000. Spatial and Temporal Changes of Sage Grouse Habitat in the Sagebrush Biome. Oregon State University, Agricultural Experiment Station. Tech. Bull. 151. Corvallis, OR.

Monsen, S. B., and S. G. Kitchen (compilers). 1994. Proceedings—ecology and management of annual rangelands. USDA Forest Service General Technical Report INT-GTR-313. Intermountain Forest and Range Experiment Station, Ogden, UT. 416 p.

Morgan, R.P.C. 1986. Soil erosion and conservation. D.A. Davidson (ed). Longman Scientific & Technical, Wiley, New York.

Morgan, R.P.C., K. McIntyre, A.W. Vickers, J.N. Quinton, and R.J. Rickson. 1997. A rainfall simulation study of soil erosion on rangeland in Swaziland. Soil Technology 11:291-99.

Ott, J. E., E. D. McArthur, and B. A. Roundy. 2003. Vegetation of chained and non-chained seedings after wildfire in Utah. Journal of Range Management 56: 81.91.

Pellant, M. and S.B. Monsen. 1993. Rehabilitation on public rangelands in Idaho, USA: a change in emphasis from grass monocultures. Pages 778-779 *IN*: anonymous (compilers), Proceedings of the XVII International Grassland Congress, 8-21 February 1993, Palmerston North, Hamilton, and Lincoln, New Zealand and Rockhampton, Australia. New Zealand Grassland Association, Tropical Grasslands Society of Australia, New Zealand Society of Animal Production, Australian Society of Animal Production – Queensland Branch, and New Zealand Institute of Agricultural Science. Keeling & Mundy, Palmerston North, New Zealand.

Pyke, D.A., P.H. Smith, J.M. Patterson, K.A. Ticknor, J.F. Henson, and S.D. Warren. 1999. Selecting Native Plants Using VegSpec – A Web-based Expert System. Pages 159-160, *IN*: Rose, R. & Haase, D. (eds.) Symposium proceedings -- Native plants: propagation and planting. Oregon State Univ., Nursery Technology Cooperative, Dept. of Forest Science, Corvallis.

Pyke, D.A., J.E. Herrick, P. Shaver, and M. Pellant. 2002. Rangeland health attributes and indicators for qualitative assessment. J. Range Manage. 55:584-597.

Rasmussen, G.A., M.P. O'Neill, and L. Schmidt, 1998. Monitoring Rangelands: Interpreting What You See. Utah State University Cooperative Extension Service: Department of Rangeland Resources, Logan UT.

Reynolds, T.D., C.H. Trost. 1980. The Response of Native Vertebrate Populations to Crested Wheatgrass Planting and Grazing by Sheep. Journal of Range Management 33:122-125.

Richards, R.T., J.C. Chambers and C. Ross. 1998. Use of native plants on federal lands: policy and practice. Journal of Range Management 51:625-632.

Robichaud, P.R. and R.E. Brown. 2002. Silt fences: an economical technique for measuring hillslope soil erosion. USFS Rocky Mountain Research Station, General Technical Report RMRS-GTR-94, Ft. Collins CO

Robichaud, P.R., J.L. Beyers, and D.G. Neary. 2000. Evaluating the effectiveness of postfire rehabilitation treatments. USDA Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-63, Fort Collins, CO.

Roundy, B.A., N.L. Shaw, D.T. Booth. 1997. Using Native Seeds on Rangelands. p. 1-8. *In:* N.L. Shaw and B.A. Roundy, comps. Proceedings: Using Seeds of Native Species on Rangelands. United States Department of Agriculture. Forest Service. Intermountain Research Station. Gen. Tech. Rep. INT-GTR-372. Ogden, UT.

SAS 1999. The Statistical Analysis System, Release 8.02 SAS Institute, Cary, NC.

Shaw, N. L., and B. A. Roundy (compilers). 1997. Proceedings: using seeds of native species on rangelands. USDA Forest Service General Technical Report INT-GTR-372. Intermountain Research Station, Ogden, UT. 30 p.
Page: 44

Tilman, D., J. Knops, D. Wedin, P. Reich, M. Ritchie, and E. Siemann 1997. The influence of functional diversity and composition on ecosystem processes. Science Vol. 277:1300-1302.

Thompson, T W. 2002. Fire rehabilitation in Tintic Valley, Utah using native and exotic species. M.S. thesis, Brigham Young University, Provo, UT. 67 p.

USDA NRCS (U.S. Department of Agriculture, Natural Resources Conservation Service). 2001. VegSpec Version 3.1 (http://plants.usda.gov and follow link to VegSpec). USDA NRCS Information Technology Center, Ft. Collins CO. October 23, 2003.

USDA NRCS (U.S. Department of Agriculture, Natural Resources Conservation Service). 2002. The PLANTS database, Version 3.5. (http://plants.usda.gov). National Plant Data Center, Baton Rouge LA.

Warren, S. D. 1995. Ecological role of microphytic soil crusts in arid ecosystems. p. 199-209 *in* D. Allsopp, R. R. Caldwell, and D. L. Hawksworth (eds.). Microbial diversity and ecosystem function CAB International.

West, N.E. 1988. Intermountain deserts, shrub steppes, and woodlands. p. 209-230. *In*: M.G. Barbour, and W.D. Billings. North American Terrestrial Vegetation. Cambridge University Press, New York.

Whisenant, S. G. 1990. Changing fire frequencies on Idaho's Snake River Plains: Ecological and management implications. p. 4-10 in E. D. McArthur, E. M. Romney, S. D. Smith, and P. T. Tueller, compilers. Proceedings—symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management. USDA Forest Service General Technical Report INT-276. Intermountain Forest and Range Experiment Station, Ogden, UT.

Wright, H. A. 1980. The role and use of fire in the semidesert grass-shrub type. USDA Forest Service General Technical Report INT-85. Intermountain Forest and Range Experiment Station, Ogden, UT. 24 p.

Wright, H. A., L. F. Newenschwander, and C. M. Britton. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities, a state-of-the-art review. USDA Forest Service General Technical Report INT-58. Intermountain Forest and Range Experiment Station, Ogden, UT. 48 p.

APPENDICES

APPENDIX 1. Administered Survey

EMERGENCY FIRE REHABILITATION OF BLM LANDS IN THE INTERMOUNTAIN WEST: REVEGETATION & MONITORING
SURVEY QUESTIONS

Introduction Dialogue*: Hello, My name is Ted McArthur I am working on a review of the Emergency Fire Rehabilitation program for the Washington D.C. office of the BLM. We are conducting a survey in the northern Intermountain West Field Offices of the BLM to get input from managers that, at one point or another, were in charge of developing EFR projects in the last 13 years. This survey is designed to get your thoughts on Native and non-Native species use as part of EFR projects, as well as your views on Monitoring of EFR projects. This will be an opportunity for you to express your ideas concerning these aspects of the EFR program. The summarized results will be published and presented to the Washington D.C. office of the BLM. Your name and field office and all your survey information will be kept confidential. This phone call will be recorded to help me get everything down exactly as you state it*, I will be the only person with access to the audiotapes from this conversation. All audiotapes will be locked in a file cabinet until the report is completed, and at that point all tapes will be destroyed, the latest date that this will occur is June 1st 2001. Participation in this survey is voluntary, and should you decide to participate in this survey you may decline to answer any of the questions. *This survey should take about forty-five minutes to complete.*
For future questions regarding the purpose of this study, or specifically about this survey please feel free to contact:
Ted McArthur at (541) 737-1604

Preliminary Question:
Are you willing to participate in this survey?
1. Yes ***(continue with survey)***
2. No ***(Thank for time and hang up)***

1. How would you define Native Species?

2. How would you define Introduced species?

3. In order of Importance, what elements do you consider when selecting plant species for EFR projects?

APPENDIX 1. Continued. Administered Survey

4. What are your reasons for using native species on EFR projects?

5. Do you feel that the **native** plants used on EFR projects have been beneficial?
   A. No (**If No go to question 7**)
   B. Yes

6. *If Yes to question 5*, why do you feel that the **native** plants are beneficial to EFR projects?

GO TO QUESTION 8

7**.** *If No, to question 5,* why do you feel that the **native** plants are not beneficial for EFR projects?

8. Why would you **not** use native species on EFR projects?

9. Would you use more native species if more seeds were available?

10. Would you have used more native species if they were less expensive?

11. How has your perception towards native plant use in EFR projects changed over time?

12. Do you feel that the **non-native** plants used in EFR projects are beneficial?
   A. No (**If No got to question 14**)
   B. Yes

APPENDIX 1. Continued. Administered Survey

13. *If Yes to question 12*, why do your feel that the **non-native** plants are beneficial to EFR projects?

GO TO QUESTION 15

14. *If No, to question 12*, why do you feel that the **non-native** plants are not useful to the EFR projects?

15. How has your perception towards non-native plant use in EFR projects changed over time?

16. Have monitoring plans generally been implemented for EFR projects that you have worked on?
A. No **(If No, go to question 27)**
B. Yes

17. *If Yes to question 16*, is the data collection for the monitoring plans usually completed?
A. Yes **(If Yes, go to question 19)**
B. No **(If No, go to question 18)**

18. *If No to question 16*, Why were data collection for monitoring plans not generally completed?

19. *If Yes to question 17,* is the monitoring/evaluation process useful?
A. No (If No, **go to question 21**)
B. Yes

20. *If Yes to question 19*, what makes the monitoring and evaluation useful?

GO TO QUESTION 22

21. *If No to Question 19*, why was the process and data not useful?

APPENDIX 1. Continued. Administered Survey

22. Do you prepare reports to summarize your findings?
A. No (**If No go to question 26**)
B. Yes

23. *If Yes to question 22*, do you distribute the results of your monitoring and evaluation?
A. No (**If No, go to question 25**)
A. Yes

24. *If Yes to question 23*, what motivates you to do so?

GO TO QUESTION #27

25. *If No to Question 23*, why do you not distribute your results?

GO TO QUESTION #27

26. *If No to question 22*, why do you **not** prepare reports to summarize your findings?

27. For what reasons do you **not** monitor and evaluate EFR projects?

28. How has your perception towards monitoring of EFR projects changed over time?

29. If information was readily available from other EFR projects would you use it as a resource?

30. If information was readily available from other EFR projects, rank in order of preference which of the following types of resources would you tend to use?
(Rank)
A Written report (e.g. publication)
B. Searchable database on a CD
C. Searchable database on the World Wide Web
D. I would not use other resources
E. E. Other (Please State)______________________

31. Do you feel that the goals of EFR projects are generally met?

32. Are there any issues about EFR policy and procedures that has not been adequately addressed in this survey that you would like to add?

APPENDIX 2. EFR Survey Results

	Number of Respondents	Proportion of Respondents
1. How would you define native species?		
Species that occurred in an area naturally (before Euro-American humans' influence)	**8**	**29%**
Species indigenous to (or evolved in) a specific local ecosystem	**20**	**71%**
2. How would you define introduced species?		
Species that do not occur naturally (introduced by European humans or through their activities) in an ecosystem	**12**	**43%**
Species that originated outside of North America	**8**	**29%**
Species that did not evolve in a specific (local) Ecosystem	**8**	**29%**
3. In order of importance, what elements do you consider when selecting plant species for EFR projects?		
Primary considerations-		
Species that have been successful in the past	**1**	**4%**
Species listed in the Ecological Site Description for that site	**2**	**7%**
Species that will meet objectives of the EFR plan	**4**	**14%**
Species with the ability to establish and survive on the site (under the specific seedbed conditions)	**17**	**61%**
Species' origin (native vs. introduced)	**4**	**14%**
Secondary considerations-		
Species that will meet objectives of the EFR plan	**3**	**11%**
Species with the ability to establish and survive on the site (under the specific seedbed conditions)	**13**	**46%**
Species that existed on the site before the fire	**3**	**11%**
Topography	**2**	**7%**
Species' origin (native vs. introduced)	**4**	**14%**
4. What are your reasons for using native species on EFR projects?		
To return the site to what was historically there (Return site to a natural state)	**8**	**29%**
To meet the needs for wildlife habitat	**7**	**25%**
To establish plants that are well adapted to the conditions on site while meeting EFR objectives and maintaining ecological processes on site (we do not understand all of the processes occurring on a site)	**7**	**25%**
To meet the requirements (recommendations) of the BLM Standards and Guidelines for Rangeland Health, unless they would not meet the EFR objectives.	**6**	**21%**

APPENDIX 2. Continued EFR Survey Results

5. Do your feel that native plants used on EFR projects have been beneficial?

No	**2**	**7%**
Yes and No	**18**	**64%**
Yes	**8**	**29%**

6. Why do you feel that the native plants are beneficial to EFR projects?

Native plants provide optimal wildlife habitat	**6**	**21%**
Native plants increase biodiversity	**3**	**11%**
Native plants, if those listed in the Ecological Site Description for the site, do not change the plant community found on the Ecological Site	**3**	**11%**
Native plants are adapted to area/site	**5**	**18%**
Native plants maintain ecological processes (keep site how it was; we do not understand all of the interactions on a site)	**7**	**25%**
Native plants belong there	**3**	**11%**
No response. Disagreed with the statement.	**1**	**4%**

7. Why do you feel that the native plants are not beneficial for EFR projects?

Native plants are difficult to establish when site conditions have changed or deteriorated (soils, species composition, etc..)	**15**	**54%**
Seeds of native plants are too expensive	**3**	**11%**
No response. Disagree with the statement.	**10**	**36%**

8. Why would you not use native species on EFR projects?

Native plant seed is not available	**6**	**21%**
Native plants do not tend to establish well, thus allowing for weeds to invade rapidly	**3**	**11%**
Available native species do not establish well in low precipitation zones	**2**	**7%**
Native plant seed is too expensive	**6**	**21%**
Native plants are not competitive when there is an extensive weed problem on the site	**6**	**21%**
I always use native species in seed mixtures	**3**	**11%**
Native plants are not effective for protecting sites prone to extreme erosion	**2**	**7%**

9. Would you use more native species if more seed was available?

Yes	**24**	**86%**
No	**4**	**14%**

10. Would you have used more native species if they were less expensive?

Yes	**21**	**75%**
No (not limited by funds)	**5**	**18%**
No	**2**	**7%**

APPENDIX 2. Continued EFR Survey Results

11. How has your perception towards native plant use in EFR projects changed over time?

My perception has not changed (have always seen value of using natives whenever possible, usually in a mix)	**11**	**39%**
I use more native species now because they are more available or cost less	**5**	**18%**
I am more willing to use natives as I learn about more about successes in using natives	**2**	**7%**
It has not changed; I use more because of the agency requirements	**2**	**7%**
In past I used to put out a simple monoculture of a species (e.g., crested wheatgrass), now I see the importance of using a complex seed mixture for site recovery and wildlife needs	**2**	**7%**
I am more willing to use natives	**2**	**7%**
Need to use more native seed in mixes to increase the probability of establishment	**2**	**7%**
My perception has not change. I use what will work best and will be economical, which is primarily introduced species)	**2**	**7%**

12. Do you feel that non-native plants used in EFR projects are beneficial?

Yes	**24**	**86%**
Yes and No	**4**	**14%**
No	**0**	**0%**

13. Why do you feel that the non-native plants are beneficial to EFR projects?

Non-native plants compete with the invasives species	**7**	**25%**
Non-native plants stabilize soils	**4**	**14%**
Non-native plants can establish on tough sites and prepare the site for later seral stages	**3**	**11%**
Non-native plants are easier to establish	**4**	**14%**
Non-native plants have good vigor (drought, grazing and cold resistant)	**4**	**14%**
Non-native plants are inexpensive	**3**	**11%**
Non-native plants successfully achieve desired results (proven track record over last 20 years)	**3**	**11%**

14. Why do you feel that the non-native plants are not useful to the EFR projects?

Non-native plants out-compete the desired native plants	**2**	**7%**
Non-native plants cause additional grazing pressure on natives	**1**	**4%**
Non-native plants make it harder for native forbs to establish	**1**	**4%**
Non-native plants increase fine fuel loads	**1**	**4%**
Non-native plants should not be used on some sites, because they are in good enough shape to support native species	**1**	**4%**
Non-native plants do not provide the diversity that natives do	**1**	**4%**
No response	**21**	**75%**

APPENDIX 2. Continued EFR Survey Results

15. How has your perception towards non-native plant use in EFR projects changed over time?

My perception towards the use of non-native plants in EFR projects has not changed. I always thought a mix of natives and non-natives is the most effective way revegetation	**3**	**11%**
My perceptions towards the use of non-native plants in EFR projects has not changed. I look at what species will work on the site and it is predominantly non-natives)	**4**	**14%**
I am now less likely to use just non-natives, but I like to use a mix of both native and non-native plants.	**5**	**18%**
I use less non-natives than I did historically	**5**	**18%**
I am now more likely to consider using native species first	**5**	**18%**
I use more complex seed mixtures now (grasses, forbs, and shrubs) that now includenative species	**6**	**21%**

16. Have monitoring plans generally been implemented for EFR projects in which you have worked?

Yes	**18**	**64%**
Yes and No	**4**	**14%**
No	**5**	**18%**
No response	**1**	**4%**

17. Is the data collection for the monitoring plans usually completed?

Yes	**13**	**46%**
Yes and No	**6**	**21%**
No	**3**	**11%**
No response	**6**	**21%**

18. Why was data collection for the monitoring plans not generally completed?

Not enough time or staffing	**4**	**14%**
Change in priority, work load limitations, monitoring first not to get done	**4**	**14%**
Unfamiliar with techniques	**1**	**4%**
No response	**19**	**68%**

19. Is the monitoring/evaluation process useful?

Yes	**17**	**61%**
Yes and No	**1**	**4%**
No	**2**	**7%**
No response	**8**	**29%**

20. What makes the monitoring and evaluation process useful?

Can assess success of plan at meeting objectives and goals	**11**	**39%**
Can learn about success of specific species (establishment and recruitment)	**6**	**21%**
No response	**11**	**39%**

APPENDIX 2. Continued EFR Survey Results

21. Why was the monitoring/evaluation process not useful?		
Ocular monitoring does not provide useful data	**1**	**4%**
Photo points are not real useful	**1**	**4%**
No follow up or evaluation of data, it is not required	**1**	**4%**
No response	**25**	**89%**
22. Do you prepare reports to summarize your findings?		
Yes	**12**	**43%**
No	**7**	**25%**
Yes and No	**1**	**4%**
No response	**8**	**29%**
23. Do you distribute the results of your monitoring and evaluation?		
Within the office yes	**3**	**11%**
No	**5**	**18%**
Yes	**4**	**14%**
Yes and No	**1**	**4%**
No response	**15**	**54%**
24. What motivates you to distribute the results of your monitoring and evaluation?		
To be able to show that EFR program is good and to show what does and does not work under what conditions	**2**	**7%**
Required for allotment reports	**2**	**7%**
It is done by an outside group	**2**	**7%**
No response	**22**	**79%**
25. Why do you not distribute your results?		
In house files are available on request	**1**	**4%**
Lack of staff to complete this	**1**	**4%**
Too busy	**1**	**4%**
I do not know who to send it to	**2**	**7%**
No response	**23**	**82%**
26. Why do you not prepare reports to summarize your findings?		
Not enough time	**3**	**11%**
Not required to prepare reports, no demand	**4**	**14%**
No response	**21**	**75%**
27. What are the reasons why you do not monitor and evaluate EFR projects?		
Monitoring is done for allotments, not for rehabs specifically	**2**	**7%**
Lack the money or people to complete the job	**5**	**18%**
Project is too small	**5**	**18%**
Work load is too heavy with other higher priorities and commitments set by management	**10**	**36%**
Standard seed mixture under normal conditions, no need to monitor	**2**	**7%**
Should always monitor	**2**	**7%**
No response	**2**	**7%**

APPENDIX 2. Continued EFR Survey Results

28. How has your perception towards monitoring of EFR projects changed over time?

My perception toward monitoring has not changed. I have always felt that monitoring is important in order to learn	**9**	**32%**
I feel that feel that monitoring is more important than I used to	**10**	**36%**
I have changed from using qualitative to more quantitative methods over the years	**4**	**14%**
I feel like we should be doing more monitoring than we are doing currently	**4**	**14%**
N/A	**1**	**4%**

29. If information from past EFR projects was readily available, would you use it as a resource?

Yes (if specific to sites that I am working on)	**6**	**21%**
Yes	**22**	**79%**
Yes and No	**0**	**0%**
No	**0**	**0%**
No response	**0**	**0%**

1st choice - Written report	**13**	**46%**
1st choice - Searchable database on WWW	**13**	**46%**
1st choice - Searchable database on CD	**2**	**7%**
2nd choice - Searchable database on WWW	**5**	**18%**
2nd choice - Searchable database on CD	**10**	**36%**
2nd choice - Written report	**6**	**21%**
Would not look at a secondary source	**7**	**25%**

31. Do you feel that the goals of EFR projects are generally met?

Yes	**23**	**82%**
No	**5**	**18%**

32. Are their any issues about EFR policy and procedures that has not been adequately addressed in this survey that you would like to add?

Need a standardized monitoring protocol, that is easy to understand and analyze	**2**	**7%**
Politics and policy can be driving forces; pushed to do things don't want to do (has taken creativity out, our hands are tied too much)	**2**	**7%**
Some people have an unrealistic perception of what you can do with natives	**2**	**7%**
Respondent understands that natives are good, but do not want to lose the option of using non-natives when needed	**2**	**7%**
Is their a way to develop a more efficient EFR process? There is too much paper work associated with plans.	**5**	**18%**
Get full time people to do rehab, not just temporary workers. Provide them with long-term training and follow-up	**2**	**7%**
Need to enforce recommendations (trespass issues)	**3**	**11%**

APPENDIX 3. Seeded Species with Associated Composition and Cover

Site	Seeded Species	Origin	% Comp in seed mix (seeds/lb)	% Community Composition at 5+ years	% Cover at 5+ years
F-550	*Elymus macrourus*; Thickspike wheatgrass	Nat.	22.0	11.0	7.7
	Onobrychis viciifolia; Sainfoin	Int.	22.0	0.0	0.0
	Pseudoroegneria spicata; Bluebunch wheatgrass	Nat.	27.0	3.0	2.1
	Agropyron fragile; Siberian wheatgrass	Int.	11.0	15.0	10.5
	Thinopyrum intermedium; Intermediate wheatgrass	Int.	11.0	0.0	0.0
	Psathyrostachys juncea; Russian wildrye	Int.	5.0	0.0	0.0
	Linum lewisii; Prairie flax	Nat.	2.0	2.0	1.4
Total			**100.0**	**31.0**	**21.7**
F-367	*Achnatherum hymenoides*; Indian ricegrass	Nat.	24.0	0.0	0.0
	Agropyron desertorum; Desert wheatgrass	Int.	13.0	0.0	0.0
	Thinopyrum intermedium; Intermediate wheatgrass	Int.	13.0	16.0	9.6
	Psathyrostachys juncea; Russian wildrye	Int.	8.0	1.0	0.6
	Pseudoroegneria spicata; Bluebunch wheatgrass	Nat.	6.0	7.0	4.2
	Medicago sativa; Alfalfa	Int.	6.0	0.0	0.0
	Sanguisorba minor; Small burnet	Int.	6.0	1.0	0.6
	Pursia tridentate; Antelope bitterbrush	Nat.	6.0	0.0	0.0
	Atriplex canescens; Four-wing saltbush	Nat.	6.0	1.0	0.6
	Dactylis glomerata; Orchardgrass	Int.	5.0	0.0	0.0
	Linum lewisii; Prairie flax	Nat.	3.0	1.0	0.6
	Artemisia tridentata wyomingensis; Wyoming big sagebrush	Nat.	2.0	0.0	0.0
	Artemisia tridentata vaseyana; Mountain big sagebrush	Nat.	2.0	1.0	0.6
Total			**100.0**	**28.0**	**16.8**

APPENDIX 3. Continued. Seeded Species With Associated Composition and Cover

F-445	*Psathyrostachys juncea*; Russian wildrye	Int.	17.0	0.0	0.0
	Agropyron fragile; Siberian wheatgrass	Int.	17.0	0.0	0.0
	Thinopyrum intermedium; Intermediate wheatgrass	Int.	17.0	2.0	0.8
	Agropyron desertorum; Desert wheatgrass	Int.	8.0	6.0	2.4
	Elymus macrourus; Thickspike wheatgrass	Nat.	8.0	0.0	0.0
	Medicago sativa; Alfalfa	Int.	16.0	0.0	0.0
	Atriplex canescens; Four-wing saltbush	Nat.	8.0	0.0	0.0
	Kochia prostrate; Forage kochia	Int.	4.0	0.0	0.0
	Artemisia tridentata wyomingensis; Wyoming big sagebrush	Nat.	2.5	0.0	0.0
	Artemisia tridentata vaseyana; Mountain big sagebrush	Nat.	2.5	0.0	0.0
Total			**100.0**	**8.0**	**3.2**
M-352	*Secale cereale*; Cereal rye	Int.	38.0	0.0	0.0
	Thinopyrum intermedium; Intermediate wheatgrass	Int.	24.0	6.0	3.4
	Pseudoroegneria spicata; Bluebunch wheatgrass	Nat.	13.0	20.0	11.4
	Melilotus officinalis; Yellow sweetclover	Int.	13.0	2.0	1.1
	Bromus marginatus; Mountain brome	Nat.	12.0	0.0	0.0
Total			**100.0**	**28.0**	**16.0**
M-379	*Pseudoroegneria spicata*; Bluebunch wheatgrass	Nat.	43.0	5.0	3.0
	Achnatherum hymenoides; Indian ricegrass	Nat.	21.0	1.0	0.6
	Leymus cinarius; Basin wildrye	Nat.	21.0	1.0	0.6
	Secale cereale; Cereal rye	Int.	11.0	1.0	0.6
	Native Forbs (not specifically identified in seed mix)	Nat.	4.0	2.0	1.2
Total			**100.0**	**10.0**	**5.9**

APPENDIX 3. Continued. Seeded Species With Associated Composition and Cover

M-380	*Pseudoroegneria spicata*; Bluebunch wheatgrass	Nat.	53.0	5.0	3.1
	Leymus cinarius; Basin wildrye	Nat.	24.0	0.0	0.0
	Atriplex canescens; Fourwing saltbush	Nat.	12.0	0.0	0.0
	Medicago sativa; Alfalfa	Int.	6.0	0.0	0.0
	Native Forbs (not specifically identified in seed mix)	Nat.	2.5	1.0	0.6
	Linum perenne; Blue flax	Int.	2.5	0.0	0.0
Total			**100.0**	**6.0**	**3.7**
R-349	*Thinopyrum intermedium*; Intermediate wheatgrass	Int.	30.0	36.0	20.5
	Bromus inermus; Smooth brome	Nat.	30.0	19.0	10.8
	Melilotus officinalis; Yellow sweetclover	Int.	8.0	0.0	0.0
	Medicago sativa; Alfalfa	Int.	7.0	0.0	0.0
	Sanguisorba minor; Small burnet	Int.	7.0	0.0	0.0
	Pseudoroegneria spicata; Bluebunch wheatgrass	Nat.	7.0	10.0	5.7
	Pursia tridentate; Antelope bitterbrush	Nat.	7.0	0.0	0.0
	Linum lewisii; Prairie flax	Nat.	4.0	0.0	0.0
Total			**100.0**	**65.0**	**37.1**
R-372	*Agropyron desertorum*; Desert wheatgrass	Int.	60.0	26.0	13.3
	Sanguisorba minor; Small burnet	Int.	15.0	1.0	0.5
	Kochia prostrate; Forage kochia	Int.	15.0	0.0	0.0
	Psathyrostachys juncea; Russian wildrye	Int.	8.0	23.0	11.7
	Atriplex canescens; Fourwing saltbush	Nat.	2.0	19.0	9.7
Total			**100.0**	**69.0**	**35.2**

APPENDIX 3. Continued. Seeded Species With Associated Composition and Cover

R-384	*Agropyron cristatum*; Crested wheatgrass	Int.	25.0	27.0	11.9
	Thinopyrum intermedium; Intermediate wheatgrass	Int.	13.0	6.0	2.6
	Bromus inermus; Smooth brome	Nat.	13.0	0.0	0.0
	Sanguisorba minor; Small burnet	Int.	13.0	0.0	0.0
	Dactylis glomerata; Orchardgrass	Int.	6.0	0.0	0.0
	Melilotus officinalis; Yellow sweetclover	Int.	6.0	0.0	0.0
	Medicago sativa; Alfalfa	Int.	6.0	0.0	0.0
	Linum lewisii; Prairie flax	Nat.	6.0	27.0	11.9
	Kochia prostrate; Forage kochia	Int.	6.0	0.0	0.0
	Pursia tridentate; Antelope bitterbrush	Nat.	6.0	0.0	0.0
Total			**100.0**	**60.0**	**26.4**
K-392	*Lolium perenne*; Perennial ryegrass	Int.	24.0	1.0	0.5
	Agropyron cristatum; Crested wheatgrass	Int.	19.0	26.0	12.5
	Thinopyrum intermedium; Intermediate wheatgrass	Int.	19.0	19.0	9.1
	Leymus cinarius; Basin wildrye	Nat.	10.0	5.0	2.4
	Pursia tridentate; Antelope bitterbrush	Nat.	10.0	0.0	0.0
	Sanguisorba minor; Small burnet	Int.	7.0	0.0	0.0
	Melilotus officinalis; Yellow sweetclover	Int.	7.0	0.0	0.0
	Achnatherum hymenoides; Indian ricegrass	Nat.	4.0	0.0	0.0
Total			**100.0**	**51.0**	**24.5**
Y-020	*Pseudoroegneria spicata*; Bluebunch wheatgrass	Nat.	49.0	15.0	8.0
	Elymus macrourus; Thickspike wheatgrass	Nat.	22.0	0.0	0.0
	Hesperostipa comata; Needleandthread	Nat.	16.0	0.0	0.0
	Elymus trachycaulus; Slender wheatgrass	Nat.	11.0	30.0	15.9
	Poa secunda; Sandberg bluegrass	Nat.	2.0	2.0	1.1
Total			**100.0**	**47.0**	**24.9**

APPENDIX 3. Continued. Seeded Species With Associated Composition and Cover

R-521	*Leymus cinarius*; Basin wildrye	Nat.	31.0	3.0	1.2
	Psathyrostachys juncea; Russian wildrye	Int.	21.0	9.0	3.7
	Secale cereale; Cerealrye	Int.	21.0	0.0	0.0
	Sanguisorba minor; Small burnet	Int.	11.0	0.0	0.0
	Atriplex canescens; Fourwing saltbush	Nat.	11.0	0.0	0.0
	Melilotus officinalis; Yellow sweetclover	Int.	5.0	0.0	0.0
Total			**100.0**	**12.0**	**4.9**
R-566	*Bromus inermus*; Smooth brome	Nat.	na	2.0	0.6
	Agropyron desertorum; Desert wheatgrass	Int.	na	1.0	0.3
	Pseudoroegneria spicata; Bluebunch wheatgrass	Nat.	na	24.0	7.7
	Achnatherum hymenoides; Indian ricegrass	Nat.	na	2.0	0.6
	Artemisia tridentate; Big sagebrush	Nat.	na	0.0	0.0
	Ericameria naseosa; Rubber rabbitbrush	Nat.	na	0.0	0.0
	Kochia prostrate; Forage kochia	Int.	na	0.0	0.0
	Sanguisorba minor; Small burnet	Int.	na	0.0	0.0
	Medicago sativa; Alfalfa	Int.	na	1.0	0.3
	Atriplex canescens; Fourwing saltbush	Nat.	na	0.0	0.0
	Melilotus officinalis; Yellow sweetclover	Int.	na	0.0	0.0
	Psathyrostachys juncea; Russian wildrye	Int.	na	6.0	1.9
Total				**36.0**	**11.5**
R-465	*Agropyron desertorum*; Desert wheatgrass	Int.	32.0	6.0	1.9
	Leymus cinarius; Basin wildrye	Nat.	23.0	0.0	0.0
	Thinopyrum intermedium; Intermediate wheatgrass	Int.	15.0	0.0	0.0
	Atriplex canescens; Fourwing saltbush	Nat.	15.0	0.0	0.0
	Atriplex confertifolia; Shadscale saltbush	Nat.	15.0	10.0	3.1
Total			**100.0**	**16.0**	**5.0**

APPENDIX 3. Continued. Seeded Species With Associated Composition and Cover

F-277	*Agropyron cristatum*; Crested wheatgrass	Int.	35.0	41.0	20.1
	Pseudoroegneria spicata; Bluebunch wheatgrass	Nat.	20.0	2.0	1.0
	Artemisia tridentate; Big Sagebrush	Nat.	13.0	1.0	0.5
	Medicago sativa; Alfalfa	Int.	13.0	2.0	1.0
	Pascopyrum smithii; Western wheatgrass	Nat.	10.0	4.0	2.0
	Atriplex canescens; Fourwing saltbush	Nat.	5.0	0.0	0.0
	Achillea millefolium; Common Yarrow	Nat.	4.0	0.0	0.0
Total			**100.0**	**50.0**	**24.5**
F-190	*Agropyron desertorum*; Desert wheatgrass	Int.	63.0	20.0	10.8
	Artemisia tridentata wyomingensis; Wyoming big sagebrush	Nat.	18.0	0.0	0.0
	Medicago sativa; Alfalfa	Int.	16.0	0.0	0.0
	Achillea millefolium; Yellow sweetclover	Int.	3.0	0.0	0.0
Total			**100.0**	**20.0**	**10.8**
F-113	*Agropyron fragile*; Siberian wheatgrass	Int.	29.0	20.0	9.6
	Thinopyrum intermedium; Intermediate wheatgrass	Int.	17.0	0.0	0.0
	Artemisia tridentata wyomingensis; Wyoming big sagebrush	Nat.	17.0	4.0	1.9
	Sanguisorba minor; Small burnet	Int.	9.0	0.0	0.0
	Onobrychis viciifolia; Sainfoin	Int.	9.0	1.0	0.5
	Medicago sativa; Alfalfa	Int.	9.0	0.0	0.0
	Elymus macrourus; Thickspike wheatgrass	Nat.	8.0	0.0	0.0
	Linum lewisii; Prairie flax	Nat.	2.0	0.0	0.0
Total			**100.0**	**25.0**	**12.0**
I-111	*Pseudoroegneria spicata*; Bluebunch wheatgrass	Nat.	94.0	6.0	2.4
	Sporobolus criptandrus; Sand dropseed	Nat.	4.0	1.0	0.4
	Artemisia tridentata wyomingensis; Wyoming big sagebrush	Nat.	2.0	0.0	0.0
Total			**100.0**	**7.0**	**2.8**

APPENDIX 3. Continued. Seeded Species With Associated Composition and Cover

N-113	*Pseudoroegneria spicata*; Bluebunch wheatgrass	Nat.	44.0	35.0	31.9
	Leymus cinarius; Basin wildrye	Nat.	44.0	4.0	3.6
	Artemisia tridentate; Big Sagebrush	Nat.	6.0	1.0	0.9
	Sporobolus criptandrus; Sand dropseed	Nat.	6.0	17.0	15.5
Total			**100.0**	**57.0**	**51.9**
M-726	*Pseudoroegneria spicata*; Bluebunch wheatgrass	Nat.	40.0	21.0	15.1
	Leymus cinarius; Basin wildrye	Nat.	30.0	0.0	0.0
	Atriplex canescens; Fourwing saltbush	Nat.	20.0	0.0	0.0
	Linum lewisii; Prairie flax	Nat.	5.0	0.0	0.0
	Penstemon palmeri; Palmer penstemon	Nat.	5.0	0.0	0.0
Total			**100.0**	**21.0**	**15.1**
X-393	*Agropyron desertorum*; Desert wheatgrass	Int.	57.0	35.0	15.8
	Atriplex canescens; Fourwing saltbush	Nat.	23.0	0.0	0.0
	Medicago sativa; Alfalfa	Int.	10.0	4.0	1.8
	Linum lewisii; Prairie flax	Nat.	9.0	0.0	0.0
	Artemisia tridentata wyomingensis; Wyoming big sagebrush	Nat.	1.0	0.0	0.0
Total			**100.0**	**39.0**	**17.6**
J-485	*Agropyron desertorum*; Desert wheatgrass	Int.	75.0	14.0	9.7
	Medicago sativa; Alfalfa	Int.	25.0	0.0	0.0
Total			**100.0**	**14.0**	**9.7**
J-484	*Agropyron cristatum*; Crested wheatgrass	Int.	58.0	6.0	2.2
	Atriplex canescens; Fourwing saltbush	Nat.	20.0	0.0	0.0
	Kochia prostrate; Forage kochia	Int.	10.0	1.0	0.4
	Linum lewisii; Prairie flax	Nat.	10.0	0.0	0.0
	Artemisia tridentata wyomingensis; Wyoming big sagebrush	Nat.	2.0	2.0	0.7
Total			**100.0**	**9.0**	**3.3**