AN ABSTRACT OF THE THESIS OF

Troy A. Wirth for the degree of Master of Science in Rangeland Resources and minor in Wildlife Science Presented on Febuary 29th, 2000. Title: Emergence, Survival and Reproduction of Three species of Forbs Important to Sage Grouse Nutrition in Response to Fire, Microsite and Method of Establishment

Abstract Approved (Signature redacted for privacy.
David Pyke

Since settlement of the Intermountain West, sage grouse abundance and productivity has declined and their range has decreased. The decline of sage grouse populations is primarily due to permanent loss and degradation of sagebrush-grassland habitat. Recently, several studies have shown that sage grouse productivity may be limited by the availability of certain preferred, highly nutritious forb species that have also declined within sagebrush ecosystems of the Intermountain West.

During the spring and summer, forbs are extremely important in maintaining the nutritional status and productivity of pre-laying hens and growth and survival of rapidly growing chicks. Researchers studying sage grouse have suggested several methods for restoring forbs in depleted sage grouse habitat. Among the methods proposed are prescribed fires that produce small mosaics of burned and unburned patches on the landscape. For this to occur, an adequate pre-burn forb community must exist in the location of the fire. In areas without adequate pre-burn forb communites, forbs must re-seed naturally or be revegetated. The purpose of this study was to determine the suitability of three species of forbs for revegetation projects where improving sage grouse habitat is a goal. Species suitability was determined by evaluating the emergence, survival and reproduction of *Crepis modocensis* Greene, *Crepis occidentalis* Nutt. and *Astragalus purshii* in response to method of establishment (seeding or transplanting), pre-establishment treatment (burned or unburned), and microsite (mound or interspace). Four prescription burns of sagebrush grassland were set at the United States Fish and Wildlife Service Hart Mountain National Antelope Refuge, Oregon. After burning, one experimental plot was randomly located within each burned and unburned site. Of the seeds planted in 1997, *A. purshii* had the lowest emergence (8%) of all three species. Both *Crepis* species had similar overall emergence (38%). Significantly more *Crepis* seedlings emerged from shrub mounds in unburned areas (50%) than in any other fire by microsite treatment (33 to 36%). Significantly more *A. purshii* emerged in the burned interspace (10.9) compared to the burned mounds (3.5). Nearly twice as many emerging *Crepis* seedlings survived in the burned areas as opposed to unburned areas ($P<0.01$). This resulted in more plant establishment in burned mounds despite higher emergence in unburned mounds. Microsite also significantly affected survival of *Crepis* seedlings ($P<0.01$). Approximately 10% more *Crepis* seedlings survived in mounds compared to interspaces. *A. purshii* seedlings also survived better in burned areas ($P=0.06$), but had no differential response to microsite. Fire enhanced survival of both *Crepis* and *A. purshii* transplants ($P=0.08$ and $P=0.001$), although, transplanting did not enhance plant establishment over seedings. Therefore, I conclude that revegetation of sage grouse habitat with *Crepis* species is a viable option given its high germinability, favorable response to fire and wide distribution.

Emergence, Survival and Reproduction of Three Species of Forbs Important to Sage Grouse Nutrition in Response to Fire, Microsite and Method of Establishment

By

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CONTRIBUTION OF AUTHORS

Dr. David Pyke was involved with the design and analysis of this experiment as well as the writing of this manuscript.

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INTRODUCTION

Sage Grouse Abundance and Habitat

The sage grouse (*Centrocercus urophasianus* Bonaparte) is a native upland gamebird found in the Intermountain West. Currently, there are two subspecies of sage grouse recognized by the American Ornithologists Union (AOU). These are the eastern (*C. u.* ssp. *urophasianus* Bonaparte) and western subspecies (*C. u.* ssp. *phaios* Aldrich). Sage grouse are sagebrush (*Artemisia* L. sp.) obligates; they are found only in areas dominated by this plant.

Since settlement of the Intermountain West, sage grouse abundance and productivity has declined and their range has decreased (Dalke et al. 1963, Crawford & Lutz 1985). The western subspecies was listed as a candidate for threatened and endangered status in 1985 by the United States Department of the Interior (Drut 1994) and subsequently reduced to a species of concern. Currently, remnant populations of sage grouse in the state of Washington as well as the Gunnison sage grouse in Colorado have been formally petitioned under the Endangered Species Act. Remaining populations of sage grouse are expected to be petitioned for listing in 2000. The state of Oregon has designated the sage grouse as a sensitive species.

The decline of sage grouse populations is primarily due to permanent loss and degradation of habitat. Large tracts of suitable sage grouse habitat have been lost due to removal of sagebrush (Drut 1994). The habitat that remains has been degraded by reseeding with exotic grasses, invasion of exotic annual plants, fire suppression, and historical overgrazing by livestock (Drut 1994).

Before settlement of the Intermountain West in the 1840's, much of the sagebrush steppe consisted of "open stands of shrubs with a strong component of long-lived perennial grasses and forbs in the understory" (Miller et al. 1994). Since settlement, the abundance of perennial grasses and forbs in these communities has decreased while the abundance and density of sagebrush has increased. Historical overgrazing and fire suppression are the primary causes of this shift in the plant community (Laycock 1967, Eddleman 1989, Winward 1991, Miller et al. 1994).

Sage Grouse Nutrition

During fall and winter, when grasses and forbs are dormant and insects are scarce, sage grouse depend wholly upon sagebrush for food. During the spring, their diet changes to reflect the availability of insects and herbaceous vegetation in their environment, primarily beetles and forbs (Klebenow and Gray 1968). In spring and summer, sage grouse movements and habitat use are affected by the availability of forbs. In areas where forbs are abundant, broods will remain near their nesting sites until forbs become unavailable (Autenrieth 1981). As desiccation of forbs occurs in upland areas, sage grouse move toward more mesic meadows, lakebeds and springs where forbs are still green.

Forbs contain higher amounts of protein, calcium and phosphorous than sagebrush. During the pre-laying and chick-rearing periods, forbs are extremely important in maintaining the nutritional status and productivity of pre-laying hens, and growth and survival of rapidly growing chicks (Barnett and Crawford 1994, Drut et al. 1994). In feeding trials, Johnson & Boyce (1990) showed that decreased nutritional intake resulted in higher mortality of sage grouse chicks. Also, two recent studies have shown that adult sage grouse productivity is lower in areas where highly nutritious foods (i.e. forbs and insects) are less abundant (Barnett & Crawford 1994, Drut et al. 1994). These studies compared abundance of foods important to sage grouse chicks and pre-laying hens at two ecological sites in eastern Oregon (Hart Mountain and Jackass Creek) that differed in long-term sage grouse productivity. Hart Mountain averaged 1.6 sage grouse chicks/hen and Jackass Creek averaged 0.9 chicks/hen from 1985 to 1992. At Hart Mountain, there were significantly greater amounts of forbs, insects and grasses than at the Jackass Creek site. These studies also determined the genera of forbs selected by sage grouse with greater frequency than their occurrence in the environment. Plants most consumed by pre-laying hens based on frequency and mass were *Crepis* L. spp., *Astragalus purshii* Dougl. ex Hook., *Phlox longifolia* Nutt. and *Lomatium* Raf. spp. (Barnett & Crawford 1994). Sage grouse chicks most frequently consumed *Crepis* L. spp., *Trifolium* L. spp., *Astragalus* L. spp., *Taraxacum* G. H. Weber ex Wiggers, *Agoseris* Raf. spp. and *Microsteris gracilis* (Hook.) Greene. (Drut et al. 1994).

Sage Grouse Habitat Management

Many techniques to manage semi-arid lands for sage grouse habitat in the Great Basin have been developed (Autenrieth 1981). Fire and herbicides have been used to reduce sagebrush density and allow establishment or recovery of perennial forbs and grasses. Fire is effective at reducing sagebrush densities while increasing forb biomass and cover until shrub dominance is re-established (Pechanec et al. 1954, Harniss and Murray 1973). Forb response to fire is dependent on plant morphology and the timing and intensity of burning (Bunting et al. 1988, Young 1983, Wright 1982). Herbicides have the potential to damage forb populations if applied incorrectly and may have other undesirable effects such as persistence in the environment and toxicity to other life forms.

Revegetation with non-native grasses and forbs has been used to increase available foods for sage grouse, but no research has been done to confirm that non-native forbs are preferred and fulfill the nutritional requirements of sage grouse. Sage grouse require sagebrush for cover, nesting, and food. Fire, herbicides, and traditional methods of revegetation sacrifice one habitat requirement, sagebrush, to satisfy another, forbs. Grazing management is employed to avoid disturbance of sage grouse leks and nests. Cattle outcompete sage grouse for forage especially in mesic areas where they are more likely to interact. Grazing cattle at appropriate times and locations can reduce harmful cattle-grouse interactions (Autenrieth 1981).

Researchers studying sage grouse have suggested several methods for restoring depleted sage grouse habitat (Autenrieth 1981, Barnett & Crawford 1994, Drut 1994, Welch et al. 1990). Among the methods proposed are prescribed fires that produce small mosaics of burned and unburned patches on the landscape (Crawford et al. 1992). With this method, forbs would increase in burned areas when released from competition with sagebrush, while leaving nearby unburned patches for sage grouse nesting and cover. For this to occur, an adequate pre-burn forb community must exist in the location of the fire. In areas without adequate pre-burn forb communities, forbs must re-seed naturally or be revegetated.

Factors Affecting Forb Establishment

Microtopography plays an important role in the establishment of plants by providing safe sites for germination and growth. Blackburn (1975) discussed the biophysical characteristics of the two most common microsites in semi-arid regions of the Great Basin. These are coppice dunes, which are found underneath canopies of sagebrush, and dune playettes, which are found in the areas between sagebrush canopies. Eckert et al. (1986a) refined the microtopography concept and related it to plant establishment. They defined four microsites that occur in *A. tridentata* ssp. *wyomingensis* Beetle and Young plant communities in the northern Great Basin. These microsites are coppices, coppice benches, intercoppice microplains, and playettes, each with a unique soil surface type. Coppices consist of conical-raised areas in topography and are found primarily under shrub canopies. Coppice benches are the sloping areas next to coppices while intercoppice microplains are flat areas next to coppice benches. Playettes consist of slightly depressed or flat areas and have the lowest elevation of the four microtopographic areas. Eckert et al. (1986b) found that establishment of desirable species was highest on the coppices and coppice benches and suggested that areas with higher percentages of these microsites may be more successful in natural revegetation.

Because the coarser scale microtopography described by Blackburn (1975) is easier to distinguish than the four microsites described by Eckert (1986a) after a fire, my study focused on mounds (coppice dunes) and interspaces (dune interspaces). Mounds encompass both coppices and coppice benches, while interspaces encompass the intercoppice microplains and playettes described by Eckert et al. (1986a). Mounds have slightly higher microtopography, higher vegetative cover, increased water infiltration, cooler temperatures, and lower levels of solar radiation than interspaces. Doescher et al. (1984) found that soil from mounds in high grass, low shrub sites contained twice the nitrogen and organic matter than interspace areas. Furthermore, phosphorous, potassium, calcium and magnesium were also higher on mounds than interspaces. Magnesium and pH did not differ among microsites in the upper 20 cm of the soil. However, magnesium in deep horizons was significantly higher in the interspace than in the mound. Significantly higher amounts of available nutrients within mounds may allow higher seedling establishment in these microsites.

PURPOSE

The purpose of this study was to determine the suitability of three species (*Crepis modocensis* Greene, *Crepis occidentalis* Nutt. and *Astragalus purshii* Dougl. ex Hook. var. *tinctus* M.E. Jones) for revegetation projects where improving sage grouse habitat is a goal. Species suitability was determined by evaluating the emergence, survival and reproduction in response to method of establishment (seeding or transplanting), pre-establishment treatment (burned or unburned), and microsite (mound or interspace).

I hypothesized that strategic placement of seeds or transplants in mound microsites during a revegetation effort would significantly improve plant establishment. Broadcast seeding and drilling are two techniques commonly used for grass-forb mixtures; however, they distribute seeds in regular patterns across the landscape. Since native forb seed is expensive and often commercially unavailable, this approach may not be the most cost-effective method of establishment because many seeds will land on unfavorable microsites. Planting seeds or transplants in microsites with favorable environmental factors may maximize the establishment of native forb populations.

STUDY SITES

The U. S. Fish and Wildlife Service (USFWS) chose eight similar 400-hectare study areas at Hart Mountain National Antelope Refuge in southeastern Oregon that are located within current and historical sage grouse range (Fig. 1). The climate in this region is semi-arid, temperate and continental, with hot, dry summers, and cold, moist winters. Annual precipitation ranges from 203 to 305 mm per year. The USFWS excluded livestock grazing in December 1990 (USFWS 1994); however, wild horses, pronghorn antelope, mule deer and small mammals had free access to all sites.

All sites occur on the clayey 10-12 inch ecological site (USDA-NRCS 1998). The potential natural plant community for this ecological site is Wyoming big sagebrush – bluebunch wheatgrass association, with approximately 75% grass, 10% forb and 15% shrub composition by weight. Current dominant plants at the site are *Artemisia tridentata* ssp. *wyomingensis* associated primarily with perennial grasses, *Poa secunda* J. Presl., *Elymus elymoides* (Raf.) Swezey and to a lesser extent *Achnatherum thurberianum* (Piper) Barkworth and *Pseudoroegneria spicata* (Pursh) A. Löve. Some meadows do occur at the sites and are dominated by *Artemisia arbuscula* Nutt., *Poa secunda* and associated forbs, but these areas were not included in this study.

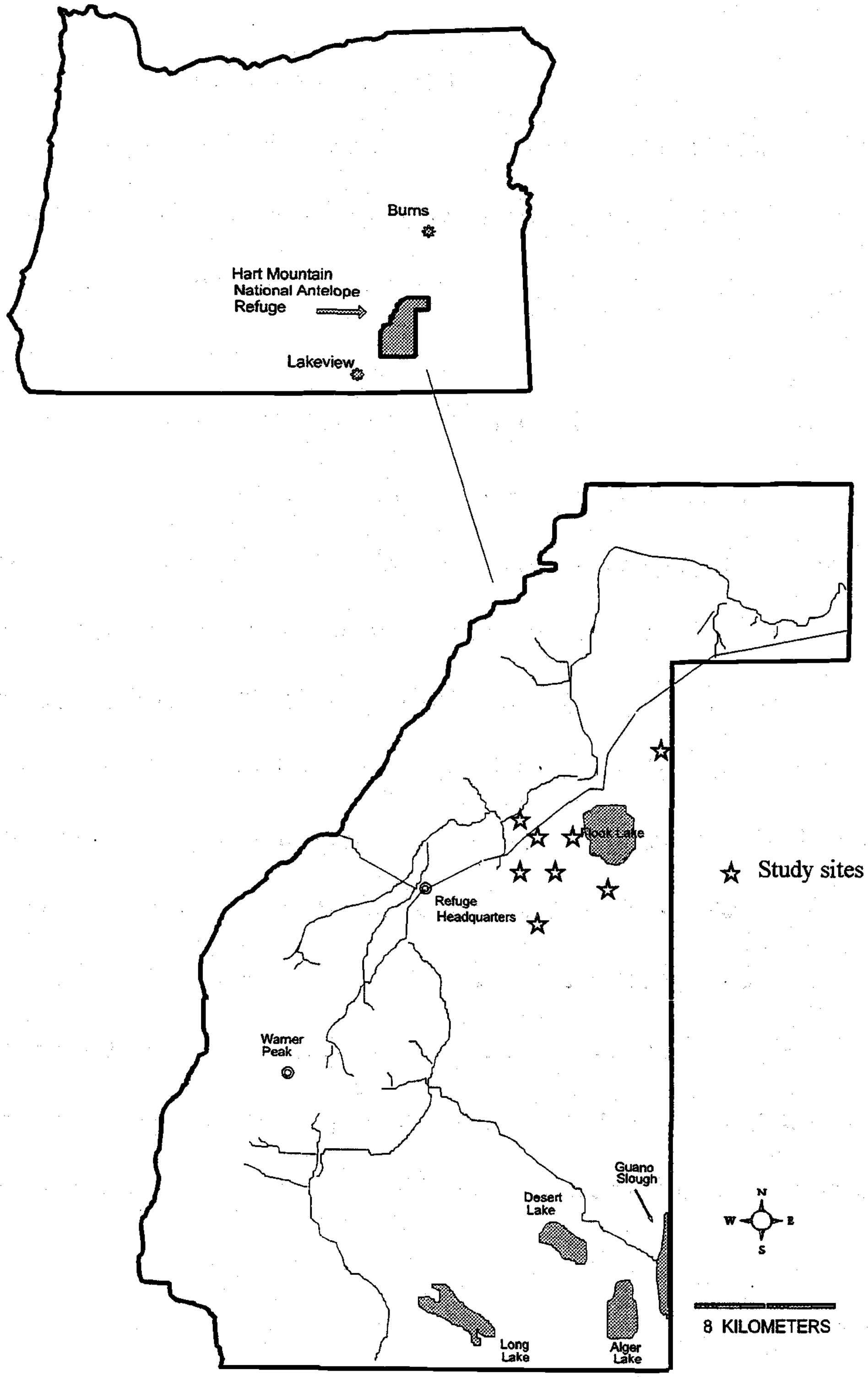

Figure 1. Location of Hart Mountain National Antelope Refuge study sites, Lake County , Oregon. Map courtesy of OSU Gamebird Research Program.

MATERIALS AND METHODS

Prescribed Fires and Community Response

In autumn 1997, the USFWS randomly selected and burned four of the eight sites. Fires were ignited by two methods, drip torch (site 1) and helitorch (sites 2-4). Fire behavior varied among and within each fire due to differing weather conditions and the large size of treated areas.

I clipped, dried (60°C for 48 hours) and weighed pre- and post-burn fine fuel loads (herbaceous vegetation and litter) within 25 randomly located 20 x 50-cm plot frames (Table 1). Fire consumption of fine fuel (percentage consumed) was calculated as the difference between the average before- and after-fire biomass divided by the before–fire biomass multiplied by 100 (Table 1). I estimated sagebrush biomass per ha by harvesting five randomly selected whole plants at each site before the fires and multiplied the combined average by the sagebrush density at each site. Sagebrush density (plants/ha) was estimated using the point-centered-quarter method (n=50) (Pieper 1973).

Immediately before each fire, I took ten samples per site of both the understory and overstory vegetation to determine pre-ignition moisture content (Table 1). These samples were placed in paper bags and then sealed in airtight plastic bags to avoid loss of moisture, weighed, and then dried at 60°C for 48 hours and re-weighed to determine moisture content.

Table 1. Mean sagebrush density (plants/ha), biomass (kg/ha), pre and post-fire understory biomass (kg/ha), and overstory and understory moisture (%) at the four burned sites at Hart Mountain National Antelope Refuge in the autumn of 1997. Figures in parentheses are standard errors. The average sagebrush plant weighed 0.36 kg.

Site	Brush Density	Brush Biomass	Pre-fire Understory	Post-fire Understory	% Consumed	Overstory Moisture	Understory Moisture
1	29,091	10,482	1406 (365)	562 (281)	60.0%	20.86 (1.67)	4.27 (0.09)
2	16,063	5,788	1855 (228)	126 (15)	93.2%	22.53 (3.04)	4.15 (0.63)
3	17,308	6,236	1677 (279)	153 (21)	90.8%	24.23 (1.30)	4.60 (0.49)
4	17,655	6,361	1262 (132)	328 (71)	74.0%	20.05 (1.55)	6.46 (0.58)

Fire behavior data at each site were difficult to obtain due to the size of the fire, smoke, topography and fire hazard. Fire behavior data were collected when possible, but these data are subject to bias by the location of the observer, wind at the time of observation, lighting technique for that particular "run" of flame and other factors. During the fire, observers visually estimated flame height, depth, angle and length (**F_L**). Rate of spread (**R**) was estimated by timing how long the fire took to move a specific distance, or by the visual estimates of experienced observers (Table 2). Fireline intensity (**I**, kW/m^2) and heat per unit area (**H_A**, kJ/m^2) were estimated according to Rothermel & Deeming (1980) with the following equations:

$$\mathbf{I} = 258\ \mathbf{F_L}^{2.17},$$

$$\mathbf{H_A} = 60\mathbf{I} / \mathbf{R}$$

Table 2. Mean flame length (m), height (m), depth (m), angle (%), spread (m/s), residence time (s), intensity (kW/m^2), and heat/area (kJ/m^2) of each fire at Hart Mountain National Antelope Refuge, OR in autumn 1997.

Site	Flame Length	Flame Height	Flame Depth	Flame Angle	Flame Spread	Residence Time	Intensity	Heat/Area
1	4.0	2.7	2.7	44.3	.10	153	9,128.93	91,289
2	4.2	3.25	4.0	52.5	.07	92.5	9,422.68	123,982
3	4.4	3.3	7.8	4.0	.20	49	9,897.21	52,090
4	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data

All four fires were head fires. Site one was ignited shortly after 12:00 on 23 September 1997. The relative humidity at the time of ignition was 19-21%, windspeed was 11.3 – 16.1 km/h from the southeast and the temperature was 26.6 °C. Due to an accident involving the transport of helicopter fuel to the helipad in Lakeview, OR, this fire was ignited by driptorch only. The fire carried little and required constant re-lighting. Site two was ignited at 15:20 on 24 September 1997 by helitorch. The relative humidity at the time of ignition was 17% and windspeed was 3.2 to 8.0 km/h from the west. The fire at site two carried more than at site one due to decreased humidity and the arrival of the helitorch. This fire had the highest $\mathbf{H_A}$ of all four fires. No burning took place on 25 through 27 September 1997 due to adverse weather conditions. Site three was ignited at noon on 28 September 1997. At the time of ignition, windspeed was 8.0 to 11.3 km/h from the east, relative humidity was 24% and the temperature was 18.9 °C. The fire at site three was relatively intense, fast moving, and carried well. Site four was ignited at 14:30 on 28 September 1997. At site four, relative humidity was 18%, wind speed was

8.0 to 11.3 km/h from the east and the temperature was 23.3 °C. Fire behavior at site four was not obtained due to high fire hazards, however, site four appeared to burn similar to site three.

I estimated species composition by the Daubenmire (1959) canopy coverage method modified by locating 50 quadrats individually and randomly at each site. Coverage data were collected for each plant species in June 1997 before burning. Eight, 1-ha experimental plots were established in September 1997. Coverage was measured at the 1-ha experimental plots in July 1998 and 1999. Because pre-fire data were collected in larger areas than post-fire data, direct comparisons should not be made between years, but general trends can be implied as to effects of fire on species composition (Table 3). A list of species cover and composition by site is given in appendix F.

Table 3. Shrub, grass and forb cover (%) and composition (%) at the eight locations in 1997, 1998 and 1999 at Hart Mountain National Antelope Refuge, OR

	Cover			Composition		
1997	**Shrub**	**Grass**	**Forb**	**Shrub**	**Grass**	**Forb**
Site 1 - Burned	33.8	10.6	11.5	60.6	18.9	20.5
Site 2 - Burned	24.2	16.6	8.0	49.6	34.0	16.4
Site 3 - Burned	30.1	12.8	8.8	58.0	25.0	17.0
Site 4 - Burned	21.7	8.9	9.1	54.7	22.4	23.0
Site 5 - Unburned	22.2	11.8	15.9	44.5	23.6	31.9
Site 6 - Unburned	20.6	9.7	7.2	54.9	25.8	19.3
Site 7 - Unburned	20.0	11.6	8.0	50.5	29.2	20.2
Site 8 – Unburned	27.9	9.9	11.4	56.5	20.3	23.3
	Cover			**Composition**		
1998	**Shrub**	**Grass**	**Forb**	**Shrub**	**Grass**	**Forb**
Site 1 - Burned	0.2	6.9	37.2	0.5	15.7	84.3
Site 2 - Burned	0.0	8.7	39.8	0.0	17.9	82.1
Site 3 - Burned	0.2	8.1	42.9	0.2	15.8	84.0
Site 4 - Burned	0.0	24.5	23.2	0.0	51.3	48.7
Site 5 - Unburned	22.4	9.4	26.1	38.7	16.3	45.0
Site 6 - Unburned	27.2	14.8	11.3	51.0	27.7	21.3
Site 7 - Unburned	18.5	18.3	15.2	35.5	35.2	29.3
Site 8 - Unburned	31.2	8.1	8.9	64.8	16.8	18.4
	Cover			**Composition**		
1999	**Shrub**	**Grass**	**Forb**	**Shrub**	**Grass**	**Forb**
Site 1 - Burned	0.0	10.0	42.0	0.0	19.2	80.8
Site 2 - Burned	0.0	17.5	38.2	0.0	31.4	68.6
Site 3 - Burned	0.3	19.0	64.6	0.6	35.3	64.1
Site 4 - Burned	0.3	34.6	7.6	0.6	82.0	18.0
Site 5 - Unburned	20.4	14.2	16.6	39.9	27.7	32.4
Site 6 - Unburned	19.3	16.4	8.2	44.0	37.4	18.5
Site 7 - Unburned	20.5	14.8	7.5	47.9	34.5	17.6
Site 8 - Unburned	28.1	8.7	4.9	67.4	20.8	11.8

Forb Restoration

I used a randomized block split-plot design for the forb restoration experiment (Fig. 2). After burning, one 1-ha (100 x 100m) experimental plot was randomly located within each of the eight original 400 ha sites, resulting in four burned and four unburned site replicates.

In late June 1997, I collected seeds of three forb species, *Crepis occidentalis*, *Crepis modocensis* and *Astragalus purshii* within 10 km of the sites. Seeds were collected to sample the highest amount of genetic diversity (Knapp and Rice 1994). In the laboratory I sorted viable seeds from nonviable seeds by fruit presence, size and color. For *Crepis occidentalis*, viable seeds were dark brown, firm, and visibly wider than nonviable seeds. Viable seeds of *Crepis modocensis* were firm, usually dark green, but some were light brown. There were three kinds of *A. purshii* seeds, green, brown and black. Green seeds were small and undeveloped while brown seeds were small and brittle. Only black seeds that were large compared to the green and brown seeds were selected for planting. The Oregon State University Seed Research Laboratory in Corvallis, OR conducted standard seed viability tests with tetrazolium chloride.

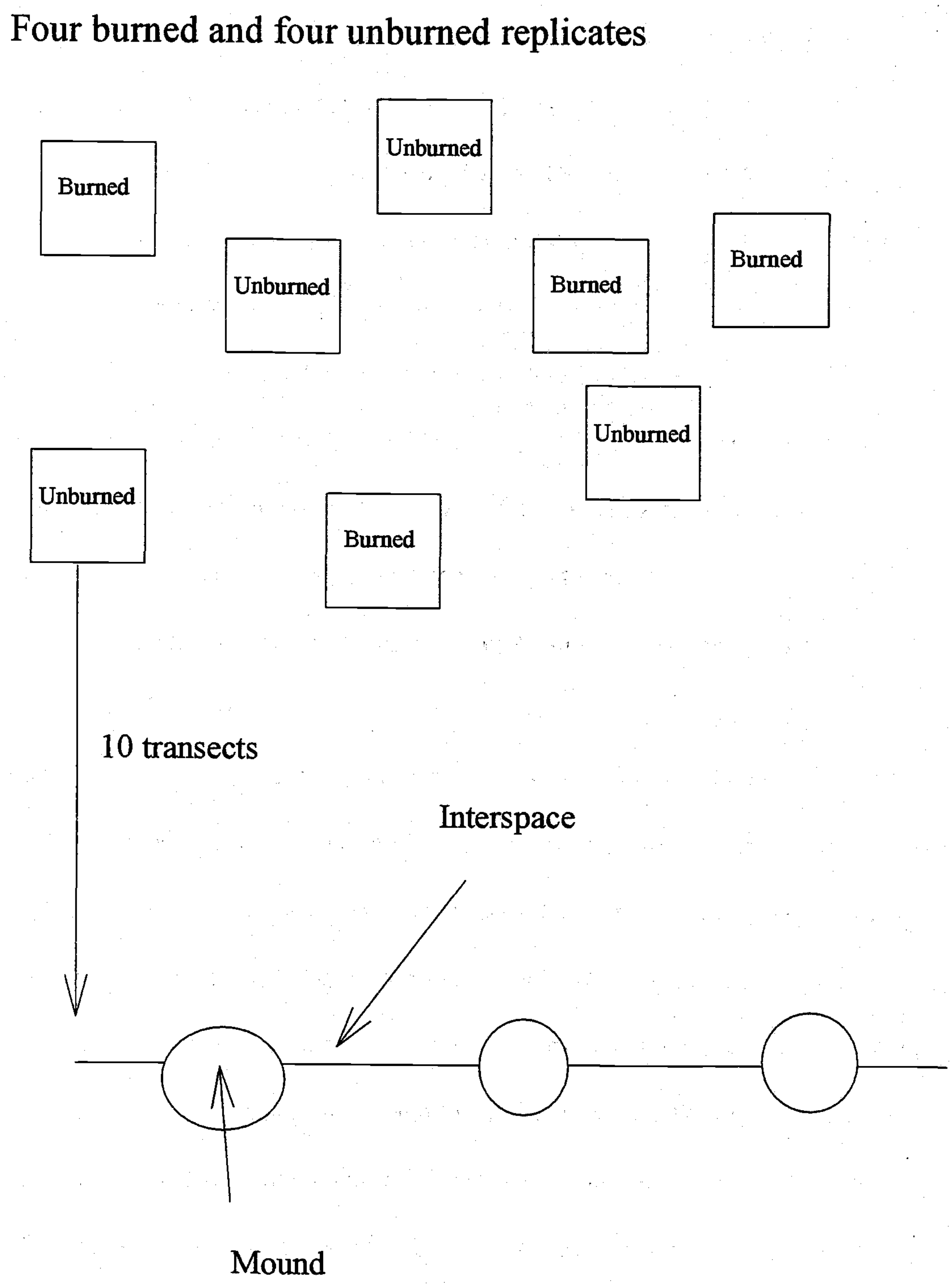

Figure 2. Experimental design of forb restoration project at Hart Mountain National Antelope Refuge

In October 1997, I sowed 250 seeds of each species at each site along 10, 80-m transects. Each transect was randomly located along and perpendicular to a 100-m baseline. At each location, one seed was planted 1 cm deep within alternating microsites, mounds and interspaces, as they occurred naturally along each transect. I randomized the species order along each transect. The distance of each seed along each transect baseline was recorded and marked by a nail 10 cm after each seed.

Monitoring for seedling emergence began on 21 March 1998 by checking the location of each planted seed along each transect. If the seedling emerged, I noted its survival status and placed a wire ring around the stem to facilitate relocation. Censuses occurred on 8 and 28 April, 19 May, 17 June, 7 and 28 July in 1998 and 17 April, 15 May, 15 June and 20 July in 1999.

Seedlings of each species were raised at Oregon State University during the winter of 1997/8. These seeds came from the same accession as those sown in the field in autumn 1997. All seeds underwent cold stratification while buried 1.0 cm deep in moist sand at 2.2° C for 6 weeks beginning in December 1997 and then were placed in a heated greenhouse (20 °C day/night) to germinate. When the cotyledon emerged from the sand, I transplanted the seedlings into styrofoam vent blocks (1.9-cm diameter by 12.7-cm deep) filled with a mixture of 30% potting soil and 70% loam. Transplants were grown for 10 weeks in the greenhouse and then placed in a cold frame for 3 weeks to harden before transplantation. I planted the seedlings into the field on 28 April 1998 and censused their survival status on the same dates as the seeded transects. Due to a limited number of

Crepis transplants, only three burned and three unburned sites received transplants. Sites one, two, three, five, seven and eight received 50 transplants per *Crepis* species and microsite. All sites received 50 transplants per microsite of *A. purshii.*

I analyzed establishment of emerged seedlings and transplants using two techniques. I tested for significant differences among treatments in emergence and proportional survival using analyses of variance (SAS, PROC MIXED; SAS Institute 1996). The ANOVA's for emergence compared the proportion of those plants that emerged by the second growing season (15 June 1999) in each treatment, while the ANOVA's for proportional survival compared the proportion of emerged plants that survived to the end of the second growing season (15 June 1999). These ANOVA's used individuals from all cohorts in each analysis. Full ANOVA tables for each analysis are presented in appendix G. The SAS MIXED procedure calculates population parameters based on density functions. Therefore, these ANOVA tables do not have some of the information normally given in ANOVA tables. Data for ANOVA's of *A. purshii* emergence and *Crepis* transplant survival were arcsin squareroot transformed because these mean proportions were below 0.3, resulting in non-normal distributions. Proportional emergence and survival in all other analyses were between 0.3 and 0.7 and transformation has little effect in this region (Steel et al. 1997). Back-transformed means are reported where appropriate.

Survival rates were compared among treatments for individuals from cohort 1 of each species using Peto and Peto's logrank test (Pyke and Thompson 1986, Hutchings et al. 1991). Cohort 1 consisted of plants emerging from seed before 21 March 1998. This cohort was the largest of any cohort with 72% and 68% of all emerging *Crepis* and *A. purshii* seedlings, respectively. This analysis generated an estimate of the daily risk of mortality during each census period and treatment combination. The 95% confidence intervals around each rate for each treatment and census date were used to determine differences among treatments at each census period.

RESULTS

In 1998, there was above average precipitation, leading to a longer growing season than normal. In 1999, the growing season was shortened due to cold temperatures lasting farther into the spring than normal followed by very little precipitation. Although viability was high for the three species, emergence of *A. purshii* was approximately 10% that of the two *Crepis* species. Seed viability for both *Crepis* species was 93%, whereas for *A. purshii* it was 100%. Because of this large difference in emergence, *A. pur*shii was analyzed separately from the two *Crepis* species for both emergence and survival.

Emergence did not differ between the two species of *Crepis* regardless of fire and microsite treatments (P=0.87). The mound microsite was only an advantage for *Crepis* emergence in unburned sites (fire by microsite interaction, P<0.01, Fig. 3a). Emergence from all other treatments was statistically similar.

As with the *Crepis* species, I found a fire by microsite interaction for emergence of *A. purshii* seedlings (P=0.02), however, the microsite effect was opposite that of *Crepis.* Emergence of *A. purshii* was higher in the burned interspace compared with the burned mound (P=0.01 Fig 3b). All other comparisons did not differ statistically.

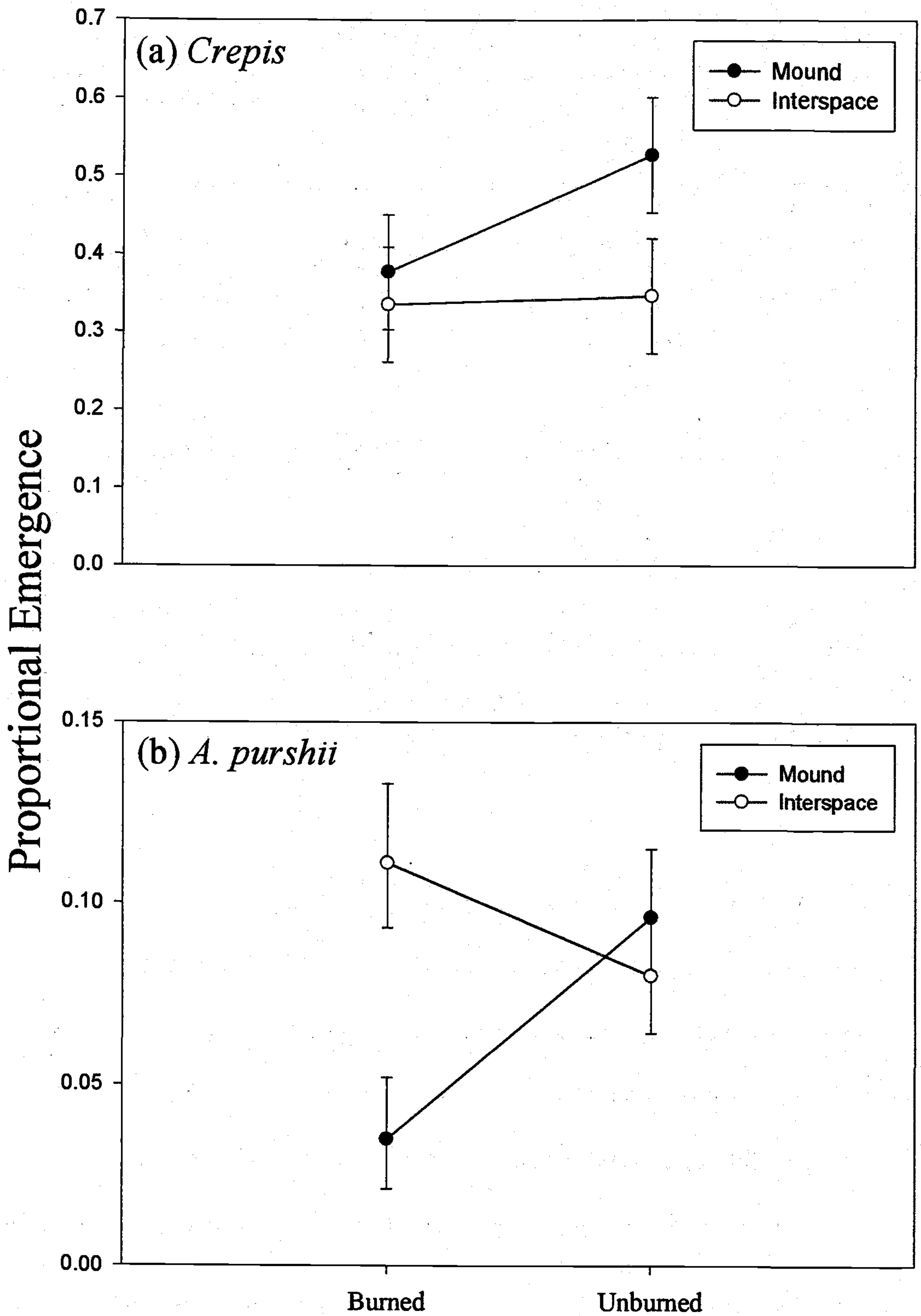

Figure 3. (a) Mean emergence (± S.E.) of *Crepis occidentalis* and *C. modocensis* combined in response to fire and microsite and (b) mean emergence (± S.E.) of *A. purshii* in response to fire and microsite.

Table 4. Mean emergence and survival from seed and transplants (± 1 S.E.) at the end of the second growing season (July 1999) for all cohorts of plants emerging in four treatments at Hart Mountain National Antelope Refuge, OR

Autumn 1997 Emergence	**Burned Mound**	**Burned Interspace**	**Unburned Mound**	**Unburned Interspace**
C. modocensis	34.6 (7.8)	33.8 (7.8)	55.3 (7.8)	35.6 (7.8)
C. occidentalis	40.7 (7.8)	33.3 (7.8)	50.2 (7.8)	33.6 (7.8)
A. purshii	3.5 (+1.7,-1.4)	10.9 (+2.2,-1.8)	9.6 (+1.9,-1.9)	8.0 (+1.7,-1.6)
Autumn 1997 Seedling Survival	**Burned Mound**	**Burned Interspace**	**Unburned Mound**	**Unburned Interspace**
C. modocensis	60.0 (5.7)	46.1 (5.7)	38.1 (5.7)	25.7 (5.7)
C. occidentalis	62.6 (5.7)	53.6 (5.7)	34.3 (5.7)	24.9 (5.7)
A. purshii	39.8 (8.5)	44.3 (8.5)	26.0 (8.5)	18.5 (8.5)
Spring 1998 Transplant Survival	**Burned Mound**	**Burned Interspace**	**Unburned Mound**	**Unburned Interspace**
C. modocensis	14.9 (+4.6,-4.0)	6.6 (+3.2,-2.6)	4.9 (+2.8,-2.2)	2.0 (+1.9,-1.3)
C. occidentalis	22.4 (+5.5,-4.9)	15.2 (+4.6,-4.0)	9.7 (+3.8,-3.2)	8.1 (+3.5,-2.9)
A. purshii	50.5 (4.4)	50.7 (4.4)	16.0 (4.4)	18.5 (4.4)

Proportional survival of the two *Crepis* species emerging from seed was similar under all treatments (P=0.69). *Crepis* survival was higher in burned compared to unburned sites and was nearly 10% higher on mounds than interspaces (P<0.01 for each treatment, Figs. 4 and 5). There were no interactions among any treatments (P=0.29).

Survivorship of the first cohort of seeded *Crepis* differed during different census periods (*C. modocensis,* df=3, χ^2= 22.2, P<0.01; *C. occidentalis,* df=3, χ^2 =37.4, P<0.01). Generally, *Crepis* seedlings emerging from burned mounds had the highest

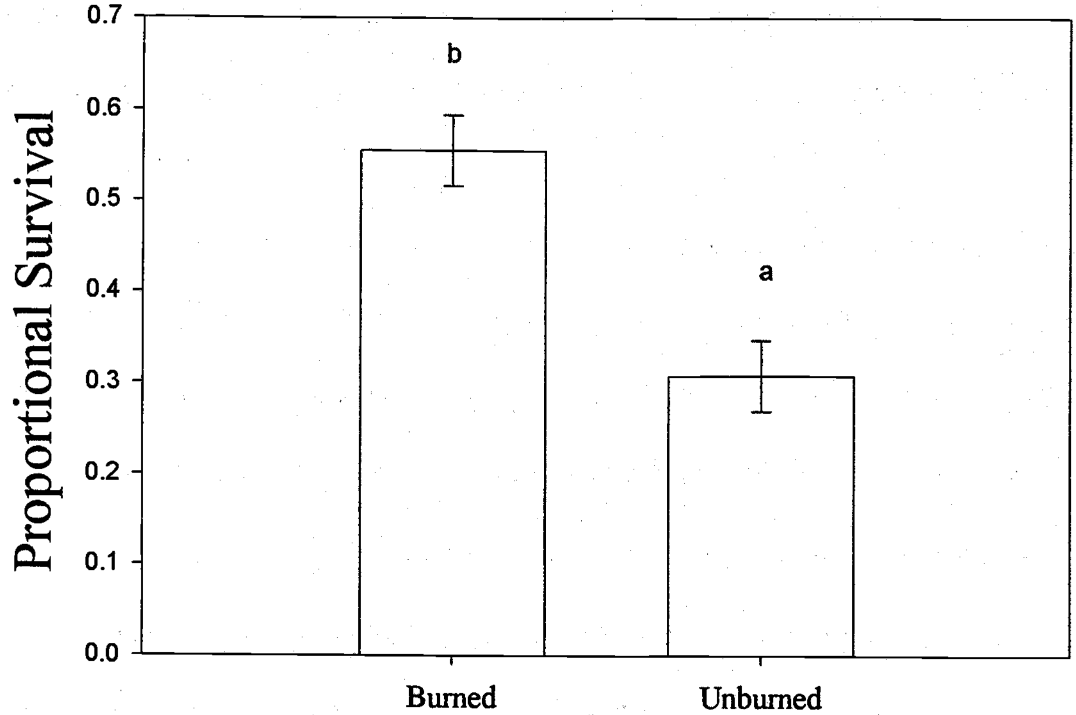

Figure 4. Mean proportional survival (± S.E.) of combined emergent seedlings of *Crepis occidentalis* and *C. modocensis* in response to fire. Different lower case letters represent statistically significant differences at $P<0.05$.

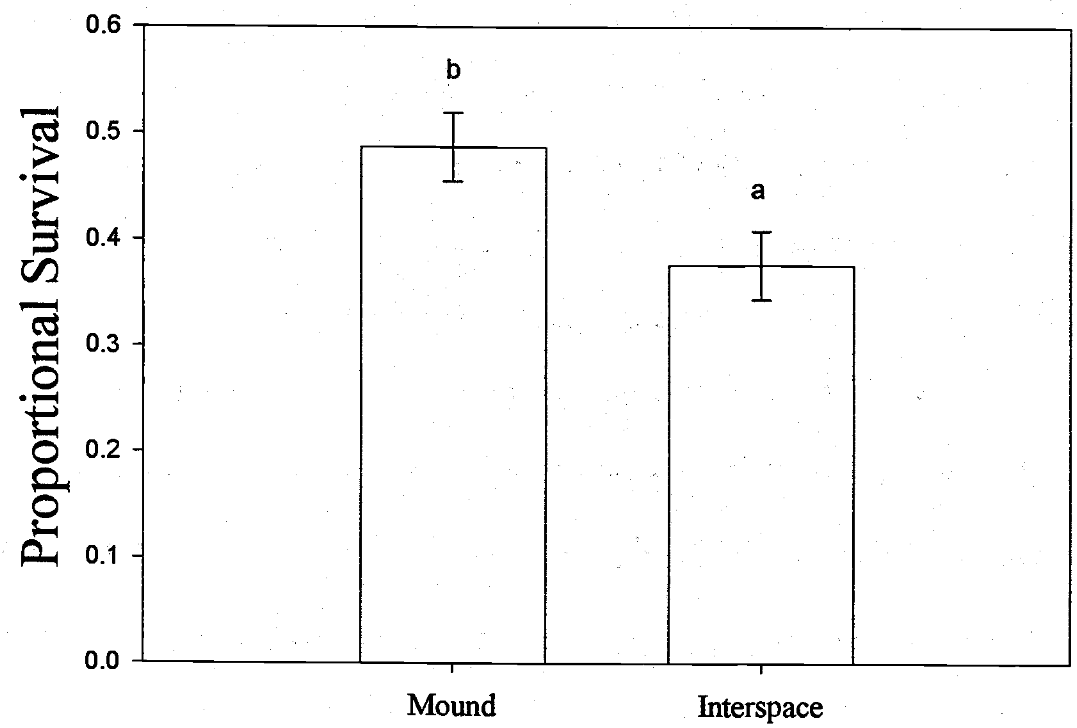

Figure 5. Mean proportional survival (± S.E.) of combined emergent seedlings of *Crepis occidentalis* and *C. modocensis* in response to microsite. Different lower case letters represent statistically significant differences at $P<0.1$.

mortality rates early in the growing season. However, the mortality risk of seedlings in other treatments, especially those in the interspace microsites, quickly surpassed those on the burned mounds (Figs. 6 & 7).

Burning was the only treatment that affected the proportional survival of *A. purshii* seedlings. Seedlings of *A. purshii* that emerged in the burned locations survived at twice the rate of those in unburned locations (P=0.06, Fig. 8). Survivorship for the first cohort of *A. purshii* did not differ among the treatments (Peto and Peto's logrank test, df=3, χ^2=4.3, P>0.25). There was some winter mortality among seeded *A. purshii* which was distributed evenly among treatments (Fig. 9). The low emergence for *A. purshii* resulted in low numbers of established plants with establishment higher in burned than unburned microsites.

Proportional survival of *Crepis* transplants differed between the factors within each main effect of species, burning and microsite, but no interactions occurred. Proportional survival of *Crepis* transplants was low for both species (< 14%), however survival of *C. occidentalis* was twice that of *C. modocensis* (P<0.01, Fig. 10). Regardless of species, survival of *Crepis* transplants was higher in burned treatments than unburned treatments (P=0.08, Fig. 11) and higher in mound than interspace microsites (P=0.02, Fig. 12).

Survivorship of the first cohort of *Crepis* transplants differed among treatments during different census periods (*C. modocensis* df=3, χ^2=9.8, P<0.025 and *C. occidentalis* df=3, χ^2 = 9.7, P<0.025). There was an initial rapid decline in survivorship (30 to 70%

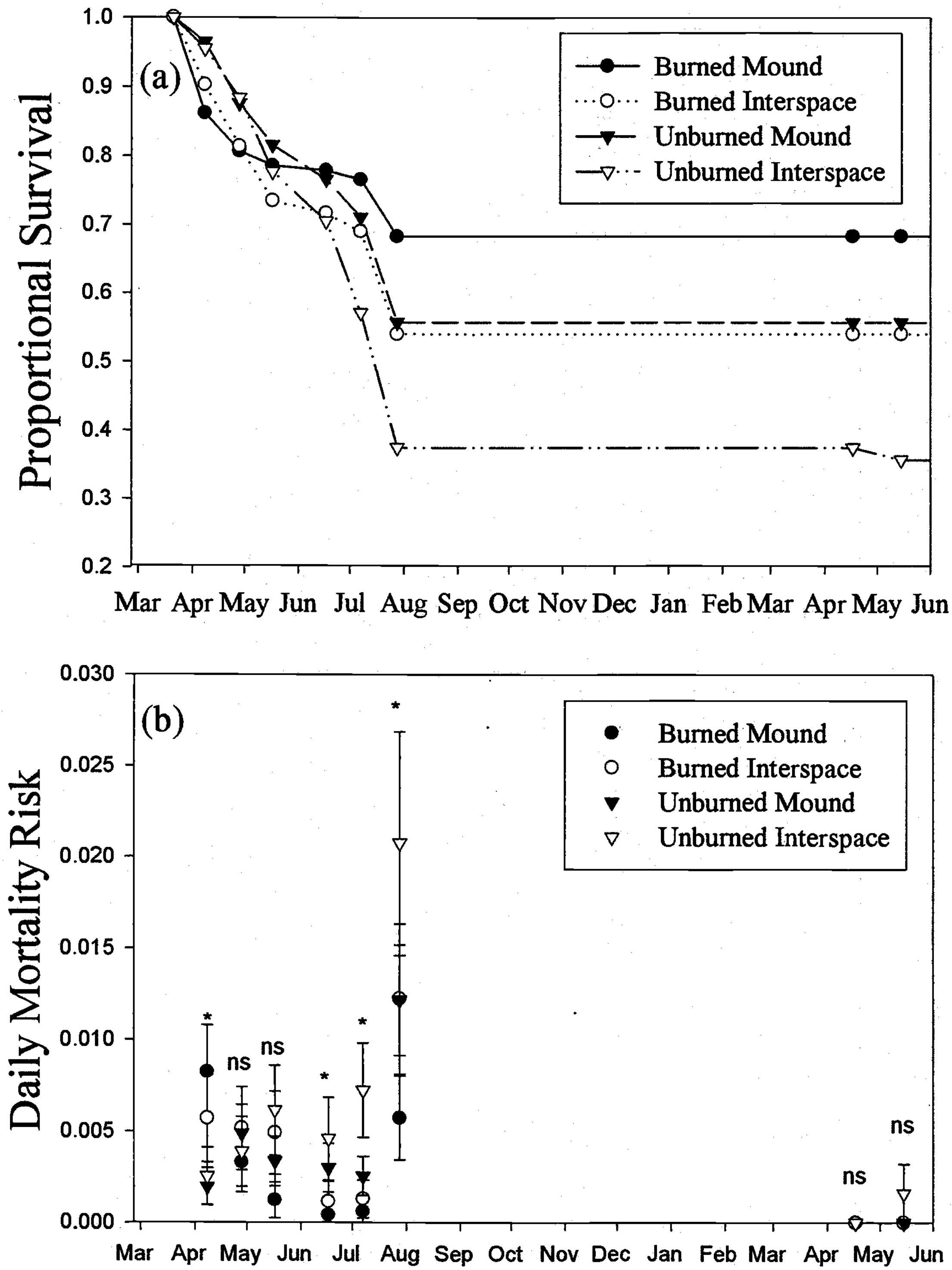

Figure 6. (a) Survivorship and (b) daily risk of mortality (95%C.I.) for seeded *C. modocensis* in four treatments during the 1998-1999 growing seasons. Daily mortality risks represent the average daily risk of dying for an individual plant in a particular treatment for the preceding period. Asterisks above a set of daily mortality risks indicates that at least one treatment significantly differs from the others at that date. Sets with ns above them do not differ significantly.

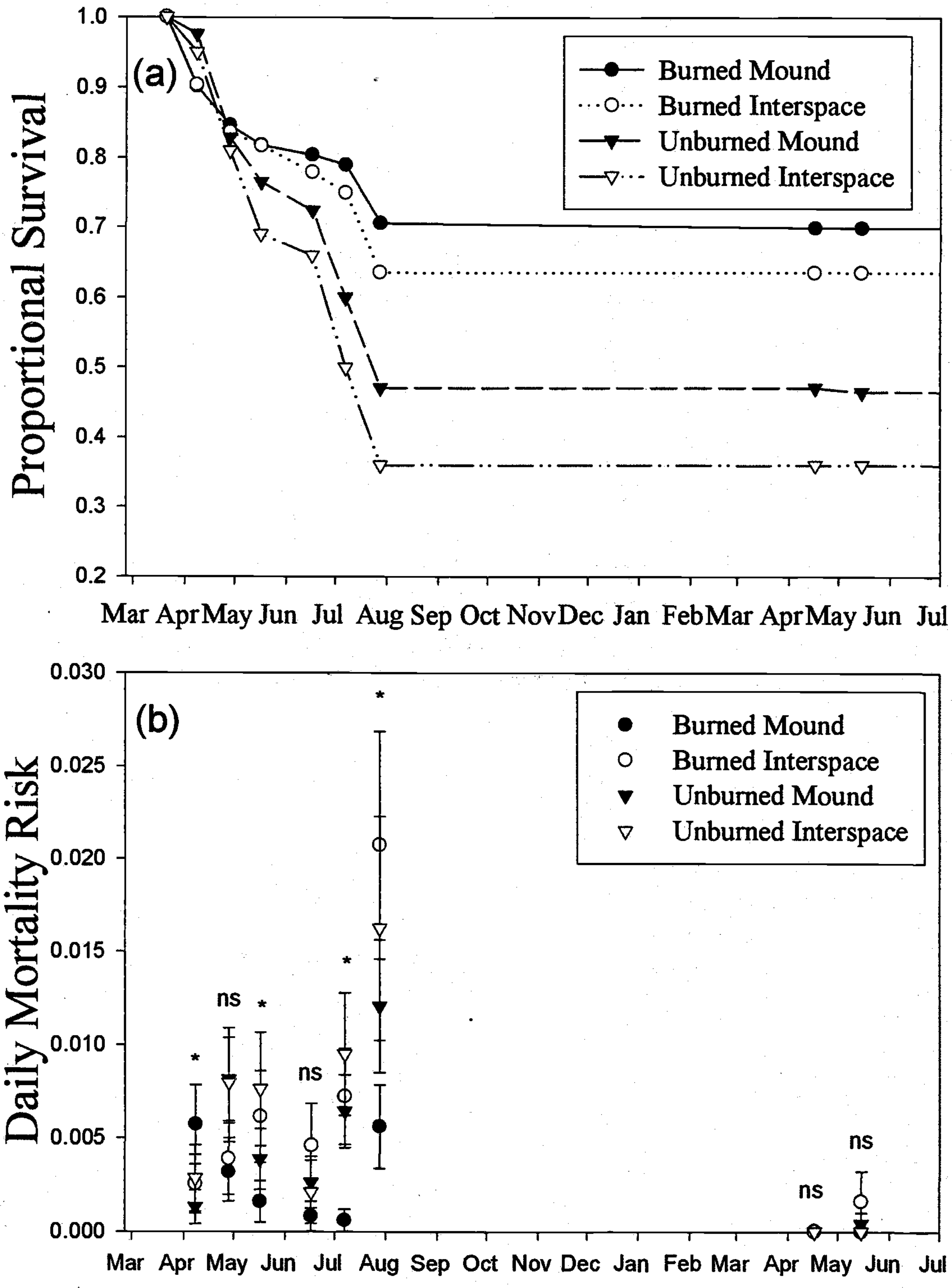

Figure 7. (a) Survivorship and (b) daily risk of mortality (95% C.I) for seeded *C. occidentalis* in four treatments during the 1998-1999 growing seasons. Daily mortality risks represent the average daily risk of dying for an individual plant in a particular treatment for the preceding period. Asterisks above a set of daily mortality risks indicates that at least one treatment significantly differs from the others at that date. Sets with ns above them do not differ significantly.

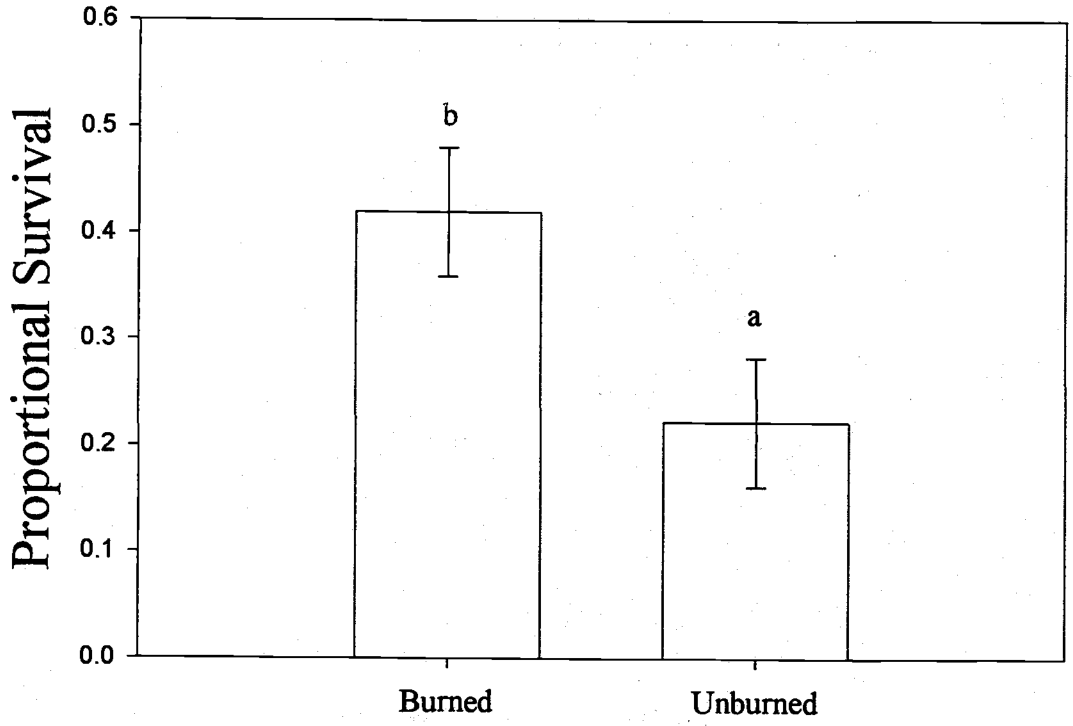

Figure 8. Mean proportional survival (± S.E.) of *A. purshii* seeds in response to fire. Different lower case letters represent statistically significant differences at P<0.1.

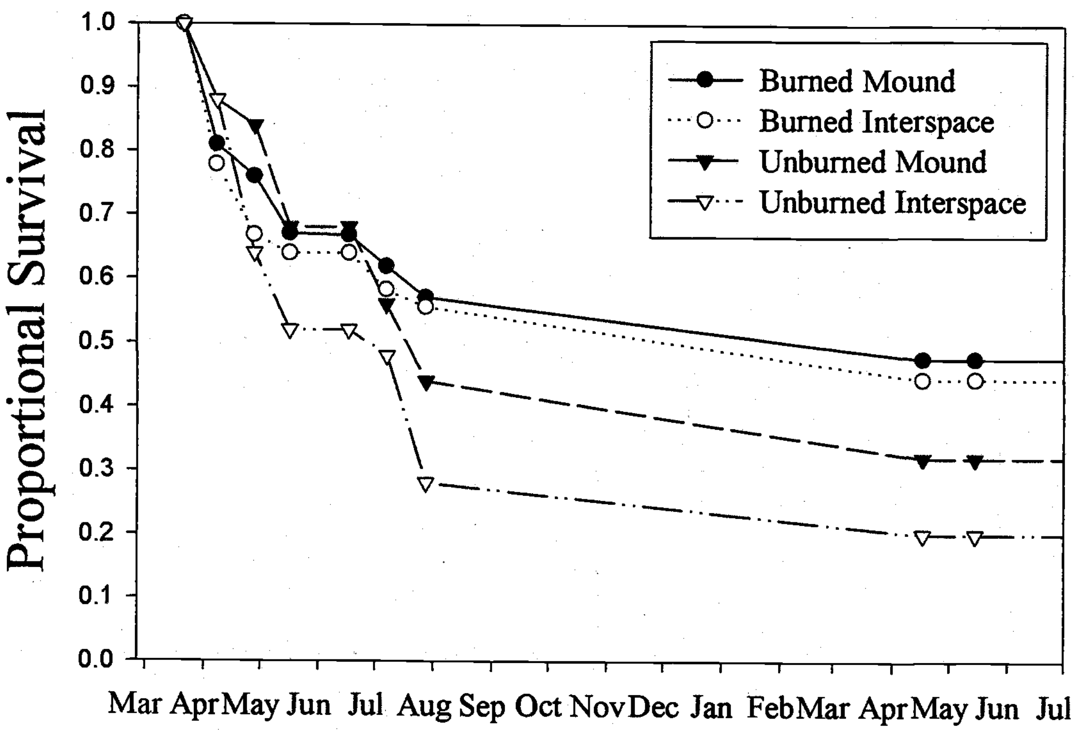

Figure 9. Survivorship of seeded *A. purshii* by treatment and census date during the 1998-1999 growing seasons.

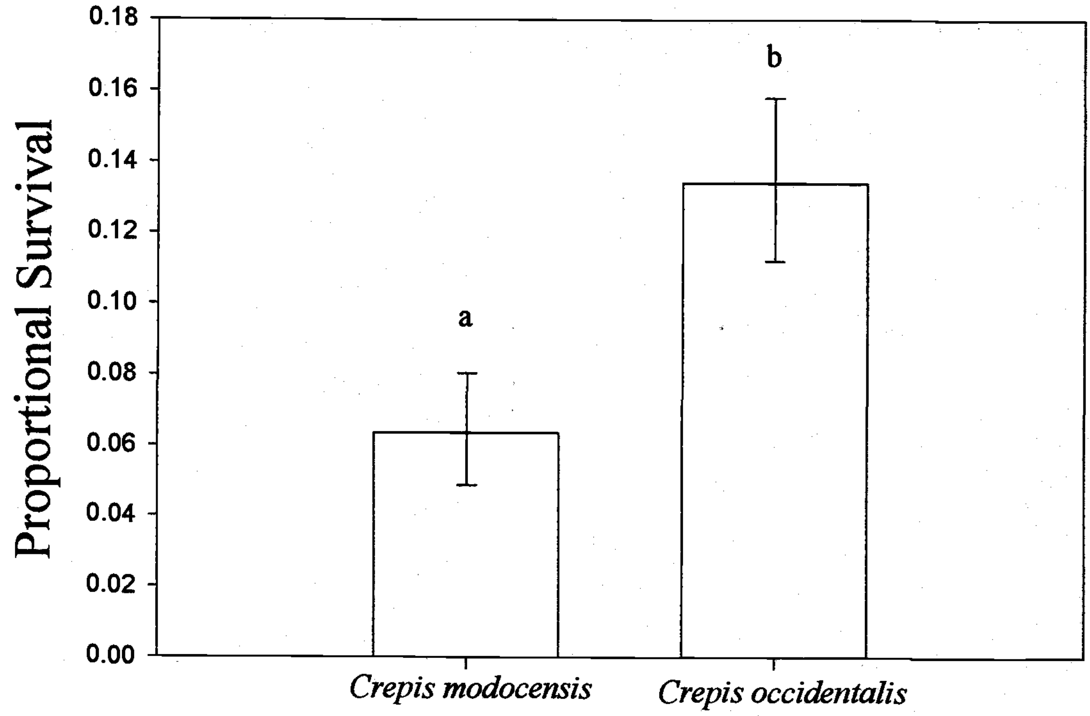

Figure 10. Mean proportional survival (± S.E.) of *Crepis* transplants by species. Different lower case letters represent statistically significant differences at P<0.05.

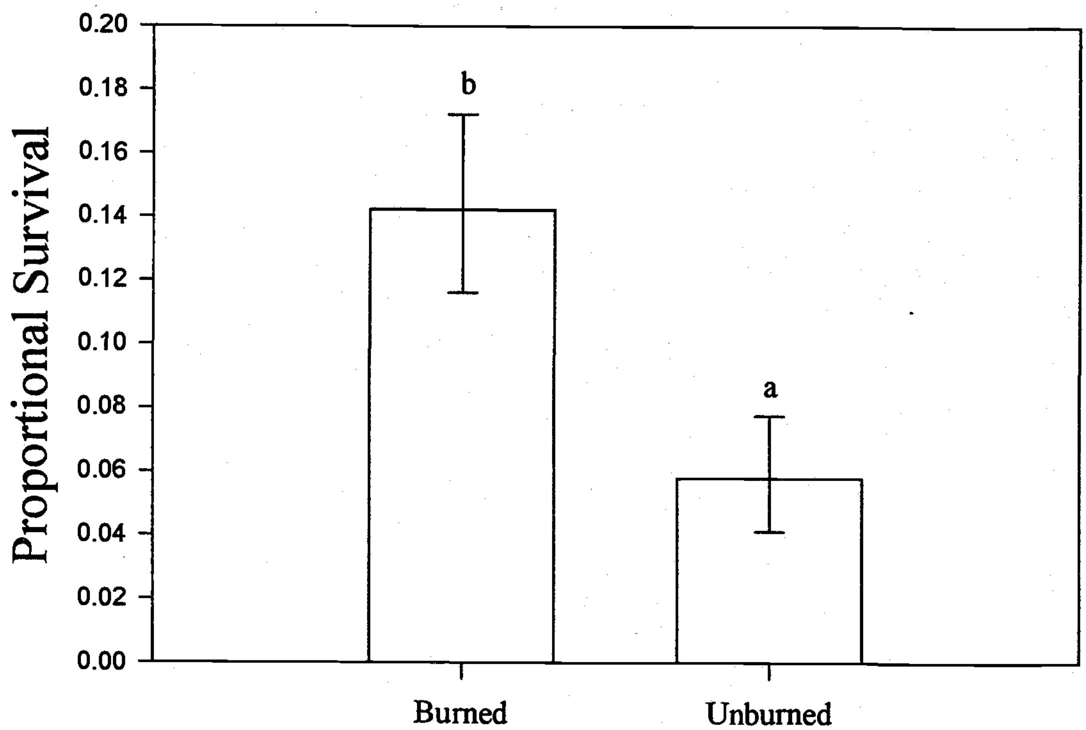

Figure 11. Mean proportional survival (± S.E.) of combined transplants of *Crepis* in response to fire. Different lower case letters represent statistically significant differences at P<0.1.

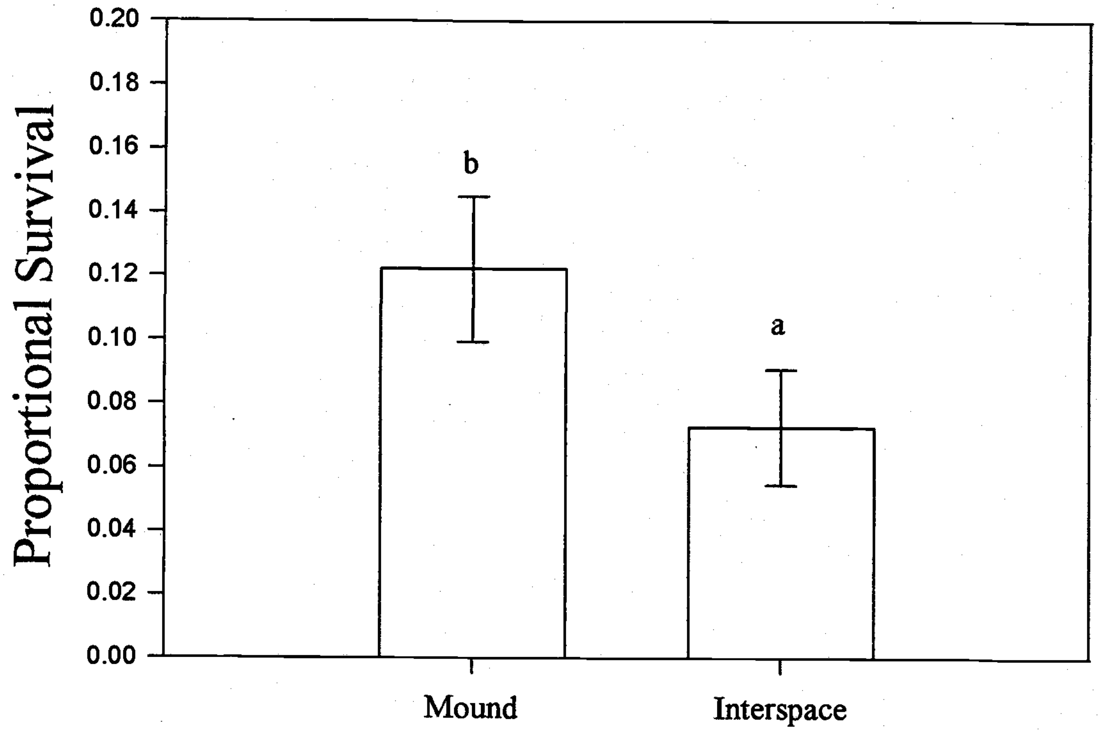

Figure 12. Mean proportional survival (± S.E.) of combined transplants of *Crepis* in response to microsite. Different lower case letters represent statistically significant differences at P<0.05.

mortality) during the first census after planting (Figs. 13a & 14a), but the only difference among treatments for daily risk of mortality occurred during the 15 May through 15 June 1998 census date (Figs. 13b & 14b). In this period, the burned mound microsite for *C. modocensis* had significantly lower mortality and the unburned interspace for *C. occidentalis* had significantly higher mortality than the other three treatments. During all other census periods mortality risk did not differ significantly.

Transplants of *A. purshii* had similar proportional survival to those that emerged from seed. As with the seeded plants, transplants in burned treatments survived better than those in the unburned treatments (P=0.001, Fig. 15). Proportional survival did not differ significantly between microsites (P=0.53).

Survivorship of *A. purshii* transplants differed among treatments (df=3, χ^2= 57.9, P<0.01). Differential survival of *A. purshii* transplants in the burned vs. unburned treatments became apparent by the second census period and continued through most of the first year (Fig. 16). Daily mortality risk was significantly higher for at least one of the unburned treatments during all 1998 censuses.

Burning did enhance the likelihood of flowering of *A. purshii* transplants, 97 of the 99 transplants that flowered were in burned areas (24.6% vs. 0.5% flowered in the burned vs. unburned sites). Also, all of the 7 *Crepis* plants that flowered in this study were found in burned areas (6 in mounds, 1 in the interspace). Only the *A. purshii* transplants in burned areas reproduced enough for analysis. No significant difference in seed production

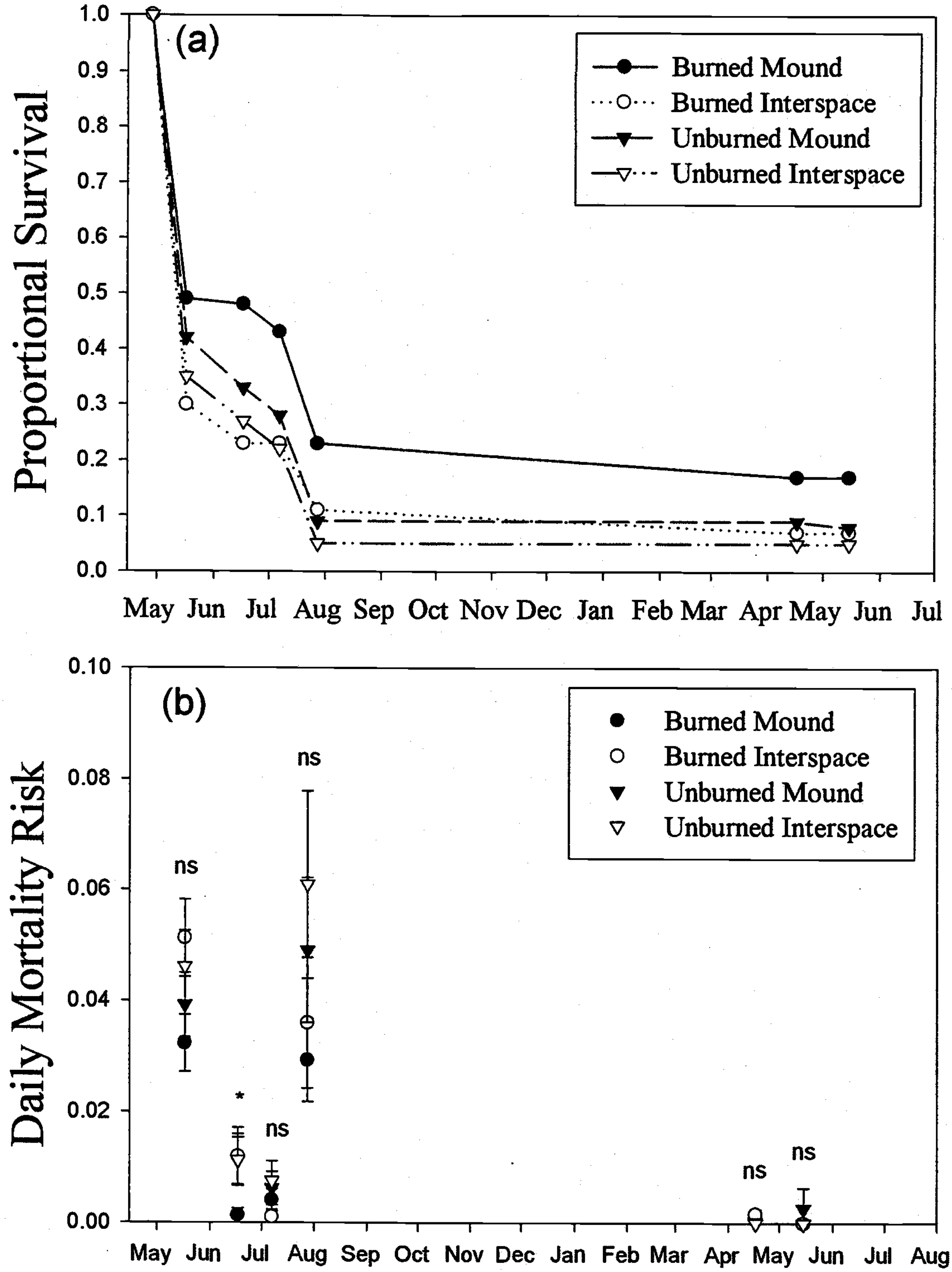

Figure 13. (a) Survivorship and (b) daily risk of mortality (95% C.I) for transplanted *C. modocensis* in four treatments during the 1998-1999 growing seasons. Daily mortality risks represent the average daily risk of dying for an individual plant in a particular treatment for the preceding period. Asterisks above a set of daily mortality risks indicates that at least one treatment significantly differs from the others at that date. Sets with ns above them do not differ significantly.

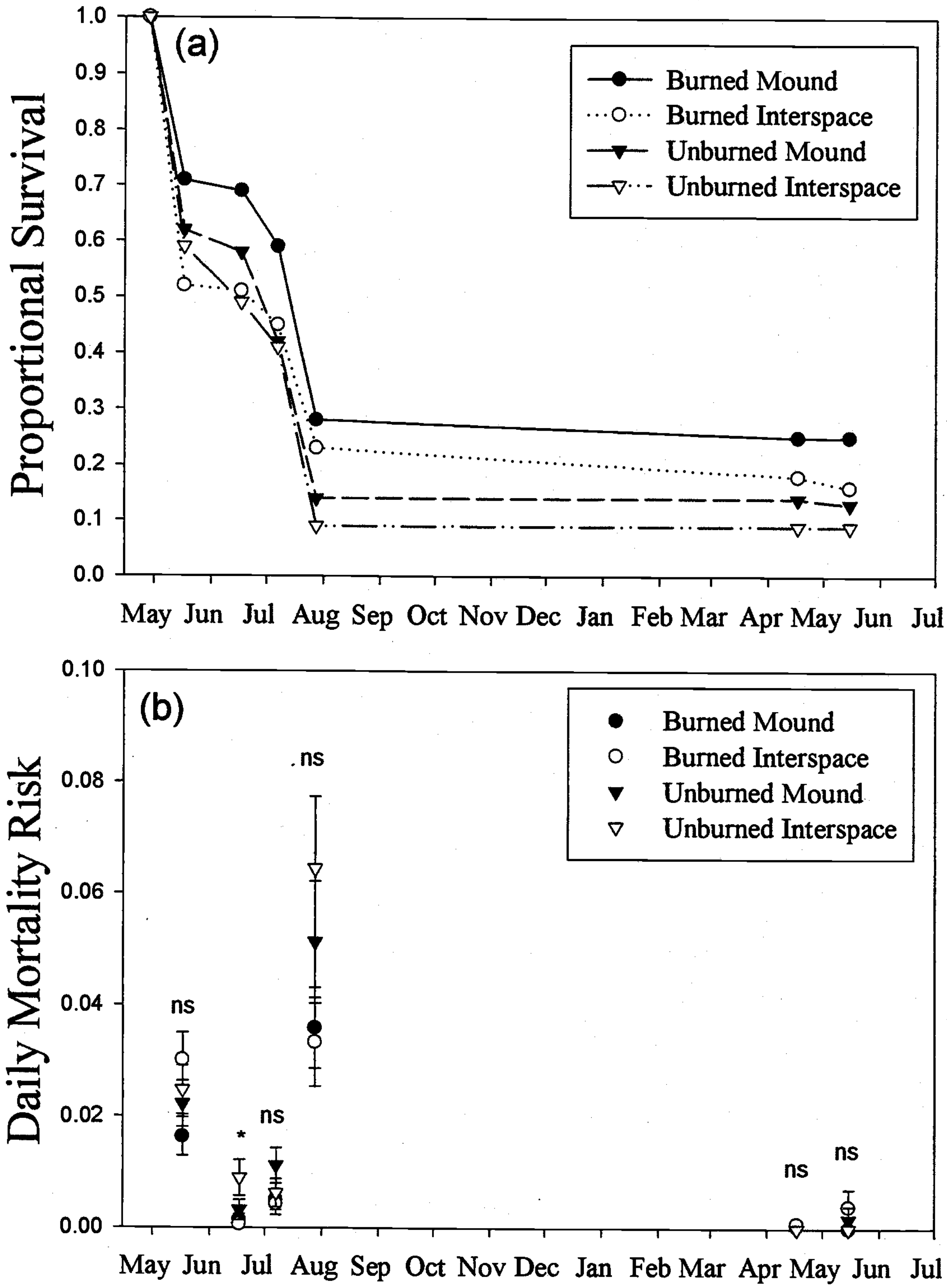

Figure 14. (a) Survivorship and (b) daily risk of mortality (95% C.I.) for transplanted *C. occidentalis* in four treatments during the 1998-1999 growing seasons. Daily mortality risks represent the average daily risk of dying for an individual plant in a particular treatment for the preceding period. Asterisks above a set of daily mortality risks indicates that at least one treatment significantly differs from the others at that date. Sets with ns above them do not differ significantly.

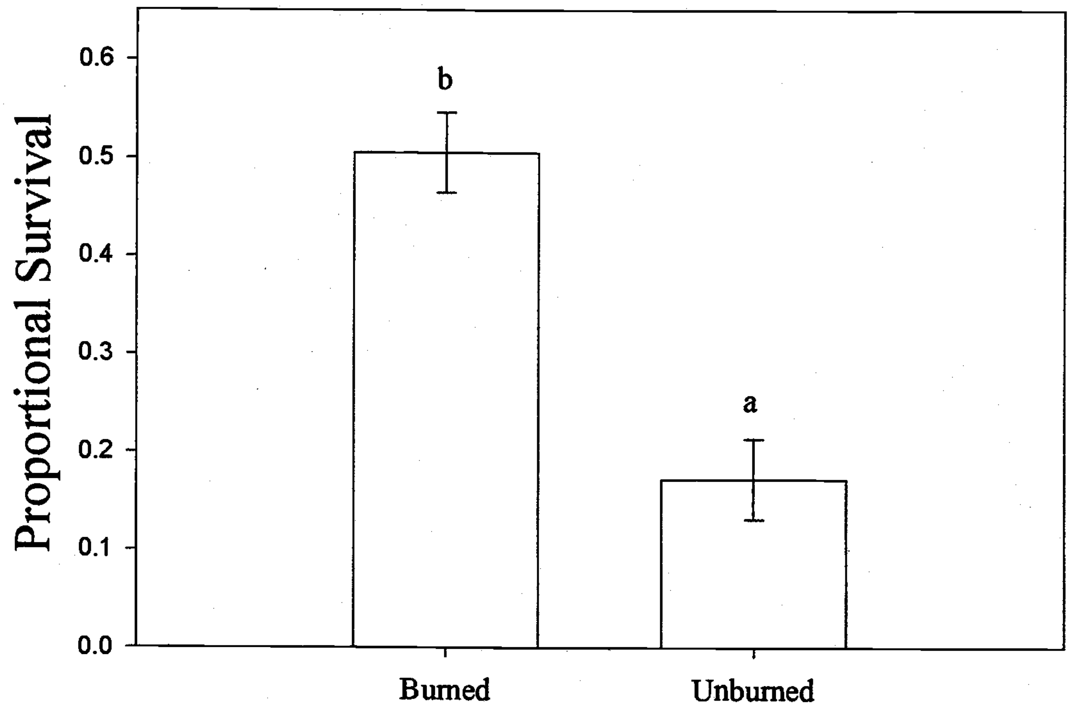

Figure 15. Mean proportional survival (± S.E.) of *A. purshii* transplants in response to fire. Different lower case letters represent statistically significant differences at $P<0.05$.

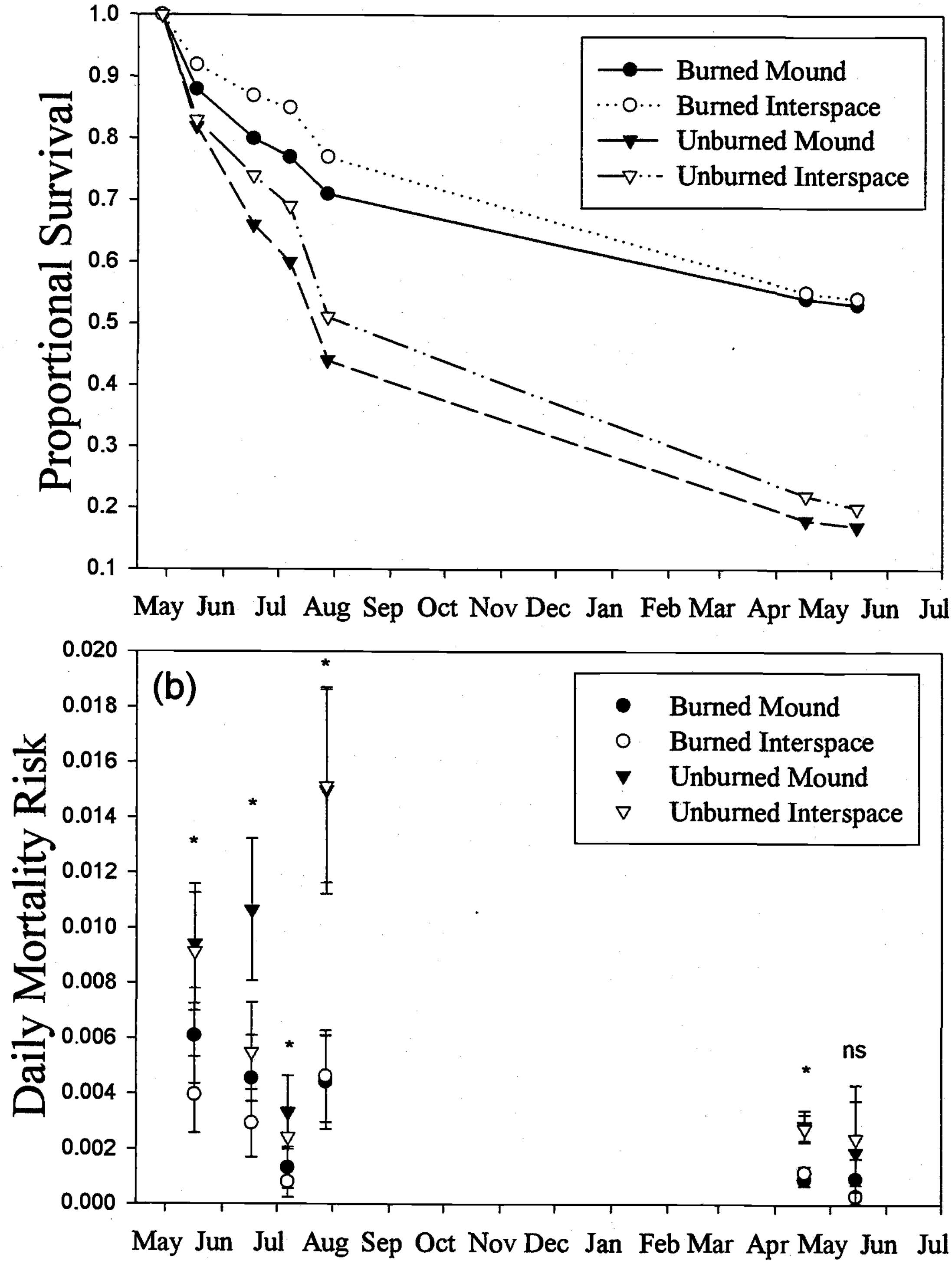

Figure 16. (a) Survivorship and (b) daily risk of mortality (95% C.I.) for transplanted *A. purshii* in four treatments during the 1998-1999 growing seasons. Daily mortality risks represent the average daily risk of dying for an individual plant in a particular treatment for the preceding period. Asterisks above a set of daily mortality risks indicates that at least one treatment significantly differs from the others at that date. Sets with ns above them do not differ significantly.

was found between burned mound microsites and burned interspace microsites (45.4 ± 7.9 vs. 29.6 ± 7.9 seeds per plant, P=0.25).

By combining the emergence and survival into a diagrammatic life table, comparisons can be made of seeding versus transplanting under the different treatments (Figs. 17-19). Transplants were assumed to begin with the same number of seedlings as those emerging from seed in these diagrams (instead of 150 for *Crepis* and 200 for *A. purshii*). These numbers were then multiplied by the actual survival of seeded and transplanted treatments. *Crepis* transplants showed a much lower survival and establishment than seedings, although the general pattern of higher survival in the burn treatments was similar to that of seeded plants. *C. modocensis* transplants yielded fewer established plants in all treatments than *C. occidentalis* transplants (Figs. 18 & 19). *A. purshii* had the highest survival and establishment of all transplants, however, when compared with the survival of an equal number of plants emerging from seeds, transplanting produced similar numbers of established plants (Fig. 19). At the end of the experiment, the overall survival of *A. purshii* in the two microsites was similar, however the burned treatments produced more plants than unburned treatments.

Crepis modocensis establishment

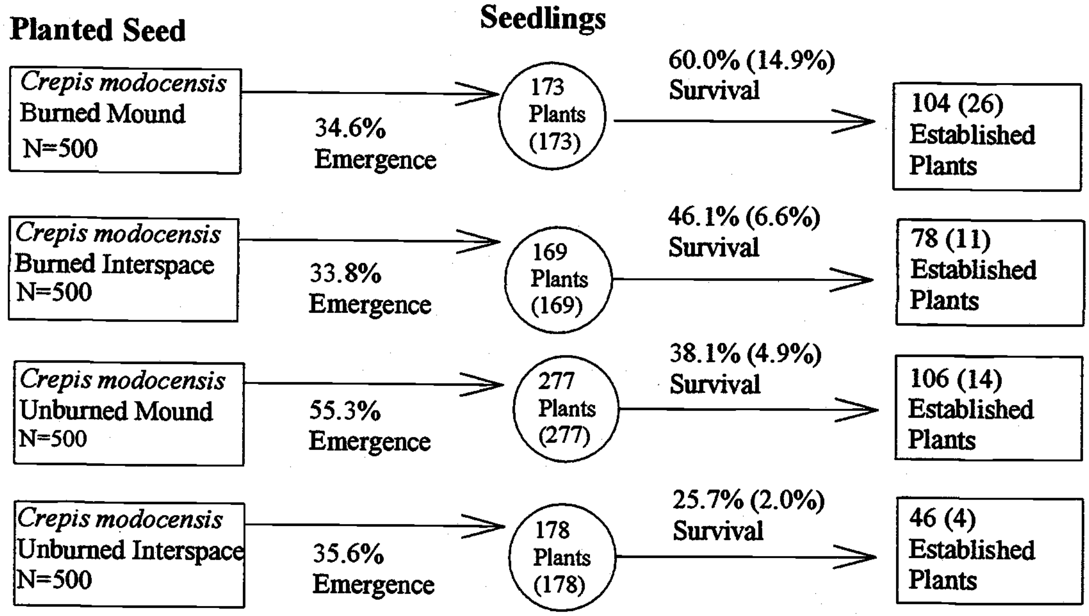

Figure 17. Diagrammatic life table of emergence, survival and establishment of *C. modocensis* plants. Figures in parentheses are begining number of transplants, transplant survival and established transplants of *C. modocensis*. To facilitate a direct comparison between seeds and transplants, beginning numbers of transplants were adjusted to match numbers of those emerging from seeds.

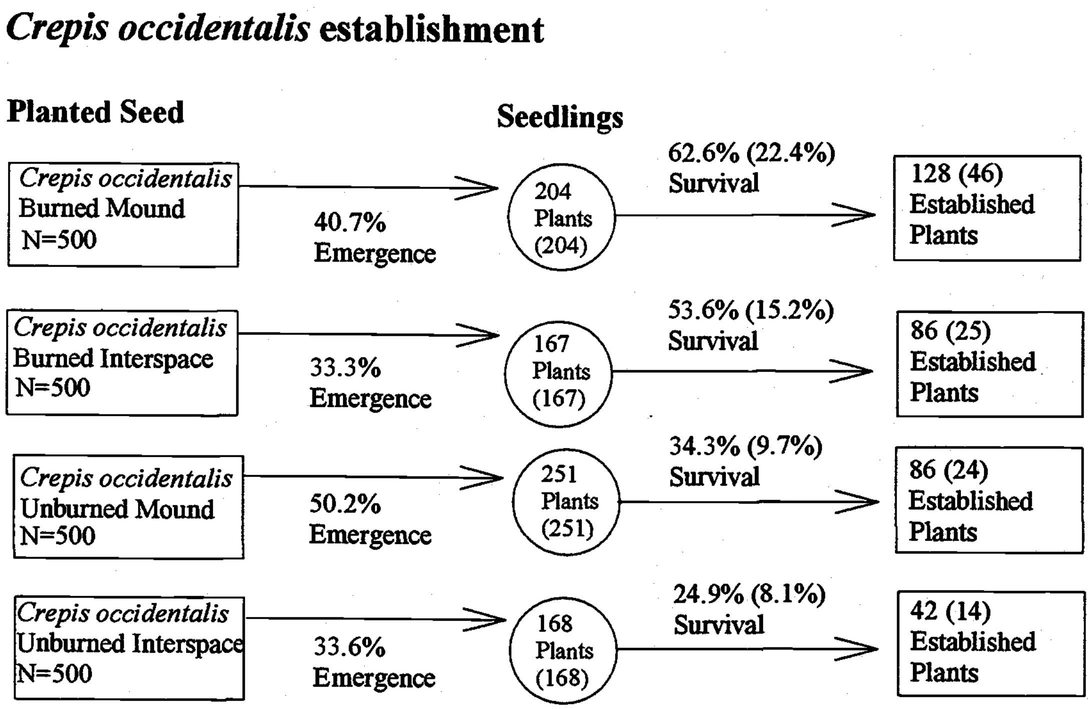

Figure 18. Diagrammatic life table of emergence, survival and establishment of *C. occidentalis* plants. Figures in parentheses are begining number of transplants, transplant survival and established transplants of *C. occidentalis*. To facilitate a direct comparison between seeds and transplants, beginning numbers of transplants were adjusted to match numbers of those emerging from seeds.

Astragalus purshii establishment

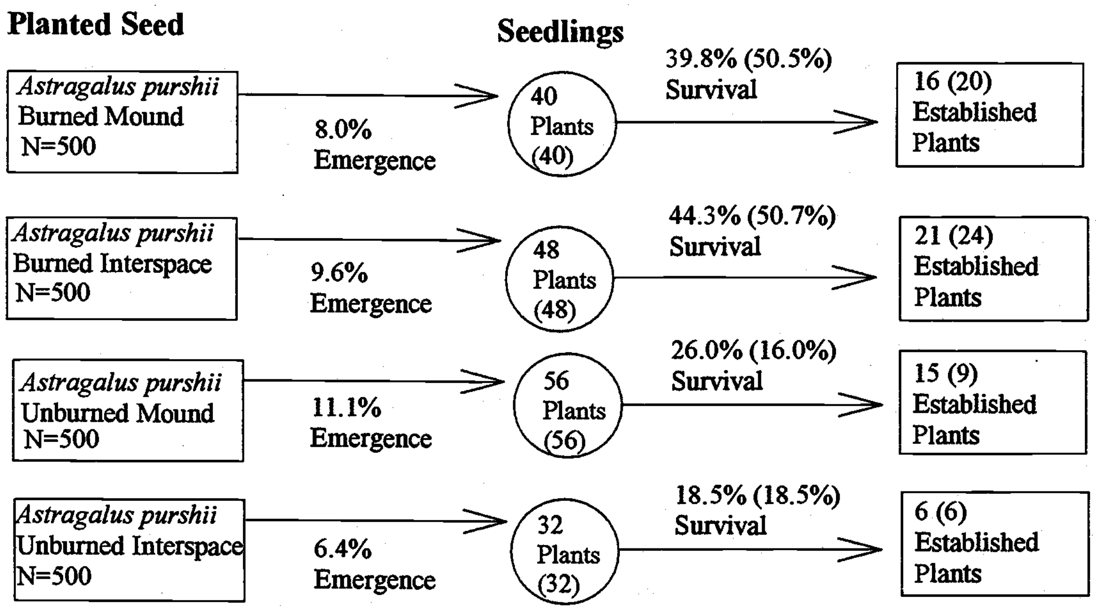

Figure 19. Diagrammatic life table of emergence, survival and establishment of *A. purshii*. Figures in parentheses are numbers for transplants. To facilitate a direct comparison between seed and transplants, beginning numbers of transplants were adjusted to match numbers of those emerging from seeds.

DISCUSSION

Plant Establishment

This study demonstrated that burning followed by seeding of *Crepis* species is a viable method of revegetation for enhancing sage grouse habitat. *Crepis* seedlings emerging from burned areas survive and establish well following fire. This effect is greater in mound microsites than in interspace microsites. Burned areas with greater proportions of mound microsites (i.e. higher densities of sagebrush) may show higher success when revegetated as suggested by Eckert et al. (1986b). Seeding with *A. purshii* resulted in low plant establishment due to low emergence in all treatments. Since seed viability was high in this species, and scarification enhanced germination for transplants, the low emergence is presumably because of physical dormancy derived from the hard legume seed coat. Seeds of *A. purshii* may continue germinating in successive years as seed coats are weakened and scarified, allowing imbibition to occur. However, the advantages to seedlings provided by prescribed fire such as reduced competition with sagebrush and increased nutrient availability decline with time following the fire (Young 1983, Bunting et al. 1988, Halvorson et al. 1997). We do not know if planting scarified seed of *A. purshii* would enhance spring germination, but this option warrants study. Transplanting of these species in this study resulted in few established plants and was considerably more laborious and costly than seeding.

Differences in soil surface microtopography are known to be important as safe sites in the emergence of plants (Harper et al. 1977, Eckert et al. 1986a, 1986b).

Although microsite and burning did influence emergence of *Crepis* and *A. purshii*, no single treatment favored emergence of all species. For *Crepis*, emergence was highest in unburned mounds. There are several reasons why higher emergence might be expected in mounds as opposed to interspaces. Germination in the soil depends on several conditions including soil-seed contact, depth of planting, temperature, light, moisture availability and dormancy (Booth and Haferkamp 1995) . Soil in mound microsites has a soft consistency and fine structure whereas interspace areas often form hard surfaces called vesicular crusts which have low water infiltration often leading to pooling and movement of soil due to freezing and thawing of soil water (Eckert et al. 1986a, Hugie and Passey 1964). The fine soil structure within mounds increases the chance of good soil-seed contact while the lack of a physical soil crust lowers the chance that the seedling will be physically hampered from breaking through the soil surface. Higher levels of organic carbon in the soil and litter of mounds capture and hold water more efficiently than interspace areas. Inhibitory characteristics of interspace microsites include the presence of vesicular crusts, low organic matter content in soil and lack of a litter layer. Moisture stress of seedlings in interspaces is more common due to lack of litter, runoff of moisture, increased irradiation and evaporation. Interspaces often exhibit higher water potentials in the first 5 cm of soil than mounds (Chambers 2000).

Crepis emergence in the unburned mounds might be higher than burned mounds due to two factors. Moisture capture in the form of snow is increased around intact sagebrush canopies (Allen 1988), thus unburned mounds gain relatively more moisture during the important winter period for soil moisture recharge than burned mounds. Also, lower *Crepis* emergence in burned mounds may be due to wind erosion following the fire (personal observation). This erosion might reduce the seed pool in burned areas by physically moving seeds to unfavorable microsites.

Contrary to my expectations, the emergence of *A. purshii* was highest in burned interspaces despite potentially unfavorable microsite conditions. *A. purshii* often occurs naturally in interspace areas next to rocks (personal observation), the harsh interspace soils may be more susceptible to frost heaving than litter covered mounds, providing *A. purshii* seed with more abrasion, a mechanism for scarification, and allowing germination to begin.

While emergence sets the upper limit of established plants for a treatment, it was not indicative of future establishment in this study. Greater emergence of *Crepis* in unburned mounds was accompanied by greater mortality, resulting in lower overall establishment. Burning significantly increased the survival of both seeded and transplanted plants of all three species. Although not significant during every census period, there was generally greater risk of mortality for plants in the unburned microsites compared to the burned microsites in 1998, with the exception of the first census date. Therefore, increased plant establishment in burned treatments was primarily due to increased survivorship rather than differential emergence.

Higher survival in burned areas is likely a result of three factors, decreased competition due to removal of sagebrush, release of nutrients following fire and early phenology. Competition with adult sagebrush has been shown to be effective at reducing seedling establishment (Reichenberger and Pyke, 1990). Therefore, removal of sagebrush would be expected to increase the chance of seedling establishment compared to an intact stand. Secondly, fire increases the amount nitrogen, phosphorus, potassium, calcium, magnesium and sodium that was previously bound in living and dead materials (Wright and Bailey 1982). This nutrient flush is available to plants emerging from seed or vegetative organs the following spring, providing an enhanced nutrient environment for growth and establishment. The third factor for increased establishment in burned areas is earlier seedling emergence due to increased temperatures caused by higher interception of sunlight and greater albedo of the black soil surface in the vicinity of the mounds. Lack of vegetation in burned areas and unburned interspace areas result in more extreme fluctuations of temperature on the soil surface (Daubenmire 1968), possibly stimulating germination earlier than in the unburned mound areas. Earlier emergence in burned treatments would cause a higher chance of observing mortality during the first census date in these treatments compared to unburned treatments. In this situation, the growing season for plants in burned areas would be longer, possibly aiding establishment. During 1999, mortality was low among all species and treatments, supporting the conclusion that these plants had established. These three factors allowed seedlings of *Crepis* and *A. purshii* in burned areas to attain a size where establishment was likely.

For *Crepis*, overall survival was higher in the mounds than in interspaces, although within the burned and unburned areas there was no statistical difference between microsites. Higher survival in mound microsites is most likely a combination of those factors that resulted in higher emergence in unburned mounds and those factors that led to higher survival in the burned mounds.

Although there was little reproduction among the plants in this study, it is obvious that burning does increase the chance of reproduction for *A. purshii*. Burning may also reduce the age-to-first-reproduction for these forbs, which should aid in population fitness and contribute to increases in population sizes over time.

Management Implications

Results from this study suggest that burning has a beneficial effect on the establishment of these three forbs. The effect of microsite on survival is smaller, but could be important for large scale revegetation efforts.

Prescribed fire is effective at reducing sagebrush density, but forb response after fire is dependent on the pre-burn community. Forbs that are present in the pre-burn community respond well after fires because they are released from competition with sagebrush and are able to capture and use available nutrients (Wright 1985). Still, prescribed burning has not been shown conclusively to increase forbs important to sage grouse (Fischer 1996), but some evidence points to this possibility (Pyle & Crawford 1996, Wrobleski 1999). As Humphrey (1984) notes, succession is not always predictable, but is dependent on pre-disturbance site conditions and the vital attributes of the pre-disturbance species present on a particular site (Drury and Nisbet 1973, Noble and Slatyer

1980). Three groups of vital attributes described by Noble and Slatyer (1980) are 1) method of persistence and arrival during and after a disturbance, 2) length of time to reach certain life stages and 3) the ability to establish and grow in the post-disturbance community. The vital attributes of each species interact to define the composition of the post-disturbance community.

There are many areas where forbs and more palatable perennial grasses have been depleted and less preferred grasses, exotic annuals, and sagebrush remain in the community (Miller et al. 1994). The vital attribute of dispersal is important for forbs after disturbance in these conditions. A species can be considered present on a site if it occurs in vegetative form or as seeds in the soil. The determination of whether a species is present and at what levels is simple if the foliage is visible, however, determining whether a species is present in the seed bank is more difficult. Plants that have long-lived seed may not be present in the current community, but may occur in the seedbank (such as *A. purshii*). Plants with short-lived seed (such as *Crepis*) that are not present in the community probably do not have a local seedbank and must arrive either through emigration or revegetation. Questions that need to be asked include: are there populations of forbs on site or close enough for dispersal to the site to occur? If so, what are the mechanisms of dispersal? Wind dispersal (such as *Crepis*) may allow forbs from adjacent areas to colonize burns, but even wind dispersal is limited in its effective distance (Silvertown 1993). Plants dispersed by insects or without special dispersal mechanisms will require long periods of time to reach the site. If forbs are depleted and dispersal to the site is not likely to occur, seeding forbs may be required.

Seeding of forbs with a seed drill will create a higher risk of mortality to existing perennial grasses. Drilling seeds of both grasses and forbs may be necessary to maintain the desired grass-forb mixture. However, drilling presents technical problems due to the different seed sizes and planting depth requirements. Broadcast seeding and harrowing may be a less invasive and effective method of adding forb seed to depleted sites that already maintain a perennial grass cover.

Prescribed burning alone will have optimal benefits for improving sage grouse habitat when both grass and forb components are still present in the plant community. The results of this study indicate that increased establishment of *C. modocensis, C. occidentalis* and *A. purshii* following fire will occur when seeds of these plants are naturally in the seed bank. Burning after the forb/grass component is reduced and sagebrush density is high will decrease the chance of a favorable response to burning due to the absence of available propagules and reduction in the magnitude of resource islands surrounding sagebrush plants in dense stands. Under these conditions revegetation may be necessary.

It is unclear how much time sage grouse will spend foraging in burned patches when interspersed with stands of sagebrush. However, establishment of perennial forbs in these areas will provide future sage grouse forage as sagebrush re-invades and reaches an acceptable density for sage grouse cover requirements. Using fire to increase forage for sage grouse should be an option for land managers where appropriate, but revegetation of native forbs may also be necessary and can be effective. Currently, the major obstacles to using forbs like *Crepis* in restoration efforts is the commercial availability of the seed. Seed would need to be collected and increased by a seed producer to obtain adequate quantities. Production of native seed by growers is typically more expensive than grasses due to variable demand, crop failure and startup costs. Also, forb seeds are typically more difficult to produce due to weed invasion and limited weed control methods (Bermant and Spackeen 1997). The time and effort required for seed gathering, cleaning, germination and planting are different for each species and establishment method. *A. purshii* seed must be collected by hand due to the low stature of the plant whereas *Crepis* is taller and some mechanical collection may be possible. If transplanting is used there are the additional costs of scarification, proper storage/stratification, greenhouse care and finally field transplantation. In general, transplantation will be more expensive and require more labor than seeding operations. For transplants to be economically beneficial, the increased transplant cost (germination, greenhouse care, and planting) must be less than the costs associated with seeding (seed cleaning and planting) when differential success rates are taken into account. This means that transplants would have to show much higher establishment success than seeds to be an economically viable method of restoration. Based on this criteria, transplanting these three species is not an economically viable alternative.

Seeding of *A. purshii* could be effective if a method to increase emergence were developed or if it was found that non-scarified seed was long-lived in the soil and kept germinating over a number of years. Seeding of *Crepis* species has good potential because of its high viability, ease of germination, high seed production and wide distribution. Increasing interest is emerging in using native seeds on rangelands in the western US to maintain genetic and ecological diversity (Richards et al. 1998). *Crepis* species have the potential to be produced at the commercial level and made available to land managers to use in seeding projects.

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APPENDICES

Appendix A. Locations of Hart Mountain Study sites. UTM zone 10.

SITE	UTM NORTH (m)	UTM EAST (m)	ELEV. (m)	SOIL SERIES
1	4720917	294312	1591	Ratto-Coglin Complex (Ratto Loam) 217C
2	4718650	288502	1606	Ratto-Coglin Complex (Ratto Loam) 217C
3	4717959	289588	1587	Ratto-Coglin Complex (Ratto Loam) 217C
4	4716213	291274	1579	Ratto-Coglin Complex (Ratto Loam) 217C
5	4715335	288786	1611	Floke-Ratto Complex (Ratto Loam) 93C
6	4714450	293422	1576	Ratto-Coglin Complex (Ratto Loam) 217C
7	4717286	289279	1594	Ratto-Coglin Complex (Ratto Loam) 217C
8	4713499	290114	1608	Ratto-Coglin Complex (Ratto Loam) 217C

Appendix B. Pre-burn and Post-burn Biomass (grams)

Understory

Flook Knoll (1)

Plot	Pre-fire	Post-fire
1	18.47	1.90
2	0.37	0.00
3	23.16	1.42
4	8.39	0.69
5	20.15	0.65
6	0.86	2.54
7	0.29	1.39
8	125.72	2.51
9	0.00	4.61
10	6.98	0.05
11	44.67	0.31
12	0.86	0.03
13	0.18	2.77
14	7.32	5.39
15	29.42	5.76
16	2.38	0.32
17	2.36	0.08
18	0.81	0.33
19	0.28	0.00
20	16.90	0.05
21	9.53	1.95
22	10.49	6.39
23	3.44	0.42
24	1.34	0.30
Mean	**13.93**	**1.66**
Std. Error	**3.73**	**0.28**

Rock Creek (2)

Plot	Pre-fire	Post-fire
1	37.45	0.02
2	63.31	1.70
3	10.50	0.20
4	12.71	1.05
5	31.22	0.22
6	34.37	2.24
7	26.31	0.18
8	11.76	1.62
9	21.60	1.85
10	0.47	0.06
11	13.63	3.14
12	16.25	0.87
13	6.25	0.45
14	12.61	0.51
15	34.24	1.83
16	5.54	2.00
17	11.64	0.00
18	13.24	0.69
19	0.01	3.13
20	45.58	0.24
21	1.53	0.76
22	1.71	3.63
23	15.10	2.02
24	35.20	2.80
25	1.64	0.51
Mean	**18.55**	**1.27**
Std. Error	**2.28**	**0.16**

South Frenchglen (3)

Plot	Pre-fire	Post-fire
1	6.14	0.26
2	24.20	3.52
3	16.15	0.00
4	70.43	0.49
5	54.69	3.28
6	40.46	2.07
7	3.36	1.67
8	0.56	1.72
9	0.36	2.52
10	17.60	0.25
11	1.61	0.39
12	11.87	1.55
13	5.24	1.15
14	43.90	2.61
15	40.46	0.00
16	9.01	4.07
17	1.57	2.90
18	4.29	0.14
19	0.48	0.00
20	9.63	0.21
21	2.63	0.00
22	2.70	0.32
23	8.31	5.34
24	39.83	1.70
25	3.90	2.21
Mean	**16.78**	**1.53**
Std. Error	**2.79**	**0.21**

Flook Lake Burn (4)

Plot	Pre-fire	Post-fire
1	13.96	20.01
2	22.66	0.77
3	12.56	0.36
4	12.09	0.42
5	3.73	0.55
6	28.70	0.55
7	8.16	0.55
8	8.95	1.14
9	0.52	0.73
10	5.18	13.96
11	13.49	5.26
12	16.54	0.40
13	21.67	1.31
14	1.15	1.59
15	6.76	8.55
16	4.78	0.88
17	21.57	0.23
18	34.46	3.24
19	24.21	12.10
20	4.29	2.48
21	23.65	0.35
22	1.74	1.02
23	11.66	4.30
24	9.60	0.60
25	3.58	0.73
Mean	**12.63**	**3.28**
Std. Error	**1.32**	**0.72**

Appendix B. Continued Pre-burn and Post-burn Biomass (grams)

Overstory

Flook Knoll (1)

Sample	**Pre-fire**	**Post-fire**
1	167.58	0.00
2	85.46	0.00
3	59.96	0.00
4	111.39	0.00
5	20.98	25.77
Mean	**89.07**	**5.15**
Std. Error	**24.66**	**5.15**

Rock Creek (2)

Sample	**Pre-fire**	**Post-fire**
1	317.20	0.00
2	23.60	0.00
3	1.20	0.00
4	478.10	0.00
5	942.80	0.00
Mean	**352.58**	**0.00**
Std. Error	**172.78**	**0.00**

South Frenchglen (3)

Sample	**Pre-fire**	**Post-fire**
1	364.30	0.00
2	483.73	0.00
3	113.37	0.00
4	6.88	0.00
5.00	1182.70	0.00
Mean	**430.20**	**0.00**
Std. Error	**206.52**	**0.00**

Flook Lake Burn (4)

Sample	**Pre-fire**	**Post-fire**
1	338.30	0.00
2	581.60	0.00
3	950.65	0.00
4	567.20	22.67
5	409.80	1.17
Mean	**569.51**	**4.77**
Std. Error	**105.92**	**4.48**

Appendix C. Pre-burn Moisture Samples

Flook Knoll (1)
Overstory

Plot	Wet	Dry	Moisture (g)	Moisture (%)
1	20.44	17.59	2.85	16.20
2	22.93	17.95	4.98	27.74
3	17.24	13.89	3.35	24.12
4	10.66	9.23	1.43	15.49
5	15.82	12.48	3.34	26.76
6	24.56	20.16	4.40	21.83
7	37.64	26.78	10.86	40.55
8	18.16	13.59	4.57	33.63
9	15.16	12.26	2.90	23.65
10	35.56	25.63	9.93	38.74
Mean	21.82	16.96	4.86	26.87
Std. Err.	2.77	1.84	0.98	2.71

Rock Creek (2)
Overstory

Plot	Wet	Dry	Moisture (g)	Percent Moisture (%)
1	16.65	15.92	0.73	4.59
2	21.57	16.93	4.64	27.41
3	26.84	19.14	7.70	40.23
4	23.46	18.04	5.42	30.04
5	29.28	22.56	6.72	29.79
6	30.48	22.90	7.58	33.10
7	22.60	18.28	4.32	23.63
8	29.97	21.72	8.25	37.98
9	22.11	16.89	5.22	30.91
10	32.95	23.22	9.73	41.90
Mean	25.59	19.56	6.03	29.96
Std. Err.	1.61	2.04	0.96	3.36

Flook Knoll (1)
Understory

Plot	Wet	Dry	Moisture (g)	Moisture (%)
1	9.25	8.87	0.38	4.28
2	22.70	21.69	1.01	4.66
3	24.92	23.95	0.97	4.05
4	8.96	8.57	0.39	4.55
5	23.78	22.87	0.91	3.98
6	22.65	21.60	1.05	4.86
7	20.05	19.22	0.83	4.32
8	18.42	17.64	0.78	4.42
9	10.83	10.35	0.48	4.64
10	17.15	16.35	0.80	4.89
Mean	17.87	17.11	0.76	4.47
Std. Err.	1.94	1.86	0.08	0.10

Rock Creek (2)
Understory

Plot	Wet	Dry	Moisture (g)	Percent Moisture (%)
1	48.63	47.79	0.84	1.76
2	19.78	18.97	0.81	4.27
3	21.23	19.99	1.24	6.20
4	17.38	16.67	0.71	4.26
5	18.46	17.83	0.63	3.53
6	22.88	21.85	1.03	4.71
7	13.72	13.25	0.47	3.55
8	28.43	26.25	2.18	8.30
9	21.66	21.04	0.62	2.95
10	44.11	42.38	1.73	4.08
Mean	25.63	24.60	1.03	4.36
Std. Err.	3.68	3.60	0.19	0.57

Appendix C. Continued. Pre-burn Moisture Samples

South Frenchglen (3)
Overstory

Plot	Wet	Dry	Moisture (g)	Percent Moisture (%)
1	24.48	18.45	6.03	32.68
2	23.39	17.68	5.71	32.30
3	19.71	15.78	3.93	24.90
4	29.84	20.65	9.19	44.50
5	30.32	22.59	7.73	34.22
6	21.00	16.71	4.29	25.67
7	16.05	12.36	3.69	29.85
8	13.30	10.91	2.39	21.91
9	22.68	15.92	6.76	42.46
10	24.20	17.94	6.26	34.89
Mean	22.50	16.90	5.60	32.34
Std. Err.	1.70	1.10	0.65	2.30

South Frenchglen (3)
Understory

Plot	Wet	Dry	Moisture (g)	Percent Moisture (%)
1	42.27	41.32	0.95	2.30
2	21.22	20.37	0.85	4.17
3	20.52	19.78	0.74	3.74
4	21.31	20.22	1.09	5.39
5	15.51	14.79	0.72	4.87
6	25.84	24.81	1.03	4.15
7	43.39	41.54	1.85	4.45
8	22.95	21.17	1.78	8.41
9	17.30	16.18	1.12	6.92
10	20.75	19.95	0.80	4.01
Mean	25.11	24.01	1.09	4.84
Std. Err.	3.09	3.03	0.13	0.55

Flook Lake Burn (4)
Overstory

Plot	Wet	Dry	Moisture (g)	Percent Moisture (%)
1	26.77	20.17	6.60	32.72
2	18.93	15.12	3.81	25.20
3	28.06	21.08	6.98	33.11
4	18.20	15.09	3.11	20.61
5	21.86	17.77	4.09	23.02
6	18.33	15.07	3.26	21.63
7	18.32	14.37	3.95	27.49
8	25.20	18.07	7.13	39.46
9	19.78	16.73	3.05	18.23
10	16.66	14.67	1.99	13.57
Mean	21.21	16.81	4.40	25.50
Std. Err.	1.28	0.76	0.58	2.47

Flook Lake Burn (4)
Understory

Plot	Wet	Dry	Moisture (g)	Percent Moisture (%)
1	22.70	21.46	1.24	5.78
2	17.91	16.94	0.97	5.73
3	12.80	11.77	1.03	8.75
4	15.18	14.38	0.80	5.56
5	15.03	14.05	0.98	6.98
6	24.72	23.00	1.72	7.48
7	16.64	15.55	1.09	7.01
8	25.96	23.20	2.76	11.90
9	30.78	29.56	1.22	4.13
10	14.97	14.11	0.86	6.09
Mean	19.67	18.40	1.27	6.94
Std. Err.	1.89	1.78	0.18	0.68

Appendix D. Sagebrush Density at sites 1-4

Density Measurements (PCQ method)
Distance of each sagebrush plant from corner of quadrant (cm)

Flook Knoll (1)

Q1	Q2	Q3	Q4	Average
63	85	49	59	64
69	63	25	40	49
73	16	24	30	36
21	22	30	35	27
20	65	138	81	76
43	66	87	34	58
35	31	35	62	41
25	80	30	126	65
76	20	25	60	45
15	47	15	20	24
43	86	80	101	78
10	19	13	20	16
50	46	68	20	46
124	121	78	90	103
55	67	39	37	50
34	23	78	23	40
32	23	33	48	34
20	18	25	66	32
18	76	23	39	39
63	108	87	140	100
46	84	120	59	77
34	84	84	118	80
14	13	34	40	25
41	54	87	54	59
18	57	70	97	61
60	38	58	72	57
30	40	116	59	61
27	63	46	76	53
75	43	38	87	61
11	16	81	28	34
55	91	173	82	100
60	53	121	87	80
60	26	117	45	62
112	79	48	151	98
46	135	64	131	94
38	45	64	120	67
49	54	18	77	50
21	38	108	120	72
90	83	53	80	77
53	86	29	70	60
28	65	45	40	45
45	57	37	68	52
34	78	70	52	59
114	72	72	106	91
51	134	85	110	95
21	28	65	45	40
17	24	63	44	37
79	26	111	56	68
38	12	47	43	35
21	67	63	105	64
45.54	**56.54**	**63.38**	**69.06**	**58.63**

St. Error **3.14**
Plants/ha **29091.10**

Rock Creek (2)

Q1	Q2	Q3	Q4	Average
35	170	56	45	77
110	165	124	8	102
125	145	120	195	146
48	94	132	285	140
120	33	96	130	95
63	30	55	46	49
18	35	64	25	36
13	23	170	26	58
81	40	19	49	47
105	31	131	110	94
107	211	40	145	126
20	15	37	86	40
25	70	115	13	56
59	47	110	258	119
125	135	89	90	110
40	60	51	154	76
103	100	35	38	69
13	36	80	33	41
150	65	125	41	95
57	190	58	31	84
66	109	92	146	103
75	65	58	61	65
256	143	135	81	154
60	40	81	74	64
103	95	75	116	97
80	51	92	140	91
102	74	60	181	104
45	105	65	130	86
250	66	125	85	132
79	88	155	59	95
110	210	11	105	109
100	95	100	40	84
93	40	140	98	93
50	145	31	95	80
46	86	37	125	74
30	110	100	25	66
35	107	59	96	74
55	133	60	40	72
55	36	63	110	66
40	18	80	52	48
58	84	67	30	60
5	120	70	93	72
29	51	40	36	39
40	12	13	60	31
95	74	55	63	72
64	113	30	3	53
35	57	65	55	53
70	45	75	69	65
45	37	58	100	60
37	37	10	45	32
72.50	**82.82**	**76.18**	**84.42**	**78.98**

Std. Error **4.24**
Plants/ha **16063.72**

Appendix D Continued. Sagebrush Density at sites 1-4

South Frenchglen (3)

Q1	Q2	Q3	Q4	Average
53	72	22	81	57
47	90	41	120	75
57	81	124	139	100
60	40	85	19	51
52	112	100	106	93
16	116	65	161	90
91	57	14	115	69
28	161	106	149	111
51	36	51	16	39
88	117	123	109	109
45	39	40	56	45
28	51	57	83	55
31	97	31	82	60
61	38	80	65	61
57	80	20	11	42
51	14	51	90	52
144	90	95	93	106
71	55	121	25	68
89	154	73	186	126
69	53	34	72	57
72	81	130	109	98
43	65	56	42	52
123	115	40	75	88
213	522	37	309	270
69	12	56	87	56
174	129	53	30	97
89	39	88	137	88
64	112	109	193	120
32	28	46	87	48
142	90	108	138	120
79	66	76	160	95
11	67	132	48	65
55	73	26	80	59
66	28	53	48	49
101	85	69	84	85
43	92	83	94	78
54	89	28	58	57
25	44	75	66	53
35	87	12	41	44
7	56	110	28	50
12	63	43	110	57
70	43	25	64	51
45	0	100	83	57
193	107	56	44	100
89	89	34	57	67
70	88	78	80	79
30	43	56	35	41
144	129	38	89	100
24	46	65	38	43
64	110	74	43	73
68.54	**83.02**	**65.78**	**86.70**	**76.01**
	Std. Error			**5.17**
	Plants/ha			**17308.46**

Flook Lake Burn (4)

Q1	Q2	Q3	Q4	Average
10	103	65	83	65
45	53	110	140	87
45	90	110	58	76
85	50	70	72	69
65	45	68	42	55
41	103	26	85	64
35	19	85	82	55
65	73	81	133	88
56	95	63	72	72
65	18	61	72	54
32	65	97	95	72
96	130	130	102	115
80	110	180	82	113
36	45	82	53	54
50	55	40	43	47
115	120	100	145	120
133	35	60	52	70
90	95	65	130	95
50	80	60	46	59
48	76	55	106	71
60	25	40	41	42
61	85	13	38	49
40	48	60	98	62
118	45	18	50	58
98	104	60	191	113
55	127	100	84	92
90	80	50	95	79
90	85	25	62	66
25	103	23	81	58
116	159	45	28	87
19	105	58	65	62
145	190	100	90	131
98	210	191	95	149
45	30	50	190	79
90	153	125	177	136
64	150	95	160	117
72	55	42	115	71
65	82	189	171	127
84	135	110	34	91
27	115	80	110	83
90	45	35	35	51
113	102	116	43	94
38	36	19	35	32
56	20	11	102	47
30	12	57	60	40
65	40	40	84	57
17	51	20	45	33
43	67	80	85	69
70	30	20	33	38
45	82	45	35	52
65.42	**80.62**	**70.50**	**84.50**	**75.26**
	Std. Error			**3.97**
	Plants/ha			**17655.16**

Appendix E. Fire Behavior Data

Flook Knoll (1)

		Obs. No.	Location	Type of Fire	Flame Length (m)	Flame Height (m)	Flame Depth (m)	Flame Angle (deg)	Rate of Spread (m/s)	Residence time (min:sec)
		1	Center	Strip Head	3	2.5	4	55		71
Date:	9/23/97	2	NE	Point	4	3.2	-----	42	0.12	168
Ignition Time:	12:30	3	NE	Point	3.5	2.5	-----	60	0.06	52
Last Ignition:	5:00	4	NE	Point	3.5	2.5	-----	35	0.12	91
Wind Direction	SE	5	NE	Point	6	4	2.5	30	0.14	114
Wind Speed	-10mph	6	NE	Spot	4	3.5	1.5	45	-----	180
Relative Humidity	19-21%	7	NE	Spot	5	3.5	3	25	-----	240
Temperature	80°F	8	NE	Strip Head	8.5	3.5	11	30	0.45	150
10 hr Moisture	5.5	9	NE	Point	2.4	1.3	2	60	-----	360
		10	Center	Point	1.5	1.2	2	60	-----	210
		11	NE-Center	Strip Head	3	2.1	3.2	45	0.15	47
				Mean	4.04	2.71	3.65	44.27	0.17	153.00

Rock Creek (2)

		Obs. No.	Location	Type of Fire	Flame Length (m)	Flame Height (m)	Flame Depth (m)	Flame Angle (deg)	Rate of Spread (m/s)	Residence time (min:sec)
Date:	9/24/97	1	NW	Strip Head	4.8	3	-----	60	0.07	-----
Ignition Time:	3:20	2		Strip Head	3.1	2.5	-----	70	0.05	-----
Last Ignition:	?	3	N	Strip Head	3.5	2.8	3	65	0.11	95
Wind Direction	West	4	NW	Strip Head	3.1	2.2	3	50	-----	90
Wind Speed	2-5mph	5		Strip Head	3.5	3	4	35	-----	-----
Relative Humidity	17%	6		Strip Head	7	6	6	35	-----	-----
				Mean	4.17	3.25	4.00	52.50	0.08	92.50

Appendix E. Continued. Fire Behavior Data

South Frenchglen (3)		Obs. No.	Location	Type of Fire	Flame Length (m)	Flame Height (m)	Flame Depth (m)	Flame Angle (deg)	Rate of Spread (m/s)	Residence time (min:sec)
		1	-----	Strip Head	5	3.8	8	45	0.13	73
Date:	9/28/97	2	Center	Strip Head	4.5	4	4	35	0.24	59
Ignition Time:	12:00	3	Center	Strip Head	3	2.4	8	50	0.18	34
Last Ignition:	5:00	4	Center	Strip Head	5	3	11	30	0.23	30
Wind Direction	East	5	-----	-----	-----	-----	-----	-----	0.29	-----
Wind Speed	5-7mph	6	-----	-----	-----	-----	-----	-----	0.31	-----
Relative Humidity	24%	7	-----	-----	-----	-----	-----	-----	0.01	-----
Temperature	66°F	8	-----	-----	-----	-----	-----	-----	0.2	-----
				Mean	4.38	3.30	7.75	40.00	0.20	49.00

Flook Lake Burn (4)		Obs. No.	Location	Type of Fire	Flame Length (m)	Flame Height (m)	Flame Depth (m)	Flame Angle (deg)	Rate of Spread (m/s)	Residence time (min:sec)
Date:	9/28/97	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ignition Time:	2:30	-----	-----	-----	-----	-----	-----	-----	-----	-----
Last Ignition:	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Wind Direction	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Wind Speed	5-7mph	-----	-----	-----	-----	-----	-----	-----	-----	-----
Relative Humidity	18%	-----	-----	-----	-----	-----	-----	-----	-----	-----
Temperature	74°F	-----	-----	-----	-----	-----	-----	-----	-----	-----

Appendix F. 1997 Species Composition

Site 1: Flook Knoll Burn
Date: 6/97

	Average Cover (%)	Percent Composition
SHRUBS		
Artemisia tridentata **Nutt.**	32.89	0.589
Gutierrezia sarothrae **(Pursh) Britt. & Rusby**	0.62	0.011
Tetradymia canescens **Lag.**	0.31	0.006
GRASSES		
Achnatherum thurberianum **(Piper) Barkworth**	0.68	0.012
Agropyron smithii **Rydb.**	0.49	0.009
Bromus tectorum **L.**	0.61	0.011
Elymus elymoides **(Raf.) Swezey**	5.29	0.095
Poa secunda **J. Presl.**	3.48	0.062
FORBS		
Allium acuminatum **Hook.**	0.49	0.009
A. parvum **Kell.**	0.31	0.006
Antennaria dimorpha **(Nutt.) T. & G.**	0.06	0.001
A. Sparsiflora **Nutt.**	0.12	0.002
Astragalus malacus **Gray**	1.66	0.030
A. obscurus **Wats.**	0.37	0.007
Castilleja agustifolia **(Nutt.) G. Don**	0.31	0.006
Castilleja hispida **Benth.**	0.31	0.006
Chaenactis douglasii **(Hook.) H. & A.**	0.06	0.001
Collinsia parviflora **Lindl.**	2.45	0.044
Crepis Acuminata **Nutt.**	0.31	0.006
C. occidentalis **Nutt.**	0.43	0.008
Descurainia richardsonii **(Sweet) Schulz**	0.30	0.005
Epilobium minutum **Lindl.**	0.06	0.001
Erigeron chrysopsidis **Gray**	0.80	0.014
Gayophytum decipiens/diffusum **Lewis & Szeyk./T. & G.**	0.30	0.005
Lupinus pusillus **Pursh.**	0.06	0.001
Microsteris gracilis **(Hook.) Greene.**	1.09	0.020
Phlox longifolia **Nutt.**	1.78	0.032
Unknown borage	0.12	0.002
Unknown Eriogonum	0.06	0.001

Appendix F. Continued. 1997 Species Composition

Site 2: Rock Creek Burn
Date: 6/97

	Average Cover (%)	Percent Composition
SHRUBS		
Artemisia tridentata **Nutt.**	20.70	0.425
Atriplex spinosa **(Hook.) Collotzi**	3.46	0.071
GRASSES		
Achnatherum webberi **Thurber Barkworth**	0.24	0.005
Bromus tectorum **L.**	0.18	0.004
Elymus elymoides **(Raf.) Swezey**	6.86	0.141
Elymus multisetus **(J.G. Smith) Burtt Davy**	1.26	0.026
Poa secunda **J. Presl.**	8.05	0.165
FORBS		
Agoseris glauca **(Pursh) Raf.**	0.31	0.006
Allium acuminatum **Hook.**	0.18	0.004
Antennaria dimorpha **(Nutt.) T. & G.**	0.06	0.001
A. Sparsiflora **Nutt.**	0.06	0.001
Astragalus malacus **Gray**	0.06	0.001
A. purshii **Dougl.**	0.37	0.008
Collinsia parviflora **Lindl.**	4.04	0.083
Descurainia richardsonii **(Sweet) Schulz**	0.30	0.006
Epilobium minutum **Lindl.**	0.12	0.002
Eriastrum sparsiflorum **(Eastw.) Mason.**	0.12	0.002
Erigeron chrysopsidis **Gray**	0.12	0.002
Gayophytum decipiens/diffusum **Lewis & Szeyk./T. & G.**	0.12	0.002
Lomatium nevadense **(Wats.) Coult. & Rose**	0.06	0.001
Lupinus pusillus **Pursh.**	0.12	0.002
Microsteris gracilis **(Hook.) Greene.**	0.73	0.015
Phlox longifolia **Nutt.**	0.98	0.020
Unknown borage	0.06	0.001
Unknown Lomatium	0.12	0.002
Unknown Phacelia	0.06	0.001

Appendix F. Continued. 1997 Species Composition

Site 3: South Frenchglen Burn
Date: 6/97

	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata **Nutt.**	28.48	0.551
Atriplex spinosa **(Hook.) Collotzi**	1.32	0.026
Gutierrezia sarothrae **(Pursh) Britt. & Rusby**	0.31	0.006
GRASSES		
Achnatherum webberi **Thurber Barkworth**	0.06	0.001
Agropyron smithii **Rydb.**	1.03	0.020
Bromus tectorum **L.**	0.97	0.019
Elymus elymoides **(Raf.) Swezey**	4.23	0.082
Poa secunda **J. Presl.**	6.49	0.126
FORBS		
Agoseris glauca **(Pursh) Raf.**	0.06	0.001
Allium acuminatum **Hook.**	0.42	0.008
A. parvum **Kell.**	1.11	0.021
A. Sparsiflora **Nutt.**	0.06	0.001
Astragalus malacus **Gray**	0.12	0.002
Castilleja hispida **Benth.**	0.06	0.001
Collinsia parviflora **Lindl.**	3.60	0.070
C. occidentalis **Nutt.**	0.68	0.013
Delphinium andersonii **Gray**	0.06	0.001
Descurainia richardsonii **(Sweet) Schulz**	0.12	0.002
Epilobium minutum **Lindl.**	0.06	0.001
Eriastrum sparsiflorum **(Eastw.) Mason.**	0.18	0.003
Erigeron linearis **(Hook.) Piper**	0.06	0.001
Eriogonum strictum **Benth.**	0.30	0.006
Eriogonum vimineum **Dougl.**	0.18	0.003
Lepidium perfoliatum **L.**	0.06	0.001
Lomatium nevadense **(Wats.) Coult. & Rose**	0.06	0.001
Lupinus pusillus **Pursh.**	0.06	0.001
Microsteris gracilis **(Hook.) Greene.**	0.36	0.007
Phlox longifolia **Nutt.**	0.43	0.008
Unknown borage	0.30	0.006
Unknown Lomatium	0.12	0.002
Unknown Collinsia	0.12	0.002
Unknown Labiatae	0.12	0.002
Unknown Lewisia	0.06	0.001

Appendix F. Continued. 1997 Species Composition

Site 4: Flook Lake Burn
Date: 6/97

	Average Cover (%)	Percent Composition
SHRUBS		
Artemisia tridentata **Nutt.**	21.07	0.532
Atriplex spinosa **(Hook.) Collotzi**	0.31	0.008
Tetradymia canescens **Lag.**	0.31	0.008
GRASSES		
Achnatherum webberi **Thurber Barkworth**	0.06	0.002
Achnatherum thurberianum **(Piper) Barkworth**	0.06	0.002
Agropyron smithii **Rydb.**	0.18	0.005
Bromus tectorum **L.**	0.85	0.021
Elymus elymoides **(Raf.) Swezey**	2.80	0.071
Poa secunda **J. Presl.**	4.93	0.124
FORBS		
Allium acuminatum **Hook.**	0.18	0.005
Arabis Holboellii **Hornem.**	0.00	0.000
A. Sparsiflora **Nutt.**	0.00	0.000
Arenaria aculeata **Wats.**	0.37	0.009
Astragalus malacus **Gray**	0.18	0.005
A. obscurus **Wats.**	0.18	0.005
A. purshii **Dougl.**	0.06	0.002
Blepharipappus scaber **Hook.**	0.06	0.002
Chaenactis douglasii **(Hook.) H. & A.**	0.00	0.000
Collinsia parviflora **Lindl.**	3.14	0.079
Crepis modocensis **Greene**	0.43	0.011
C. occidentalis **Nutt.**	0.79	0.020
Descurainia richardsonii **(Sweet) Schulz**	0.12	0.003
Epilobium minutum **Lindl.**	0.18	0.005
Eriastrum sparsiflorum **(Eastw.) Mason.**	0.00	0.000
Erigeraon chrysopsidis **Gray**	0.55	0.014
*Erigeron linearis (***Hook.) Piper**	0.31	0.008
Eriogonum vimineum **Dougl.**	0.00	0.000
Gayophytum decipiens/diffusum **Lewis & Szeyk./T. & G.**	0.06	0.002
Lomatium nevadense **(Wats.) Coult. & Rose**	0.00	0.000
Lupinus pusillus **Pursh.**	0.12	0.003
Microsteris gracilis **(Hook.) Greene.**	0.54	0.014
Phlox longifolia **Nutt.**	1.29	0.033
P. muscoides **Nutt.**	0.18	0.005
Unknown borage	0.06	0.002
Unknown Eriogonum	0.12	0.003
Unknown Lomatium	0.12	0.003
Unknown Phacelia	0.06	0.002

Appendix F. Continued. 1997 Species Composition

Site 5: Hidden Waterhole Control
Species Composition
Date: 6/97

Species	Average Cover (%)	Percent Composition
SHRUBS		
Artemisia tridentata **Nutt.**	22.21	0.445
GRASSES		
Achnatherum webberi **Thurber Barkworth**	0.18	0.004
Achnatherum thurberianum **(Piper) Barkworth**	0.06	0.001
Agropyron smithii **Rydb.**	0.18	0.004
Bromus tectorum **L.**	0.18	0.004
Elymus elymoides **(Raf.) Swezey**	1.77	0.035
Poa secunda **J. Presl.**	8.41	0.169
Pseudoroegneria spicata **(Pursh) A. Löve**	0.62	0.012
Unknown	0.37	0.007
FORBS		
Allium acuminatum **Hook.**	0.24	0.005
Arabis Holboellii **Hornem.**	0.12	0.002
Arenaria aculeata **Wats.**	0.31	0.006
A. obscurus **Wats.**	0.30	0.006
Blepharipappus scaber **Hook.**	0.48	0.010
Collinsia parviflora **Lindl.**	3.15	0.063
C. modocensis **Greene**	1.09	0.022
C. occidentalis **Nutt.**	2.25	0.045
Epilobium minutum **Lindl.**	0.61	0.012
Erigeron chrysopsidis **Gray**	1.47	0.029
Erigeron linearis **(Hook.) Piper**	1.85	0.037
Eriogonum caespitosum **Nutt.**	0.31	0.006
Eriogonum strictum **Benth.**	0.85	0.017
Layia glandulosa **(Hook.) H. & A.**	0.06	0.001
Lupinus pusillus **Pursh.**	0.06	0.001
Microsteris gracilis **(Hook.) Greene.**	0.24	0.005
Phlox longifolia **Nutt.**	1.03	0.021
Plectritus macrocera **T. & G.**	1.15	0.023
Unknown Labiatae	0.06	0.001
Unknown Lomatium	0.30	0.006

Appendix F. Continued. 1997 Species Composition

Site 6: Antelope Spring Control
Date: 6/97

Species	Average Cover (%)	Percent Composition
SHRUBS		
Artemisia tridentata **Nutt.**	18.33	0.489
Atriplex spinosa **(Hook.) Collotzi**	1.40	0.037
Gutierrezia sarothrae **(Pursh) Britt. & Rusby**	0.86	0.023
GRASSES		
Achnatherum webberi **Thurber Barkworth**	0.62	0.017
Bromus tectorum **L.**	0.06	0.002
Elymus elymoides **(Raf.) Swezey**	3.87	0.103
Poa secunda **J. Presl.**	4.80	0.128
Pseudoregnaria **spicata**	0.31	0.008
FORBS		
Allium acuminatum **Hook.**	0.18	0.005
A. parvum **Kell.**	0.42	0.011
Antennaria dimorpha **(Nutt.) T. & G.**	0.06	0.002
Aster scopulorum **Gray**	0.06	0.002
Astragalus malacus **Gray**	0.18	0.005
A. obscurus **Wats.**	0.92	0.025
A. purshii **Dougl.**	0.12	0.003
Collinsia parviflora **Lindl.**	1.08	0.029
Crepis modocensis **Greene**	0.37	0.010
C. occidentalis **Nutt.**	0.06	0.002
Erigeron chrysopsidis **Gray**	1.04	0.028
E. linearis **(Hook.) Piper**	0.06	0.002
Eriogonum strictum **Benth.**	0.67	0.018
Microsteris gracilis **(Hook.) Greene.**	0.06	0.002
Phlox longifolia **Nutt.**	1.77	0.047
Unknown Lomatium	0.18	0.005

Appendix F. Continued. 1997 Species Composition

Site 7: Flook Lake Control
Date: 6/97

Species	Average Cover (%)	Percent Composition
SHRUBS		
Artemisia tridentata **Nutt.**	18.70	0.471
Atriplex spinosa **(Hook.) Collotzi**	1.34	0.034
GRASSES		
Achnatherum webberi **Thurber Barkworth**	0.31	0.008
Achnatherum thurberianum **(Piper) Barkworth**	0.12	0.003
Agropyron smithii **Rydb.**	0.12	0.003
Bromus tectorum **L.**	0.48	0.012
Elymus elymoides **(Raf.) Swezey**	4.25	0.107
Poa secunda **J. Presl.**	6.32	0.159
FORBS		
Allium acuminatum **Hook.**	0.92	0.023
Astragalus malacus **Gray**	0.49	0.012
Castilleja hispida **Benth.**	0.06	0.002
Chaenactis douglasii **(Hook.) H. & A.**	0.06	0.002
Collinsia parviflora **Lindl.**	3.30	0.083
C. modocensis **Greene**	0.12	0.003
C. occidentalis **Nutt.**	0.12	0.003
Delphinium andersonii **Gray**	0.12	0.003
Epilobium minutum **Lindl.**	0.06	0.002
Eriastrum sparsiflorum **(Eastw.) Mason.**	0.12	0.003
Erigeron chrysopsidis **Gray**	0.36	0.009
Erigeron linearis **(Hook.) Piper**	0.06	0.002
Eriogonum strictum **Benth.**	0.18	0.005
Eriogonum vimineum **Dougl.**	0.06	0.002
Microsteris gracilis **(Hook.) Greene.**	0.54	0.014
Plectritus macrocera **T. & G.**	0.31	0.008
Phlox longifolia **Nutt.**	0.73	0.018
Ranunculus testiculatus **Crantz**	0.12	0.003
Unknown Lomatium	0.24	0.006
Unknown Phacelia	0.06	0.002

Appendix F. Continued. 1997 Species Composition

Site 8: Lone Juniper Control
Date: 6/97

Species	Average Cover (%)	Percent Composition
SHRUBS		
Artemisia tridentata **Nutt.**	26.79	0.546
Gutierrezia sarothrae **(Pursh) Britt. & Rusby**	0.90	0.018
GRASSES		
Agropyron smithii **Rydb.**	0.24	0.005
Bromus tectorum **L.**	0.24	0.005
Elymus elymoides **(Raf.) Swezey**	2.08	0.042
Poa secunda **J. Presl.**	6.95	0.142
Pseudoroegneria spicata **(Pursh) A. Löve**	0.43	0.009
FORBS		
Allium acuminatum **Hook.**	0.67	0.014
Antennaria dimorpha **(Nutt.) T. & G.**	0.12	0.002
A. Sparsiflora **Nutt.**	0.06	0.001
Arenaria aculeata **Wats.**	0.72	0.015
Aster scopulorum **Gray**	0.68	0.014
Astragalus malacus **Gray**	0.06	0.001
A. obscurus **Wats.**	0.30	0.006
A. purshii **Dougl.**	0.12	0.002
Blepharipappus scaber **Hook.**	0.12	0.002
Collinsia parviflora **Lindl.**	2.92	0.060
C. modocensis **Greene**	0.97	0.020
C. occidentalis **Nutt.**	0.67	0.014
Epilobium minutum **Lindl.**	0.06	0.001
Erigeron chrysopsidis **Gray**	0.61	0.012
Erigeron linearis **(Hook.) Piper**	0.18	0.004
Lomatium nevadense **(Wats.) Coult. & Rose**	0.06	0.001
Lupinus pusillus **Pursh.**	0.06	0.001
Microsteris gracilis **(Hook.) Greene.**	0.18	0.004
Phlox longifolia **Nutt.**	1.51	0.031
P. muscoides **Nutt.**	0.74	0.015
Unknown Eriogonum	0.48	0.010
Unknown Lomatium	0.12	0.002

Appendix F. Continued. 1998 Species Composition

Site 1: Flook Knoll Burn
Date: 7/7/98

	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata **Nutt.**	0.06	0.001
Atriplex spinosa **(Hook.) Collotzi**	0.12	0.003
GRASSES		
Bromus tectorum **L.**	0.00	0.000
Elymus elymoides **(Raf.) Swezey**	6.95	0.157
Oryzopsis hymenoides **(R. & S.) Ricker**	0.00	0.000
FORBS		
Astragalus malacus **Gray**	0.31	0.007
Castilleja pilosa **(Wats.) Rydb.**	0.31	0.007
Collinsia parviflora **Lindl.**	5.27	0.119
Delphinium andersonii **Gray**	0.06	0.001
Descurainia richardsonii **(Sweet) Schulz**	21.62	0.488
Gilia sinuata **Dougl.**	1.50	0.034
Lupinus pusillus **Wats.**	1.05	0.024
Mentzelia albicaulus **Dougl.**	0.06	0.001
Microsteris gracilis **(Hook.) Greene.**	5.02	0.113
Unknown borage	1.69	0.038
Unknown	0.31	0.007

Appendix F. Continued. 1998 Species Composition

Site 2: Rock Creek Burn
Date: 7/10/98

	Average Cover (%)	Species Composition
GRASSES		
Bromus tectorum **L.**	0.18	0.004
Elymus elymoides **(Raf.) Swezey**	2.29	0.047
Oryzopsis hymenoides **(R. & S.) Ricker**	0.31	0.006
Achnatherum webberi **Thurber Barkworth**	0.74	0.015
Poa secunda **J. Presl.**	4.84	0.100
Achnatherum thurberianum **(Piper) Barkworth**	0.31	0.006
FORBS		
Agoseris heterophylla **(Nutt.) Greene**	0.12	0.002
Allium acuminatum **Hook.**	2.46	0.051
Astragalus malacus **Gray**	0.55	0.011
A. purshii **Dougl.**	0.06	0.001
Chaenactis douglasii **(Hook.) H. & A.**	0.06	0.001
Collinsia parviflora **Lindl.**	12.11	0.250
Crepis modocensis **Greene**	0.06	0.001
Crepis occidentalis **Nutt.**	0.06	0.001
Descurainia richardsonii **(Sweet) Schulz**	3.64	0.075
Epilobium minutum **Lindl.**	0.99	0.020
Eriastrum sparsiflorum **(Eastw.) Mason.**	0.37	0.008
Erigeron chrysopsidis **Gray**	0.06	0.001
Eriogonum vimineum **Dougl.**	1.50	0.031
Gayophytum decipiens/diffusum **Lewis & Szeyk./T. & G.**	0.31	0.006
Gilia sinuata **Dougl.**	7.93	0.163
Lappula redowskii **(Hornem.) Greene**	0.24	0.005
Lomatium nevadense **(Wats.) Coult. & Rose**	0.12	0.002
Lupinus pusillus **Wats.**	1.48	0.031
Mentzelia albicaulus **Dougl.**	0.37	0.008
Microsteris gracilis **(Hook.) Greene.**	3.86	0.080
Mimulus cusickii **(Greene) Piper**	0.06	0.001
Phlox longifolia **Nutt.**	0.67	0.014
Ranunculus testiculatus **Crantz**	0.06	0.001
Unknown Astragalus	0.12	0.002
Unknown Borage	2.34	0.048
Unknwon Crepis	0.06	0.001
Unknown Lomatium	0.12	0.002
Unknown	0.06	0.001

Appendix F. Continued. 1998 Species Composition

Site 3: South Frenchglen Burn
Date: 7/10/98

	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata Nutt.	0.06	0.001
Atriplex spinosa (Hook.) Collotzi	0.06	0.001
GRASSES		
Agropyron dasystachyum (Hook.) Scribn.	0.06	0.001
Bromus tectorum L.	0.24	0.005
Elymus elymoides (Raf.) Swezey	2.77	0.054
Poa secunda J. Presl.	4.99	0.098
FORBS		
Allium acuminatum Hook.	1.78	0.035
Collinsia parviflora Lindl.	13.21	0.259
Crepis occidentalis Nutt.	0.31	0.006
Cryptantha circumscissa (H. & A.) Johnst.	0.37	0.007
Cryptantha intermedia (Gray) Greene	2.79	0.055
Delphinium andersonii Gray	0.80	0.016
Descurainia richardsonii (Sweet) Schulz	1.61	0.032
Epilobium minutum Lindl.	0.61	0.012
Eriastrum sparsiflorum (Eastw.) Mason.	2.71	0.053
Erigeron chrysopsidis Gray	0.06	0.001
Eriogonum vimineum Dougl.	4.37	0.086
Gayophytum decipiens/diffusum Lewis & Szeyk./T. &	3.13	0.061
Gilia sinuata Dougl.	2.00	0.039
Lappula redowskii (Hornem.) Greene	0.43	0.008
Lepidium perfoliatum L.	0.06	0.001
Lomatium nevadense (Wats.) Coult. & Rose	0.06	0.001
Lupinus pusillus *Wats.*	1.93	0.038
Microsteris gracilis (Hook.) Greene.	2.70	0.053
Phacelia linearis (Pursh) Holz.	0.06	0.001
Phlox longifolia Nutt.	1.30	0.025
Polemonium micranthum Benth.	0.12	0.002
Ranunculus testiculatus Crantz	0.06	0.001
Unknown Antennaria	0.06	0.001
Unknown Borage	1.86	0.036
Unknown Crepis	0.49	0.010
Unknown Lomatium	0.06	0.001

Appendix F. Continued. 1998 Species Composition

Site 4: Flook Lake Burn
Date: 7/10/98

	Average Cover (%)	Species Composition
GRASSES		
Bromus tectorum **L.**	15.65	0.328
Elymus elymoides **(Raf.) Swezey**	5.86	0.123
Poa secunda **J. Presl.**	2.95	0.062
FORBS		
Agoseris heterophylla **(Nutt.) Greene**	0.37	0.008
Amsinckia tesselata **Gray**	0.31	0.007
Astragalus malacus **Gray**	0.06	0.001
Collinsia parviflora **Lindl.**	1.64	0.034
Delphinium andersonii **Gray**	0.06	0.001
Descurainia richardsonii **(Sweet) Schulz**	6.73	0.141
Eriastrum sparsiflorum **(Eastw.) Mason.**	2.29	0.048
Gilia sinuata **Dougl.**	0.49	0.010
Lappula redowskii **(Hornem.) Greene**	0.12	0.003
Lupinus pusillus **Wats.**	0.06	0.001
Mimulus cusickii **(Greene) Piper**	0.06	0.001
Phlox longifolia **Nutt.**	1.81	0.038
Unknown Borage	9.11	0.191
Unknown Crepis	0.06	0.001
Unknown Erigeron	0.06	0.001

Appendix F. Continued. 1998 Species Composition

Site 5: Hidden Waterhole Control
Date: 7/8/98

	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata **Nutt.**	20.92	0.361
Gutierrezia sarothrae **(Pursh) Britt. & Rusby**	1.52	0.026
GRASSES		
Bromus tectorum **L.**	0.06	0.001
Elymus elymoides **(Raf.) Swezey**	4.04	0.070
Achnatherum webberi **Thurber Barkworth**	0.76	0.013
Poa secunda **J. Presl.**	4.57	0.079
FORBS		
Allium acuminatum **Hook.**	1.03	0.018
Astragalus obscurus **Wats.**	2.61	0.045
A. purshii **Dougl.**	0.06	0.001
Blepharipappus scaber **Hook.**	4.16	0.072
Collinsia parviflora **Lindl.**	2.11	0.036
Crepis modocensis **Greene**	2.41	0.042
Crepis occidentalis **Nutt.**	1.98	0.034
Delphinium andersonii **Gray**	0.06	0.001
Descurainia richardsonii **(Sweet) Schulz**	0.36	0.006
Epilobium minutum **Lindl.**	0.48	0.008
Eriastrum sparsiflorum **(Eastw.) Mason.**	0.12	0.002
Erigeron chrysopsidis **Gray**	0.24	0.004
Erigeron linearis **(Hook.) Piper**	1.25	0.022
Eriogonum strictum **Benth.**	0.86	0.015
Gayophytum decipiens/diffusum **Lewis & Szeyk./T. & G.**	0.36	0.006
Lomatium nevadense **(Wats.) Coult. & Rose**	0.06	0.001
Lupinus pusillus **Wats.**	0.30	0.005
Microsteris gracilis **(Hook.) Greene.**	1.22	0.021
Phlox longifolia **Nutt.**	1.28	0.022
Plectritis macrocera **T. & G.**	3.35	0.058
Unknown Antennaria	0.06	0.001
Unknown Crepis	1.08	0.019
Unknown Erigeron	0.61	0.011

Appendix F. Continued. 1998 Species Composition

Site 6: Antelope Spring Control
Date: 7/10/98

	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata **Nutt.**	25.94	0.487
Gutierrezia sarothrae **(Pursh) Britt. & Rusby**	1.26	0.024
GRASSES		
Bromus tectorum **L.**	1.10	0.021
Elymus elymoides **(Raf.) Swezey**	1.84	0.035
Achnatherum webberi **Thurber Barkworth**	0.62	0.012
Poa secunda **J. Presl.**	11.21	0.210
FORBS		
Allium acuminatum **Hook.**	0.12	0.002
A. purshii **Dougl.**	0.06	0.001
Collinsia parviflora **Lindl.**	0.18	0.003
Crepis modocensis **Greene**	0.37	0.007
Crepis occidentalis **Nutt.**	0.06	0.001
Descurainia richardsonii **(Sweet) Schulz**	0.72	0.014
Erigeron chrysopsidis **Gray**	4.62	0.087
Eriogonum strictum **Benth.**	1.68	0.032
Gayophytum decipiens/diffusum **Lewis & Szeyk./T. & G.**	0.18	0.003
Microsteris gracilis **(Hook.) Greene.**	0.12	0.002
Mimulus cusickii **(Greene) Piper**	0.06	0.001
Phacelia linearis **(Pursh) Holz.**	0.06	0.001
Phlox longifolia **Nutt.**	1.04	0.020
Unknown Antennaria	0.06	0.001
Unknown Arabis	0.49	0.009
Unknwon Borage	0.67	0.013
Unknwon Castilleja	0.06	0.001
Unknown Crepis	0.24	0.005
Unknown Erigeron	0.55	0.010

Appendix F. Continued. 1998 Species Composition

Site 7: Flook Lake Control
Date: 7/10/98

	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata **Nutt.**	18.48	0.355
GRASSES		
Agropyron dasystachyum **(Hook.) Scribn.**	0.06	0.001
Bromus tectorum **L.**	0.43	0.008
Elymus elymoides **(Raf.) Swezey**	5.79	0.111
Oryzopsis hymenoides **(R. & S.) Ricker**	0.06	0.001
Achnatherum webberi **Thurber Barkworth**	0.31	0.006
Poa secunda **J. Presl.**	10.95	0.211
Achnatherum thurberianum **(Piper) Barkworth**	0.68	0.013
FORBS		
Agoseris heterophylla **(Nutt.) Greene**	0.06	0.001
Allium acuminatum **Hook.**	0.30	0.006
Astragalus obscurus **Wats.**	0.06	0.001
Balsamorhiza serrata **Nels. & Macbr.**	0.31	0.006
Collinsia parviflora **Lindl.**	2.72	0.052
Crepis occidentalis **Nutt.**	0.06	0.001
Descurainia richardsonii **(Sweet) Schulz**	0.24	0.005
Epilobium minutum **Lindl.**	0.12	0.002
Eriastrum sparsiflorum **(Eastw.) Mason.**	0.12	0.002
Erigeron chrysopsidis **Gray**	0.85	0.016
Eriogonum strictum **Benth.**	0.43	0.008
Eriogonum vimineum **Dougl.**	1.77	0.034
Gayophytum decipiens/diffusum **Lewis & Szeyk./T. & G.**	1.32	0.025
Lupinus pusillus **Wats.**	0.18	0.003
Microsteris gracilis **(Hook.) Greene.**	1.46	0.028
Mimulus cusickii **(Greene) Piper**	0.06	0.001
Phacelia linearis **(Pursh) Holz.**	0.06	0.001
Phlox longifolia **Nutt.**	1.84	0.035
Polygonum parryi **Greene**	0.06	0.001
Unknown Antennaria	0.06	0.001
Unknwon Arabis	0.12	0.002
Unknown Borage	1.52	0.029
Unknown Chorizanthe	0.31	0.006
Unknown Crepis	0.42	0.008
Unknwon Erigeron	0.49	0.009
Unknown Lewissia	0.06	0.001
Unknown Lomatium	0.18	0.003
Unknown	0.06	0.001

Appendix F. Continued. 1998 Species Composition

Site 8: Lone Juniper Control
Date: 7/9/98

	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata **Nutt.**	31.18	0.648
GRASSES		
Agropyron spicatum **(Pursh) Scribn. & Smith**	0.31	0.006
Bromus tectorum **L.**	0.30	0.006
Elymus elymoides **(Raf.) Swezey**	6.92	0.144
Poa secunda **J. Presl.**	0.55	0.011
FORBS		
Allium acuminatum **Hook.**	0.24	0.005
Astragalus malacus **Gray**	0.42	0.009
Blepharipappus scaber **Hook.**	0.06	0.001
Collinsia parviflora **Lindl.**	4.14	0.086
Crepis occidentalis **Nutt.**	0.06	0.001
Delphinium andersonii **Gray**	0.06	0.001
Descurainia richardsonii **(Sweet) Schulz**	0.24	0.005
Epilobium minutum **Lindl.**	0.12	0.002
Eriastrum sparsiflorum **(Eastw.) Mason.**	0.00	0.000
Eriogonum strictum **Benth.**	0.31	0.006
Gayophytum decipiens/diffusum **Lewis & Szeyk./T. & G.**	0.00	0.000
Lupinus pusillus **Wats.**	0.06	0.001
Microsteris gracilis **(Hook.) Greene.**	0.12	0.002
Phlox longifolia **Nutt.**	2.61	0.054
Unknown Borage	0.18	0.004
Unknown Crepis	0.18	0.004
Unknown Lomatium	0.06	0.001

Appendix F. Continued. 1999 Species Composition

Site 1: Flook Knoll burn
Date: 7/15/99

	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata Nutt. (seedling)	0.00	0.000
Atriplex spinosa (Hook.) Collotzi (seedling)	0.00	0.000
GRASSES		
Bromus tectorum L.	0.30	0.006
Elymus elymoides (Raf.) Swezey	9.58	0.184
Oryzopsis hymenoides (R. & S.) Ricker	0.10	0.002
FORBS		
Collinsia parviflora Lindl.	1.01	0.019
Descurainia richardsonii (Sweet) Schulz	27.85	0.535
Epilobium minutum Lindl.	3.58	0.069
Gayophytum decipiens/diffusum Lewis & Szeyk./T. & G.	0.82	0.016
Gilia Sinuata Dougl.	0.46	0.009
Lappula redowskii (Hornem.) Greene	0.20	0.004
Mentzelia albicaulus Dougl.	0.05	0.001
Microsteris gracilis (Hook.) Greene.	7.86	0.151
Cryptantha sp.	0.20	0.004

Appendix F. Continued. 1999 Species Composition

Site 2: Rock Creek Burn
Date: 7/16/98

	Average Cover (%)	Species Composition
GRASSES		
Bromus tectorum **L.**	2.94	0.053
Elymus elymoides **(Raf.) Swezey**	4.28	0.077
Oryzopsis hymenoides **(R. & S.) Ricker**	0.86	0.015
Achnatherum webberi **Thurber Barkworth**	1.57	0.028
Poa secunda **J. Presl.**	7.82	0.140
Achnatherum thurberianum **(Piper) Barkworth**	0.00	0.000
FORBS		
Agoseris heterophylla **(Nutt.) Greene**	0.05	0.001
Allium acuminatum **Hook.**	2.37	0.043
Astragalus malacus **Gray**	0.61	0.011
Collinsia parviflora **Lindl.**	2.43	0.044
Crepis occidentalis **Nutt.**	0.05	0.001
Descurainia richardsonii **(Sweet) Schulz**	1.85	0.033
Epilobium minutum **Lindl.**	17.16	0.308
Eriastrum sparsiflorum **(Eastw.) Mason.**	0.05	0.001
Erigeron linearis **(Hook.) Piper**	1.88	0.034
Eriogonum vimineum **Dougl.**	1.68	0.030
Gayophytum decipiens/diffusum **Lewis & Szeyk./T. & G.**	2.09	0.038
Gilia Sinuata **Dougl.**	0.81	0.015
Lactuca serriola **L.**	0.30	0.005
Lappula redowskii **(Hornem.) Greene**	0.05	0.001
Lupinus pusillus **Pursh.**	0.10	0.002
Microsteris gracilis **(Hook.) Greene.**	5.02	0.090
Phlox longifolia **Nutt.**	0.93	0.017
Crepis sp.	0.10	0.002
Cryptantha sp.	0.61	0.011
Lomatium sp.	0.05	0.001

Appendix F. Continued. 1999 Species Composition

Site 3: South Frenchglen Burn
Date: 7/14/99

Species	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata ssp. Wyomingensis **Nutt.**	0.31	0.006
Atriplex spinosa **(Hook.) Collotzi (seedling)**	0.00	0.000
GRASSES	0.31	0.006
Achnatherum thurberianum **(Piper) Barkworth**	0.81	0.015
Agropyron dasystachyum **(Hook.) Scribn.**	0.00	0.000
Bromus tectorum **L.**	1.11	0.021
Elymus elymoides **(Raf.) Swezey**	5.65	0.105
Poa secunda **J. Presl.**	11.47	0.213
FORBS		
Allium acuminatum **Hook.**	1.84	0.034
Astragalus obscurus **Wats.**	0.41	0.008
Chaenactis douglasii **(Hook.) H. & A.**	0.31	0.006
Collinsia parviflora **Lindl.**	2.38	0.044
Crepis occidentalis **Nutt.**	1.58	0.029
Crepis modocensis **Greene**	0.31	0.006
Delphinium andersonii **Gray**	0.35	0.006
Descurainia richardsonii **(Sweet) Schulz**	0.05	0.001
Epilobium minutum **Lindl.**	4.97	0.092
Eriastrum sparsiflorum **(Eastw.) Mason.**	0.56	0.010
Erigeron chrysopsidis **Gray**	0.20	0.004
Erigeron linearis **(Hook.) Piper**	0.36	0.007
Eriogonum strictum **Benth.**	0.10	0.002
Eriogonum vimineum **Dougl.**	6.21	0.115
Gayophytum decipiens/diffusum **Lewis & Szeyk./T. & G.**	3.75	0.070
Lactuca serriola **L.**	0.05	0.001
Lepidium perfoliatum **L.**	4.82	0.089
Lupinus pusillus **Pursh.**	0.10	0.002
Mentzelia albicaulus **Dougl.**	0.05	0.001
Microsteris gracilis **(Hook.) Greene.**	2.91	0.054
Phlox longifolia **Nutt.**	0.46	0.009
Plectritis macrocera **T. & G.**	0.36	0.007
Polemonium micranthum **Benth.**	0.67	0.012
Ranunculus testiculatus **Crantz**	0.05	0.001
Crepis sp.	0.20	0.004
Cryptantha sp.	1.38	0.026
Lomatium sp.	0.15	0.003

Appendix F. Continued. 1999 Species Composition

Site 4: Flook Lake Burn
Date: 7/15/99

	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata ssp. Wyomingensis **Nutt.**	0.31	0.006
Atriplex spinosa **(Hook.) Collotzi**	0.00	0.000
GRASSES		
Bromus tectorum **L.**	33.37	0.790
Elymus elymoides **(Raf.) Swezey**	1.17	0.028
Poa secunda **J. Presl.**	0.10	0.002
FORBS		
Collinsia parviflora **Lindl.**	0.71	0.017
Crepis occidentalis **Nutt.**	0.05	0.001
Descurainia richardsonii **(Sweet) Schulz**	1.33	0.031
Epilobium minutum **Lindl.**	2.10	0.050
Eriastrum sparsiflorum **(Eastw.) Mason.**	1.49	0.035
Microsteris gracilis **(Hook.) Greene.**	0.10	0.002
Phlox longifolia **Nutt.**	1.12	0.027
Sysimbrium altissimum **L.**	0.05	0.001
Crepis sp.	0.05	0.001
Cryptantha sp.	0.61	0.014

Appendix F. Continued. 1999 Species Composition

Site 5: Hidden Waterhole Control
Date: 7/15/99

	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata Nutt.	9.59	0.356
Atriplex spinosa (Hook.) Collotzi	0.00	0.000
GRASSES		
Elymus elymoides (Raf.) Swezey	3.39	0.126
Achnatherum webberi Thurber Barkworth	0.72	0.027
Agropyron dasystachyum (Hook.) Scribn.	0.36	0.013
Poa secunda J. Presl.	4.52	0.168
FORBS		
Allium acuminatum Hook.	0.46	0.017
Astragalus obscurus Wats.	0.36	0.013
Blepharipappus scaber Hook.	3.17	0.118
Collinsia parviflora Lindl.	0.70	0.026
Crepis modocensis Greene	0.05	0.002
Epilobium minutum Lindl.	0.66	0.024
Erigeron chrysopsidis Gray	0.51	0.019
Erigeron linearis (Hook.) Piper	0.10	0.004
Eriogonum strictum Benth.	0.10	0.004
Microsteris gracilis (Hook.) Greene.	0.30	0.011
Phlox longifolia Nutt.	0.50	0.019
Plectritis macrocera T. & G.	0.05	0.002
Crepis sp.	1.02	0.038
Lomatium sp.	0.41	0.015

Appendix F. Continued. 1999 Species Composition

Site 6: Antelope Spring
Date: 7/14/99

	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata **Nutt.**	11.89	0.504
Gutierrezia sarothrae **(Pursh) Britt. & Rusby**	0.00	0.000
GRASSES		
Bromus tectorum **L.**	0.25	0.011
Elymus elymoides **(Raf.) Swezey**	0.77	0.033
Achnatherum webberi **Thurber Barkworth**	0.41	0.017
Poa secunda **J. Presl.**	6.57	0.278
FORBS		
Allium acuminatum **Hook.**	0.05	0.002
Aster scopulorum **Gray**	0.31	0.013
Collinsia parviflora **Lindl.**	0.25	0.011
Descurainia richardsonii **(Sweet) Schulz**	0.10	0.004
Epilobium minutum **Lindl.**	0.10	0.004
Erigeron chrysopsidis **Gray**	0.81	0.034
Erigeron linearis **(Hook.) Piper**	0.36	0.015
Eriogonum strictum **Benth.**	0.72	0.031
Eurotia lanata **(Pursh) Moq.**	0.05	0.002
Microsteris gracilis **(Hook.) Greene.**	0.05	0.002
Phlox longifolia **Nutt.**	0.56	0.024
Antennaria sp.	0.05	0.002
Arabis sp.	0.05	0.002
Crepis sp.	0.15	0.006
Cryptantha sp.	0.05	0.002
Lomatium sp.	0.05	0.002

Appendix F. Continued. 1999 Species Composition

Site 7: Flook Lake Control
Date: 7/14/99

Species	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata **Nutt.**	12.09	0.502
GRASSES		
Elymus elymoides **(Raf.) Swezey**	1.84	0.076
Achnatherum webberi **Thurber Barkworth**	0.05	0.002
Poa secunda **J. Presl.**	6.16	0.256
FORBS		
Allium acuminatum **Hook.**	0.05	0.002
A. purshii **Dougl.**	0.31	0.013
Collinsia parviflora **Lindl.**	0.85	0.035
Delphinium andersonii **Gray**	0.05	0.002
Descurainia richardsonii **(Sweet) Schulz**	0.05	0.002
Epilobium minutum **Lindl.**	0.35	0.015
Eriastrum sparsiflorum **(Eastw.) Mason.**	0.05	0.002
Erigeron chrysopsidis **Gray**	0.25	0.010
Erigeron linearis **(Hook.) Piper**	0.10	0.004
Eriogonum strictum **Benth.**	0.10	0.004
Gayophytum decipiens/diffusum **Lewis & Szeyk./T. & G.**	0.05	0.002
Microsteris gracilis **(Hook.) Greene.**	0.60	0.025
Phlox longifolia **Nutt.**	0.61	0.025
Antennaria sp.	0.05	0.002
Crepis sp.	0.35	0.015
Lewissia sp.	0.05	0.002
Lomatium sp.	0.05	0.002

Appendix F. Continued. 1999 Species Composition

Site 8: Lone Juniper
Date: 7/14/99

	Average Cover (%)	Species Composition
SHRUBS		
Artemisia tridentata Nutt.	13.67	0.611
GRASSES		
Achnatherum thurberianum (Piper) Barkworth	0.05	0.002
Bromus tectorum L.	0.15	0.007
Elymus elymoides (Raf.) Swezey	5.48	0.245
Poa secunda J. Presl.	0.31	0.014
FORBS		
Astragalus malacus Gray	0.05	0.002
Astragalus obscurus Wats.	0.05	0.002
Collinsia parviflora Lindl.	1.30	0.058
Crepis occidentalis Nutt.	0.05	0.002
Delphinium andersonii Gray	0.05	0.002
Descurainia richardsonii (Sweet) Schulz	0.05	0.002
Epilobium minutum Lindl.	0.05	0.002
Erigeron chrysopsidis Gray	0.05	0.002
Gayophytum decipiens/diffusum Lewis & Szeyk./T. & G.	0.05	0.002
Microsteris gracilis (Hook.) Greene.	0.10	0.004
Phlox longifolia Nutt.	0.86	0.038
Crepis sp.	0.05	0.002

Appendix G. Peto and Peto Logrank Calculations

These abbreviations are used in tables for calculating Peto and Peto logrank statistics.

T(treat) = Total number of plants alive at beginning of census date.
D(treat) = Total number of plants dying during census period.
Alive = Total number of plants alive in all treatments at that census date.
Dead = Total number of plants dying during that census period.
P(treat) = Proportion of plants alive in that treatment divided by the total number alive in all treatments (alive).
E(treat) = Expected mortality of plants in that treatment during that census date. multiply proportion of plants alive in a particular treatment by the total number dying in all treatments (dead) during that census period.
R(treat) = Residuals. actual mortality during that census period minus expected mortality for each treatment.
Logrank statistic = Calculated from Pyke and Thompson (1986) - use chi square distribution with df=number of treatments minus one.
M(treat) = Mortality risk as calculated by Hutchings (1991).
V(treat) =Variance for mortality risk as calculated by Hutchings (1991).
UCL(treat) = One sided confidence limit around daily mortality risk.

Appendix G. Continued. Peto and Peto Logrank Calculations

SURVIVAL TABLE CRMO COHORT 1

CENSUS	T(U-M)	T(U-I)	T(B-M)	T(B-I)	ALIVE	D(U-M)	D(U-I)	D(B-M)	D(B-I)	DEAD
21-Mar-98	201	112	145	113	571	7	5	20	11	43
08-Apr-98	194	107	125	102	528	18	8	8	10	44
28-Apr-98	176	99	117	92	484	12	12	3	9	36
19-May-98	164	87	114	83	448	10	8	1	2	21
17-Jun-98	154	79	113	81	427	11	15	2	3	31
07-Jul-98	143	64	111	78	396	31	22	12	17	82
28-Jul-98	112	42	99	61	314	0	0	0	0	0
17-Apr-99	112	42	99	61	314	0	2	0	0	2
15-May-99	112	40	99	61	312	34	9	10	10	63
15-Jun-99	78	31	89	51	249	74	31	70	44	219
20-Jul-99	4	0	19	7	30					
					Total	197	112	126	106	541

Peto and Peto
20.05153

PROPORTIONAL SURVIVAL AND EXPECTED MORTALITY CRMO COHORT 1

CENSUS	P(U-M)	P(U-I)	P(B-M)	P(B-I)	E(U-M)	E(U-I)	E(B-M)	E(B-I)	R(U-M)	R(U-I)	R(B-M)	R(B-I)	Logrank Statistic
21-Mar-98	0.352	0.196	0.254	0.198	15.137	8.434	10.919	8.510	-8.137	-3.434	9.081	2.490	14.052
08-Apr-98	0.367	0.203	0.237	0.193	16.167	8.917	10.417	8.500	1.833	-0.917	-2.417	1.500	1.128
28-Apr-98	0.364	0.205	0.242	0.190	13.091	7.364	8.702	6.843	-1.091	4.636	-5.702	2.157	7.427
19-May-98	0.366	0.194	0.254	0.185	7.688	4.078	5.344	3.891	2.313	3.922	-4.344	-1.891	8.917
17-Jun-98	0.361	0.185	0.265	0.190	11.180	5.735	8.204	5.881	-0.180	9.265	-6.204	-2.881	21.071
07-Jul-98	0.361	0.162	0.280	0.197	29.611	13.253	22.985	16.152	1.389	8.747	-10.985	0.848	11.133
28-Jul-98	0.357	0.134	0.315	0.194	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	#DIV/0!
17-Apr-99	0.357	0.134	0.315	0.194	0.713	0.268	0.631	0.389	-0.713	1.732	-0.631	-0.389	0.000
15-May-99	0.359	0.128	0.317	0.196	22.615	8.077	19.990	12.317	11.385	0.923	-9.990	-2.317	11.265
15-Jun-99	0.313	0.124	0.357	0.205	68.602	27.265	78.277	44.855	5.398	3.735	-8.277	-0.855	1.828
				Total	184.804	83.390	165.469	107.337					

AGE SPECIFIC MORTALITY RISKS

CENSUS	M(U-M)	M(U-I)	M(B-M)	M(B-I)	DAYS	VAR(U-M)	VAR(U-I)	VAR(B-M)	VAR(B-I)	UCL(U-M)	UCL(U-I)	UCL(B-M)	UCL(B-I)
21-Mar-98	0.001969	0.002537	0.008230	0.005685	18	0.000001	0.000001	0.000003	0.000003	0.001031	0.001572	0.002551	0.002375
08-Apr-98	0.004865	0.003883	0.003306	0.005155	20	0.000001	0.000002	0.000001	0.000003	0.001589	0.001903	0.001620	0.002259
28-Apr-98	0.003361	0.006144	0.001237	0.004898	21	0.000001	0.000003	0.000001	0.000003	0.001345	0.002458	0.000990	0.002263
19-May-98	0.002995	0.004590	0.000420	0.001161	21	0.000001	0.000003	0.000000	0.000001	0.001313	0.002249	0.000581	0.001138
17-Jun-98	0.002554	0.007234	0.000616	0.001301	29	0.000001	0.000003	0.000000	0.000001	0.001067	0.002589	0.000603	0.001041
07-Jul-98	0.012157	0.020755	0.005714	0.012230	20	0.000005	0.000020	0.000003	0.000009	0.003026	0.006132	0.002286	0.004111
28-Jul-98	0.000000	0.000000	0.000000	0.000000	291	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
17-Apr-99	0.000000	0.001626	0.000000	0.000000	30	#DIV/0!	0.000001	#DIV/0!	#DIV/0!	#DIV/0!	0.001593	#DIV/0!	#DIV/0!
15-May-99	0.009942	0.007042	0.002955	0.004960	36	0.000003	0.000006	0.000001	0.000002	0.002363	0.003253	0.001295	0.002174

Appendix G. Continued. Peto and Peto Logrank Calculations

Peto and Peto
37.431824

SURVIVAL TABLE CROC COHORT 1

CENSUS	T(U-M)	T(U-I)	T(B-M)	T(B-I)	ALIVE	D(U-M)	D(U-I)	D(B-M)	D(B-I)	DEAD
21-Mar-98	170	100	143	112	525	4	5	14	5	28
08-Apr-98	166	95	129	107	497	25	14	8	8	55
28-Apr-98	141	81	121	99	442	11	12	4	12	39
19-May-98	130	69	117	87	403	7	3	2	8	20
17-Jun-98	123	66	115	79	383	21	16	2	15	54
07-Jul-98	102	50	113	64	329	22	14	12	22	70
28-Jul-98	80	36	101	42	259	0	0	1	0	1
17-Apr-99	80	36	100	42	258	1	0	0	2	3
15-May-99	79	36	100	40	255	17	8	1	9	35
15-Jun-99	62	28	99	31	220	60	28	73	31	192
20-Jul-99	2	0	26	0	28					
					Total	168	100	117	112	497

PROPORTIONAL SURVIVAL AND EXPECTED MORTALITY CROC COHORT 1

CENSUS	P(U-M)	P(U-I)	P(B-M)	P(B-I)	E(U-M)	E(U-I)	E(B-M)	E(B-I)	R(U-M)	R(U-I)	R(B-M)	R(B-I)	Logrank Statistic
21-Mar-98	0.324	0.190	0.272	0.213	9.067	5.333	7.627	5.973	-5.067	-0.333	6.373	-0.973	8.337
08-Apr-98	0.334	0.191	0.260	0.215	18.370	10.513	14.276	11.841	6.630	3.487	-6.276	-3.841	7.554
28-Apr-98	0.319	0.183	0.274	0.224	12.441	7.147	10.676	8.735	-1.441	4.853	-6.676	3.265	8.857
19-May-98	0.323	0.171	0.290	0.216	6.452	3.424	5.806	4.318	0.548	-0.424	-3.806	3.682	5.735
17-Jun-98	0.321	0.172	0.300	0.206	17.342	9.305	16.214	11.138	3.658	6.695	-14.214	3.862	19.387
07-Jul-98	0.310	0.152	0.343	0.195	21.702	10.638	24.043	13.617	0.298	3.362	-12.043	8.383	12.259
28-Jul-98	0.309	0.139	0.390	0.162	0.309	0.139	0.390	0.162	-0.309	-0.139	0.610	-0.162	1.564
17-Apr-99	0.310	0.140	0.388	0.163	0.930	0.419	1.163	0.488	0.070	-0.419	-1.163	1.512	0.000
15-May-99	0.310	0.141	0.392	0.157	10.843	4.941	13.725	5.490	6.157	3.059	-12.725	3.510	19.432
15-Jun-99	0.282	0.127	0.450	0.141	54.109	24.436	86.400	27.055	5.891	3.564	-13.400	3.945	3.815
				Total	151.565	76.297	180.320	88.818					

AGE SPECIFIC MORTALITY RISKS

CENSUS	M(U-M)	M(U-I)	M(B-M)	M(B-I)	DAYS	VAR(U-M)	VAR(U-I)	VAR(B-M)	VAR(B-I)	UCL(U-M)	UCL(U-I)	UCL(B-M)	UCL(B-I)
21-Mar-98	0.001323	0.002849	0.005719	0.002537	18	0.000000	0.000002	0.000002	0.000001	0.000917	0.001766	0.002118	0.001572
08-Apr-98	0.008143	0.007955	0.003200	0.003883	20	0.000003	0.000005	0.000001	0.000002	0.002257	0.002946	0.001568	0.001903
28-Apr-98	0.003866	0.007619	0.001601	0.006144	21	0.000001	0.000005	0.000001	0.000003	0.001615	0.003048	0.001109	0.002458
19-May-98	0.002635	0.002116	0.000821	0.004590	21	0.000001	0.000001	0.000000	0.000003	0.001380	0.001693	0.000805	0.002249
17-Jun-98	0.006437	0.009512	0.000605	0.007234	29	0.000002	0.000006	0.000000	0.000003	0.001947	0.003296	0.000593	0.002589
07-Jul-98	0.012088	0.016279	0.005607	0.020755	20	0.000007	0.000019	0.000003	0.000020	0.003572	0.006030	0.002243	0.006132
28-Jul-98	0.000000	0.000000	0.000034	0.000000	291	#DIV/0!	#DIV/0!	0.000000	#DIV/0!	#DIV/0!	#DIV/0!	0.000047	#DIV/0!
17-Apr-99	0.000419	0.000000	0.000000	0.001626	30	0.000000	#DIV/0!	#DIV/0!	0.000001	0.000581	#DIV/0!	#DIV/0!	0.001593
15-May-99	0.006698	0.006944	0.000279	0.007042	36	0.000003	0.000006	0.000000	0.000006	0.002251	0.003403	0.000387	0.003253

Appendix G. Continued. Peto and Peto Logrank Calculations

SURVIVAL TABLE CRMO TRANSPLANTS COHORT 1

CENSUS	T(U-M)	T(U-I)	T(B-M)	T(B-I)	ALIVE	D(U-M)	D(U-I)	D(B-M)	D(B-I)	DEAD
28-Apr-98	149	150	150	150	599	87	98	76	105	366
19-May-98	62	52	74	45	233	13	11	2	10	36
17-Jun-98	49	41	72	35	197	8	8	8	1	25
07-Jul-98	41	33	64	34	172	27	25	29	18	99
28-Jul-98	14	8	35	16	73	1	0	9	6	16
17-Apr-99	13	8	26	10	57	1	0	0	0	1
15-May-99	12	8	26	10	56	4	3	4	0	11
15-Jun-99	8	5	22	10	45	7	5	22	10	44
20-Jul-99	1	0	0	0	1					
					Total	148	150	150	150	598

Peto and Peto
9.7553592

PROPORTIONAL SURVIVAL AND EXPECTED MORTALITY CRMO TRANSPLANTS COHORT 1

CENSUS	P(U-M)	P(U-I)	P(B-M)	P(B-I)	E(U-M)	E(U-I)	E(B-M)	E(B-I)	R(U-M)	R(U-I)	R(B-M)	R(B-I)	Logrank Statistic
28-Apr-98	0.249	0.250	0.250	0.250	91.042	91.653	91.653	91.653	-4.042	6.347	-15.653	13.347	5.236
19-May-98	0.266	0.223	0.318	0.193	9.579	8.034	11.433	6.953	3.421	2.966	-9.433	3.047	11.435
17-Jun-98	0.249	0.208	0.365	0.178	6.218	5.203	9.137	4.442	1.782	2.797	-1.137	-3.442	4.822
07-Jul-98	0.238	0.192	0.372	0.198	23.599	18.994	36.837	19.570	3.401	6.006	-7.837	-1.570	4.182
28-Jul-98	0.192	0.110	0.479	0.219	3.068	1.753	7.671	3.507	-2.068	-1.753	1.329	2.493	5.150
17-Apr-99	0.228	0.140	0.456	0.175	0.228	0.140	0.456	0.175	0.772	-0.140	-0.456	-0.175	3.385
15-May-99	0.214	0.143	0.464	0.179	2.357	1.571	5.107	1.964	1.643	1.429	-1.107	-1.964	4.648
15-Jun-99	0.178	0.111	0.489	0.222	7.822	4.889	21.511	9.778	-0.822	0.111	0.489	0.222	0.000
20-Jul-99	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	#DIV/0!
				Total	143.914	132.238	183.806	138.041					

AGE SPECIFIC MORTALITY RISKS

CENSUS	M(U-M)	M(U-I)	M(B-M)	M(B-I)	DAYS	VAR(U-M)	VAR(U-I)	VAR(B-M)	VAR(B-I)	UCL(U-M)	UCL(U-I)	UCL(B-M)	UCL(B-I)
28-Apr-98	0.039269	0.046205	0.032313	0.051282	21	0.000018	0.000022	0.000014	0.000025	0.005834	0.006467	0.005136	0.006934
19-May-98	0.011154	0.011265	0.001305	0.011905	21	0.000010	0.000012	0.000001	0.000014	0.004287	0.004707	0.001279	0.005217
17-Jun-98	0.006130	0.007456	0.004057	0.001000	29	0.000005	0.000007	0.000002	0.000001	0.003004	0.003653	0.001988	0.001385
07-Jul-98	0.049091	0.060976	0.029293	0.036000	20	0.000089	0.000149	0.000030	0.000072	0.013090	0.016894	0.007538	0.011758
28-Jul-98	0.000255	0.000000	0.001014	0.001586	291	0.000000	#DIV/0!	0.000000	0.000000	0.000353	#DIV/0!	0.000468	0.000897
17-Apr-99	0.002667	0.000000	0.000000	0.000000	30	0.000007	#DIV/0!	#DIV/0!	#DIV/0!	0.003696	#DIV/0!	#DIV/0!	#DIV/0!
15-May-99	0.011111	0.012821	0.004630	0.000000	36	0.000031	0.000055	0.000005	#DIV/0!	0.007699	0.010258	0.003208	#DIV/0!

Appendix G. Continued. Peto and Peto Logrank Calculations

SURVIVAL TABLE CROC TRANSPLANTS COHORT 1

CENSUS	T(U-M)	T(U-I)	T(B-M)	T(B-I)	ALIVE	D(U-M)	D(U-I)	D(B-M)	D(B-I)	DEAD
28-Apr-98	148	148	150	150	596	56	61	44	72	233
19-May-98	92	87	106	78	363	6	15	3	1	25
17-Jun-98	86	72	103	77	338	24	12	14	9	59
07-Jul-98	62	60	89	68	279	42	47	47	34	170
28-Jul-98	20	13	42	34	109	0	0	5	7	12
17-Apr-99	20	13	37	27	97	1	0	0	3	4
15-May-99	19	13	37	24	93	4	1	5	1	11
15-Jun-99	15	12	32	23	82	15	12	29	21	77
20-Jul-99	0	0	3	2	5					
					Total	148	148	147	148	591

Peto and Peto
9.8374668

PROPORTIONAL SURVIVAL AND EXPECTED MORTALITY CROC TRANSPLANTS COHORT 1

CENSUS	P(U-M)	P(U-I)	P(B-M)	P(B-I)	E(U-M)	E(U-I)	E(B-M)	E(B-I)	R(U-M)	R(U-I)	R(B-M)	R(B-I)	*Logrank stat*
28-Apr-98	0.248	0.248	0.252	0.252	57.859	57.859	58.641	58.641	-1.859	3.141	-14.641	13.359	6.929
19-May-98	0.253	0.240	0.292	0.215	6.336	5.992	7.300	5.372	-0.336	9.008	-4.300	-4.372	19.652
17-Jun-98	0.254	0.213	0.305	0.228	15.012	12.568	17.979	13.441	8.988	-0.568	-3.979	-4.441	7.755
07-Jul-98	0.222	0.215	0.319	0.244	37.778	36.559	54.229	41.434	4.222	10.441	-7.229	-7.434	5.751
28-Jul-98	0.183	0.119	0.385	0.312	2.202	1.431	4.624	3.743	-2.202	-1.431	0.376	3.257	6.497
17-Apr-99	0.206	0.134	0.381	0.278	0.825	0.536	1.526	1.113	0.175	-0.536	-1.526	1.887	5.296
15-May-99	0.204	0.140	0.398	0.258	2.247	1.538	4.376	2.839	1.753	-0.538	0.624	-1.839	2.835
15-Jun-99	0.183	0.146	0.390	0.280	14.085	11.268	30.049	21.598	0.915	0.732	-1.049	-0.598	0.000
20-Jul-99	0.000	0.000	0.600	0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	#DIV/0!
				Total	136.344	127.751	178.725	148.180					

AGE SPECIFIC MORTALITY RISKS

CENSUS	M(U-M)	M(U-I)	M(B-M)	M(B-I)	DAYS	VAR(U-M)	VAR(U-I)	VAR(B-M)	VAR(B-I)	UCL(U-M)	UCL(U-I)	UCL(B-M)	UCL(B-I)
28-Apr-98	0.022222	0.024721	0.016369	0.030075	21	0.000009	0.000010	0.000006	0.000013	0.004115	0.004386	0.003420	0.004912
19-May-98	0.003210	0.008985	0.001367	0.000614	21	0.000002	0.000005	0.000001	0.000000	0.001816	0.003215	0.001094	0.000852
17-Jun-98	0.011184	0.006270	0.005029	0.004281	29	0.000005	0.000003	0.000002	0.000002	0.003164	0.002508	0.001863	0.001978
07-Jul-98	0.051220	0.064384	0.035878	0.033333	20	0.000062	0.000088	0.000027	0.000033	0.010950	0.013009	0.007252	0.007922
28-Jul-98	0.000000	0.000000	0.000435	0.000789	291	#DIV/0!	#DIV/0!	0.000000	0.000000	#DIV/0!	#DIV/0!	0.000270	0.000413
17-Apr-99	0.001709	0.000000	0.000000	0.003922	30	0.000003	#DIV/0!	#DIV/0!	0.000005	0.002369	#DIV/0!	#DIV/0!	0.003138
15-May-99	0.006536	0.002222	0.004026	0.001182	36	0.000011	0.000005	0.000003	0.000001	0.004529	0.003080	0.002495	0.001638

Appendix G. Continued. Peto and Peto Logrank Calculations

SURVIVAL TABLE ASPU TRANSPLANTS COHORT 1

CENSUS	T(U-M)	T(U-I)	T(B-M)	T(B-I)	ALIVE	D(U-M)	D(U-I)	D(B-M)	D(B-I)	DEAD
28-Apr-98	200	200	200	201	801	36	35	24	16	111
19-May-98	164	165	176	185	690	33	18	16	11	78
17-Jun-98	131	147	160	174	612	12	10	6	4	32
07-Jul-98	119	137	154	170	580	31	36	13	15	95
28-Jul-98	88	101	141	155	485	52	58	33	45	188
17-Apr-99	36	43	108	110	297	2	3	3	1	9
15-May-99	34	40	105	109	288	2	3	4	7	16
15-Jun-99	32	37	101	102	272	6	5	20	12	43
20-Jul-99	26	32	81	90	229					
					Total	174	168	119	111	

Peto and Peto
77.530813

PROPORTIONAL SURVIVAL AND EXPECTED MORTALITY CRMO TRANSPLANTS COHORT 1

CENSUS	P(U-M)	P(U-I)	P(B-M)	P(B-I)	E(U-M)	E(U-I)	E(B-M)	E(B-I)	R(U-M)	R(U-I)	R(B-M)	R(B-I)	*Logrank stat*
28-Apr-98	0.250	0.250	0.250	0.251	27.715	27.715	27.715	27.854	8.285	7.285	-3.715	-11.854	9.934
19-May-98	0.238	0.239	0.255	0.268	18.539	18.652	19.896	20.913	14.461	-0.652	-3.896	-9.913	16.764
17-Jun-98	0.214	0.240	0.261	0.284	6.850	7.686	8.366	9.098	5.150	2.314	-2.366	-5.098	8.095
07-Jul-98	0.205	0.236	0.266	0.293	19.491	22.440	25.224	27.845	11.509	13.560	-12.224	-12.845	26.839
28-Jul-98	0.181	0.208	0.291	0.320	34.111	39.151	54.656	60.082	17.889	18.849	-21.656	-15.082	30.823
17-Apr-99	0.121	0.145	0.364	0.370	1.091	1.303	3.273	3.333	0.909	1.697	-0.273	-2.333	4.624
15-May-99	0.118	0.139	0.365	0.378	1.889	2.222	5.833	6.056	0.111	0.778	-1.833	0.944	1.002
15-Jun-99	0.118	0.136	0.371	0.375	5.059	5.849	15.967	16.125	0.941	-0.849	4.033	-4.125	0.000
20-Jul-99	0.114	0.140	0.354	0.393	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	#DIV/0!
				Total	114.746	125.018	160.930	171.306					

AGE SPECIFIC MORTALITY RISKS

CENSUS	M(U-M)	M(U-I)	M(B-M)	M(B-I)	DAYS	VAR(U-M)	VAR(U-I)	VAR(B-M)	VAR(B-I)	UCL(U-M)	UCL(U-I)	UCL(B-M)	UCL(B-I)
28-Apr-98	0.009419	0.009132	0.006079	0.003948	21	0.000002	0.000002	0.000002	0.000001	0.002176	0.002139	0.001720	0.001368
19-May-98	0.010654	0.005495	0.004535	0.002918	21	0.000003	0.000002	0.000001	0.000001	0.002570	0.001795	0.001571	0.001219
17-Jun-98	0.003310	0.002428	0.001318	0.000802	29	0.000001	0.000001	0.000000	0.000000	0.001324	0.001064	0.000746	0.000556
07-Jul-98	0.014976	0.015126	0.004407	0.004615	20	0.000007	0.000006	0.000001	0.000001	0.003728	0.003494	0.001694	0.001652
28-Jul-98	0.002882	0.002768	0.000911	0.001167	291	0.000000	0.000000	0.000000	0.000000	0.000554	0.000504	0.000220	0.000241
17-Apr-99	0.001905	0.002410	0.000939	0.000304	30	0.000002	0.000002	0.000000	0.000000	0.001867	0.001928	0.000751	0.000422
15-May-99	0.001684	0.002165	0.001079	0.001843	36	0.000001	0.000002	0.000000	0.000000	0.001650	0.001732	0.000748	0.000965

Appendix H. ANOVA Tables

1. Crepis Emergence

The MIXED Procedure

Class Level Information

Class	Levels	Values
SITE	8	1 2 3 4 5 6 7 8
FIRE	2	NO YES
MICRO	2	I M
SPECIES	2	M O

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
FIRE	1	6	0.61	0.4656
MICRO	1	18	22.03	0.0002
SPECIES	1	18	0.02	0.8765
MICRO*SPECIES	1	18	0.13	0.7194
FIRE*MICRO	1	18	8.67	0.0087
FIRE*SPECIES	1	18	1.79	0.1981
FIRE*MICRO*SPECIES	1	18	1.04	0.3224

Least Squares Means

Effect	FIRE	MS	SP	LSMEAN	Std Error	DF	t	Pr >|t|	Alpha	Lower	Upper
FIRE (F)	NO			0.43675403	0.07285956	6	5.99	0.0010	0.05	0.2585	0.6150
FIRE	YES			0.35648743	0.07285956	6	4.89	0.0027	0.05	0.1782	0.5348
MICRO (M)		I		0.34085065	0.05287207	18	6.45	0.0001	0.05	0.2298	0.4519
MICRO		M		0.45239081	0.05287207	18	8.56	0.0001	0.05	0.3413	0.5635
SPECIES (SP)			M	0.39849444	0.05287207	18	7.54	0.0001	0.05	0.2874	0.5096
SPECIES			O	0.39474702	0.05287207	18	7.47	0.0001	0.05	0.2837	0.5058
F*M	NO	I		0.34600000	0.07477240	18	4.63	0.0002	0.05	0.1889	0.5031
F*M	NO	M		0.52750806	0.07477240	18	7.05	0.0001	0.05	0.3704	0.6846
F*M	YES	I		0.33570131	0.07477240	18	4.49	0.0003	0.05	0.1786	0.4928
F*M	YES	M		0.37727356	0.07477240	18	5.05	0.0001	0.05	0.2202	0.5344
F*SP	NO		M	0.45450806	0.07477240	18	6.08	0.0001	0.05	0.2974	0.6116
F*SP	NO		O	0.41900000	0.07477240	18	5.60	0.0001	0.05	0.2619	0.5761
F*SP	YES		M	0.34248082	0.07477240	18	4.58	0.0002	0.05	0.1854	0.4996
F*SP	YES		O	0.37049404	0.07477240	18	4.95	0.0001	0.05	0.2134	0.5276
F*M*SP	NO	I	M	0.35600000	0.07845829	18	4.54	0.0003	0.05	0.1912	0.5208
F*M*SP	NO	I	O	0.33600000	0.07845829	18	4.28	0.0004	0.05	0.1712	0.5008
F*M*SP	NO	M	M	0.55301613	0.07845829	18	7.05	0.0001	0.05	0.3882	0.7179
F*M*SP	NO	M	O	0.50200000	0.07845829	18	6.40	0.0001	0.05	0.3372	0.6668
F*M*SP	YES	I	M	0.33812045	0.07845829	18	4.31	0.0004	0.05	0.1733	0.5030
F*M*SP	YES	I	O	0.33328217	0.07845829	18	4.25	0.0005	0.05	0.1684	0.4981
F*M*SP	YES	M	M	0.34684120	0.07845829	18	4.42	0.0003	0.05	0.1820	0.5117
F*M*SP	YES	M	O	0.40770591	0.07845829	18	5.20	0.0001	0.05	0.2429	0.5725

Appendix H. Continued. ANOVA Tables

2. Astragalus Emergence ($\sin^{-1}\sqrt{y}$ transformed)

The MIXED Procedure

Class Level Information

Class	Levels	Values
SITE	8	1 2 3 4 5 6 7 8
FIRE	2	NO YES
MICRO	2	I M

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
FIRE	1	6	0.00	0.9592
MICRO	1	6	2.58	0.1593
FIRE*MICRO	1	6	10.53	0.0176

Least Squares Means

Effect	FIRE	MS	LSMEAN	Std Error	DF	t	Pr > |t|	Alpha	Lower	Upper
FIRE	NO		0.29687791	0.02738371	6	10.84	0.0001	0.05	0.2299	0.3639
FIRE	YES		0.29481438	0.02738371	6	10.77	0.0001	0.05	0.2278	0.3618
MICRO		I	0.30914544	0.02105844	6	14.68	0.0001	0.05	0.2576	0.3607
MICRO		M	0.28254686	0.02105844	6	13.42	0.0001	0.05	0.2310	0.3341
FIRE*MICRO	NO	I	0.28331504	0.02978113	6	9.51	0.0001	0.05	0.2104	0.3562
FIRE*MICRO	NO	M	0.31044078	0.02978113	6	10.42	0.0001	0.05	0.2376	0.3833
FIRE*MICRO	YES	I	0.33497583	0.02978113	6	11.25	0.0001	0.05	0.2621	0.4078
FIRE*MICRO	YES	M	0.25465293	0.02978113	6	8.55	0.0001	0.05	0.1818	0.3275

Appendix H. Continued. ANOVA Tables

3. Crepis Seed Survival

The MIXED Procedure

Class Level Information

Class	Levels	Values
SITE	8	1 2 3 4 5 6 7 8
FIRE	2	NO YES
MICRO	2	I M
SPECIES	2	M O

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
FIRE	1	6	20.27	0.0041
MICRO	1	18	10.67	0.0043
SPECIES	1	18	0.16	0.6943
MICRO*SPECIES	1	18	0.34	0.5654
FIRE*MICRO	1	18	0.01	0.9340
FIRE*SPECIES	1	18	1.17	0.2929
FIRE*MICRO*SPECIES	1	18	0.02	0.8916

Least Squares Means

Effect	FIRE	MS	SP	LSMEAN	Std Error	DF	t	Pr > |t|	Alpha	Lower	Upper
FIRE (F)	NO			0.30810653	0.03892613	6	7.92	0.0002	0.05	0.2129	0.4034
FIRE	YES			0.55597955	0.03892613	6	14.28	0.0001	0.05	0.4607	0.6512
MICRO (M)		I		0.37632320	0.03238380	18	11.62	0.0001	0.05	0.3083	0.4444
MICRO		M		0.48776288	0.03238380	18	15.06	0.0001	0.05	0.4197	0.5558
SPECIES (SP)			M	0.42522953	0.03238380	18	13.13	0.0001	0.05	0.3572	0.4933
SPECIES			O	0.43885655	0.03238380	18	13.55	0.0001	0.05	0.3708	0.5069
F*M	NO	I		0.25382034	0.04579762	18	5.54	0.0001	0.05	0.1576	0.3500
F*M	NO	M		0.36239272	0.04579762	18	7.91	0.0001	0.05	0.2662	0.4586
F*M	YES	I		0.49882605	0.04579762	18	10.89	0.0001	0.05	0.4026	0.5950
F*M	YES	M		0.61313304	0.04579762	18	13.39	0.0001	0.05	0.5169	0.7094
F*SP	NO		M	0.31977848	0.04579762	18	6.98	0.0001	0.05	0.2236	0.4160
F*SP	NO		O	0.29643458	0.04579762	18	6.47	0.0001	0.05	0.2002	0.3927
F*SP	YES		M	0.53068057	0.04579762	18	11.59	0.0001	0.05	0.4345	0.6269
F*SP	YES		O	0.58127852	0.04579762	18	12.69	0.0001	0.05	0.4851	0.6775
F*M*SP	NO	I	M	0.25785998	0.05711197	18	4.51	0.0003	0.05	0.1379	0.3778
F*M*SP	NO	I	O	0.24978070	0.05711197	18	4.37	0.0004	0.05	0.1298	0.3698
F*M*SP	NO	M	M	0.38169699	0.05711197	18	6.68	0.0001	0.05	0.2617	0.5017
F*M*SP	NO	M	O	0.34308846	0.05711197	18	6.01	0.0001	0.05	0.2231	0.4631
F*M*SP	YES	I	M	0.46117794	0.05711197	18	8.07	0.0001	0.05	0.3412	0.5812
F*M*SP	YES	I	O	0.53647416	0.05711197	18	9.39	0.0001	0.05	0.4165	0.6565
F*M*SP	YES	M	M	0.60018320	0.05711197	18	10.51	0.0001	0.05	0.4802	0.7202
F*M*SP	YES	M	O	0.62608287	0.05711197	18	10.96	0.0001	0.05	0.5061	0.7461

Appendix H. Continued. ANOVA Tables

4. Astragalus Seed survival

The MIXED Procedure

Class Level Information

Class	Levels	Values
SITE	8	1 2 3 4 5 6 7 8
FIRE	2	NO YES
MICRO	2	I M

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
FIRE	1	6	5.33	0.0603
MICRO	1	6	0.03	0.8657
FIRE*MICRO	1	6	0.49	0.5098

Least Squares Means

Effect	FIRE	MS	LSMEAN	Std Error	DF	t	Pr > |t|	Alpha	Lower	Upper
FIRE	NO		0.22263637	0.06064260	6	3.67	0.0104	0.05	0.0742	0.3710
FIRE	YES		0.42068834	0.06064260	6	6.94	0.0004	0.05	0.2723	0.5691
MICRO		I	0.31409112	0.06064260	6	5.18	0.0021	0.05	0.1657	0.4625
MICRO		M	0.32923360	0.06064260	6	5.43	0.0016	0.05	0.1808	0.4776
FIRE*MICRO	NO	I	0.18501984	0.08576159	6	2.16	0.0743	0.05	-0.0248	0.3949
FIRE*MICRO	NO	M	0.26025290	0.08576159	6	3.03	0.0230	0.05	0.0504	0.4701
FIRE*MICRO	YES	I	0.44316239	0.08576159	6	5.17	0.0021	0.05	0.2333	0.6530
FIRE*MICRO	YES	M	0.39821429	0.08576159	6	4.64	0.0035	0.05	0.1884	0.6081

Appendix H. Continued. ANOVA Tables

5. Crepis Transplant Survival ($\sin^{-1}\sqrt{y}$ transformed)

The MIXED Procedure

Class Level Information

Class	Levels	Values
SITE	6	1 2 3 5 7 8
FIRE	2	N Y
MICRO	2	I M
SPECIES	2	M O

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
FIRE	1	4	6.76	0.0600
MICRO	1	12	5.32	0.0397
SPECIES	1	12	10.70	0.0067
MICRO*SPECIES	1	12	0.47	0.5048
FIRE*MICRO	1	12	0.59	0.4558
FIRE*SPECIES	1	12	0.01	0.9372
FIRE*MICRO*SPECIES	1	12	0.00	0.9511

Least Squares Means

Effect	FIRE	MS	SP	LSMEAN	Std Error	DF	t	Pr > |t|	Alpha	Lower	Upper
FIRE (F)	N			0.24086080	0.03749438	4	6.42	0.0030	0.05	0.1368	0.3450
FIRE	Y			0.37877510	0.03749438	4	10.10	0.0005	0.05	0.2747	0.4829
MICRO (M)		I		0.26972175	0.03170137	12	8.51	0.0001	0.05	0.2007	0.3388
MICRO		M		0.34991415	0.03170137	12	11.04	0.0001	0.05	0.2808	0.4190
SPECIES (SP)			M	0.25297753	0.03170137	12	7.98	0.0001	0.05	0.1839	0.3220
SPECIES			O	0.36665836	0.03170137	12	11.57	0.0001	0.05	0.2976	0.4357
F*M	N	I		0.21415914	0.04483251	12	4.78	0.0005	0.05	0.1165	0.3118
F*M	N	M		0.26756245	0.04483251	12	5.97	0.0001	0.05	0.1699	0.3652
F*M	Y	I		0.32528435	0.04483251	12	7.26	0.0001	0.05	0.2276	0.4230
F*M	Y	M		0.43226585	0.04483251	12	9.64	0.0001	0.05	0.3346	0.5299
M*SP		I	M	0.20093291	0.04011362	12	5.01	0.0003	0.05	0.1135	0.2883
M*SP		I	O	0.33851059	0.04011362	12	8.44	0.0001	0.05	0.2511	0.4259
M*SP		M	M	0.30502216	0.04011362	12	7.60	0.0001	0.05	0.2176	0.3924
M*SP		M	O	0.39480614	0.04011362	12	9.84	0.0001	0.05	0.3074	0.4822
F*M*SP	N	I	M	0.14288454	0.05672922	12	2.52	0.0270	0.05	0.0193	0.2665
F*M*SP	N	I	O	0.28543375	0.05672922	12	5.03	0.0003	0.05	0.1618	0.4090
F*M*SP	N	M	M	0.22235945	0.05672922	12	3.92	0.0020	0.05	0.0988	0.3460
F*M*SP	N	M	O	0.31276545	0.05672922	12	5.51	0.0001	0.05	0.1892	0.4364
F*M*SP	Y	I	M	0.25898128	0.05672922	12	4.57	0.0006	0.05	0.1354	0.3826
F*M*SP	Y	I	O	0.39158743	0.05672922	12	6.90	0.0001	0.05	0.2680	0.5152
F*M*SP	Y	M	M	0.38768487	0.05672922	12	6.83	0.0001	0.05	0.2641	0.5113
F*M*SP	Y	M	O	0.47684683	0.05672922	12	8.41	0.0001	0.05	0.3532	0.6004

Appendix H. Continued. ANOVA Tables

6. Astragalus Transplant Survival

The MIXED Procedure

Class Level Information

Class	Levels	Values
SITE	8	1 2 3 4 5 6 7 8
FIRE	2	N Y
MICRO	2	I M

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
FIRE	1	6	32.82	0.0012
MICRO	1	6	0.44	0.5301
FIRE*MICRO	1	6	0.20	0.6718

Least Squares Means

Effect	FIRE	MS	LSMEAN	Std Error	DF	t	Pr > |t|	Alpha	Lower	Upper
FIRE	N		0.17218737	0.04113548	6	4.19	0.0058	0.05	0.0715	0.2728
FIRE	Y		0.50544818	0.04113548	6	12.29	0.0001	0.05	0.4048	0.6061
MICRO		I	0.34663165	0.03136398	6	11.05	0.0001	0.05	0.2699	0.4234
MICRO		M	0.33100389	0.03136398	6	10.55	0.0001	0.05	0.2543	0.4077
FIRE*MICRO	N	I	0.18522409	0.04435536	6	4.18	0.0058	0.05	0.0767	0.2938
FIRE*MICRO	N	M	0.15915064	0.04435536	6	3.59	0.0115	0.05	0.0506	0.2677
FIRE*MICRO	Y	I	0.50803922	0.04435536	6	11.45	0.0001	0.05	0.3995	0.6166
FIRE*MICRO	Y	M	0.50285714	0.04435536	6	11.34	0.0001	0.05	0.3943	0.6114

Appendix H. Continued. ANOVA Tables

7. Astragalus Transplant Reproduction

The MIXED Procedure

Class Level Information

Class	Levels	Values
SITE	4	1 2 3 4
MICRO	2	I M

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
SITE	3	3	0.46	0.7321
MICRO	1	3	1.97	0.2548

Least Squares Means

Effect	SITE	MICRO	LSMEAN	Std Error	DF	t	Pr > |t|	Alpha	Lower	Upper
SITE	1		31.80000000	11.24624673	3	2.83	0.0663	0.05	-3.9906	67.5906
SITE	2		30.57142857	11.24624673	3	2.72	0.0726	0.05	-5.2191	66.3620
SITE	3		41.37782805	11.24624673	3	3.68	0.0348	0.05	5.5873	77.1684
SITE	4		46.30555556	11.24624673	3	4.12	0.0260	0.05	10.5150	82.0961
MICRO		I	29.61538462	7.95229733	3	3.72	0.0337	0.05	4.3076	54.9231
MICRO		M	45.41202148	7.95229733	3	5.71	0.0107	0.05	20.1043	70.7198