Lepidium papilliferum (Slickspot peppergrass):

Evaluation of Trends (1998-2004) and

Analysis of 2004 Habitat Integrity and Population Monitoring Data

Final Report
June 2006

Carolyn A. Menke and Thomas N. Kaye
Institute for Applied Ecology

A Cooperative Project between

Bureau of Land Management

Idaho Fish and Game, Idaho Conservation Data Center

and

Institute for Applied Ecology

PREFACE

This report is the result of a cooperative project between the Institute for Applied Ecology (IAE), the Idaho Conservation Data Center, and the Idaho Bureau of Land Management. IAE is a non-profit organization dedicated to natural resource conservation, research, and education. Our aim is to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems, species, and effective management strategies and by conducting research, monitoring, and experiments. IAE offers educational opportunities through 3-4 month internships. Our current activities are concentrated on rare and endangered plants and invasive species.

Questions regarding this report or IAE should be directed to:

Institute for Applied Ecology
563 SW Jefferson Ave.
Corvallis, Oregon 97333
Phone: 541-753-3099
Fax: 541-753-3098
Internet: www.appliedeco.org

ACKNOWLEDGEMENTS

This project was made possible by funding from the Bureau of Land Management, Boise Office, and assistance from the Idaho Fish and Game Conservation Data Center (IDCC). Data were taken by Beth Colket, Michael Mancuso and other ID CDC staff. We thank Roger Rosentreter (Idaho BLM), Michael Mancuso and Beth Colket (ID CDC) and John Grotefend (IAE) for their valuable contributions to this project.

EXECUTIVE SUMMARY

Lepidium papilliferum (slickspot peppergrass) is a plant species of high conservation concern in southwestern Idaho. The species is specialized to occupy "slick spots," distinct small habitat patches with a clay subsurface soil horizon within the sagebrush steppe. In 1997, the Idaho Conservation Data Center, in collaboration with federal and state agencies, developed a Habitat Integrity Index (HII) method to assess and monitor long term trends in ecological integrity of the slickspots and their surrounding habitat. This method was used, with some modifications, from 1998-2001, and at a subset of areas in 2002. A modified version of the HII monitoring technique, using Habitat Integrity and Population monitoring (HIP) transects, was employed in 2004 to assess and monitor similar attributes of *L. papilliferum* element occurrences (EOs), slickspots, and surrounding habitat, using increased sample replication and a targeted approach (Colket 2005). Data from both of these monitoring efforts (from 1998 to 2002, and 2004) were analyzed to evaluate habitat and climatic factors that drive trends in *L. papilliferum* abundance and degrade slickspots and their surrounding habitat. The primary findings are outlined below.

- Dynamics in *L. papilliferum* plant abundance appear to be more strongly linked to patterns of spring precipitation than to fire disturbance events.

- Overall, element occurrences of *L. papilliferum* had negative (declining) population trends between 1998 and 2004, indicating they were decreasing in abundance region-wide.

- Several features of slickspots, including soil crust cover and weedy species cover, were consistently more degraded in burned areas, apparently as a result of past fire events.

- Across all transects sampled consistently for plant community since 1998, total vascular plant cover, species diversity and species richness have declined between 1998 and 2004.

- Recent livestock use that was estimated by HIP monitoring resulted in decreased soil crust cover in slickspots, decreased vascular plant cover, and decreased plant litter cover in the surrounding plant community.

- Previously burned habitat around slickspots had diminished soil crust cover and higher total cover of exotic species in all years sampled for plant community (1998, 2001, 2004).

The HIP transects were also used in 2005, and will be used in 2006 to monitor *L. papilliferum* and its habitat. We recommend additional analysis of the available data to evaluate the effects of slickspot habitat quality on *L. papilliferum*, and to confirm or further clarify the findings presented in this report.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Study Species and Habitat

Lepidium papilliferum (slickspot peppergrass) is a plant species of high conservation concern in the Snake River Plain and Owyhee Plateau of southwestern Idaho. *L. papilliferum* (Brassicaceae) is specialized to occupy "slick spots" (also called mini-playas or natric sites), distinct small habitat patches with a clay subsurface soil horizon. Slickspots are scattered within the sagebrush steppe, and often retain moisture later in the summer than the surrounding habitat. Slickspot areas exhibit greater alkalinity than the surrounding soils, and vegetation is typically sparse in undisturbed slickspots, which tends to result in reduced levels of organic matter and nutrients. The restricted distribution of *L. papilliferum* is likely due to its dependence on the specific soil conditions found in slickspots.

Lepidium papilliferum has a dual life history strategy, behaving both as an annual and a biennial. The majority of plants appear to be annuals, emerging in early spring, flowering and setting seed in June of the same year (Meyer et al. 2005). The biennials remain vegetative during the first growing season, then flower and set seed the following summer (Meyer et al. 2005). Populations also maintain a persistent soil seed bank that is crucial to population viability and surviving periods of low precipitation (Meyer et al. 2006). Plants are tap rooted and reach 4-12 inches in height. The abundance of above ground *L. papilliferum* plants at any given location varies widely from year to year, apparently depending on seasonal precipitation patterns (Mancuso et al. 1998; Meyer et al. 2005). *L. papilliferum* depends on pollination by bees and some beetle species to achieve successful seed production (Robertson and Klemash 2003).

In July, 2002, *Lepidium papilliferum* was proposed as a candidate for federal endangered status. The US Fish and Wildlife Service withdrew the proposed rule in January 2004, based on a lack of strong evidence for a negative population trend, and because of the implementation of conservation efforts to reduce the risk to the species (US Fish and Wildlife Service 2004). In August, 2005, the USFWS 2004 decision to withdraw this proposal was reversed, and the USFWS is currently reconsidering the listing status of the species.

Recent Monitoring History

Habitat Integrity Index (HII) Monitoring

In 1997, the Idaho Conservation Data Center, in collaboration with the Idaho Army National Guard (IDARNG) and Bureau of Land Management (BLM) developed a Habitat Integrity Index (HII) method to assess and monitor long term trends in ecological integrity of the slickspots and their surrounding habitat (Mancuso and Moseley 1998). The HII monitoring system is based on the premise that sagebrush steppe in late seral condition represents the highest integrity and the best habitat for *L. papilliferum.* This HII monitoring was used from 1998 through 2001 (and in a subset of sites in 2002) to collect habitat integrity data and vegetation data at slickspot peppergrass element occurrences (EOs), distinct geographic locations where *L. papilliferum* occurs. The HII monitoring protocol was described by Mancuso and Moseley (1998), Mancuso et al. (1998), and Mancuso (2000).

The resulting data (from 1998 to 2001) were analyzed to evaluate habitat and climatic factors that drive trends in *L. papilliferum* abundance and degrade slickspots and their surrounding habitat (Menke and Kaye 2006). Dynamics in the actual *L. papilliferum* populations appeared to be more strongly linked to patterns of spring precipitation than to the attributes of slickspots and surrounding habitat measured in the HII transects. Livestock use and past fire events that were estimated by HII monitoring did not have significant effects on *L. papilliferum* trends. Several features of slickspots, including slickspot perimeter boundary compromise, organic debris accumulation and density of weedy annual species, were consistently more degraded in burned areas, apparently as a result of past fire events. Previously burned habitat around slickspots had depleted shrub and soil crust cover, and also tended to have diminished cover by native species and elevated cover of exotic species. Livestock grazing and off highway motorized vehicle (OHV) use as measured by the HII transects had neutral effects.

Habitat Integrity and Population (HIP) Monitoring
A modified version of the HII monitoring technique, Habitat Integrity and Population (HIP) monitoring, was employed in 2004 and 2005 (and will be used in 2006) to assess and monitor similar attributes of *L. papilliferum* occurrences using increased sample replication and a targeted approach (Colket 2005). More specifically, the objectives of this newly established monitoring system were to evaluate the effectiveness of efforts outlined in the "Candidate Conservation Agreement for slickspot peppergrass" to reduce threats to *L. papilliferum,* and to collect baseline data on *L. papilliferum* dynamics, slickspot and habitat condition, disturbance and plant community composition.

This revised monitoring protocol was used at many of the sites previously monitored by the HII transects between 1998 and 2002. Although the pre-2004 data were collected using a different method, and were from a greater number of *L. papilliferum* EOs, some of the variables measured are comparable to those sampled in 2004. *L. papilliferum* abundance was taken using a similar method, and in addition, the proportion of *L. papilliferum* plants in reproductive and rosette stage was also assessed. Plant community composition was sampled using greater randomization and replication; rather than using one 11.3-m radius plot at a fixed point to asses vegetation along the entire transect, the new system randomly locates three vegetation transects along the HIP transect, and samples five 20 x 50-cm plots along each transect. Shrub cover was sampled using a line-intercept method. Variables now measured in 2004 (that were not previously measured) include cover of biological soil crusts and exotic species within slickspots. Also, data on disturbance factors (livestock prints, non-livestock prints, fire restoration activities, wildlife disturbance) were taken in more detail, particularly with respect to their cover within the slickspot, and their penetration depth relative to the slickspot clay layer.

Colket (2005) summarized the data gathered in 2004, the first season the HIP transects were established. Habitat integrity data and *L. papilliferum* population trend data were evaluated on both a range-wide scale and a Management Area (MA) scale. Fire and livestock use were common agents of disturbance in the EOs. Roughly 40% of the EOs sampled had at least some burned and unburned areas, and half of those were completely burned. Approximately 50% of EOs sampled had at least some livestock prints in slickspots, and 22% of the EOs sampled had at least 5% cover of cattle prints (Colket 2005). All livestock use detected in 2004 was from cattle. OHV use was infrequent overall, and was detected in only two of the 12 MAs (Colket 2005).

Colket (2005) described the vegetation in and around slickspots, and found 80% of EOs had at least some introduced annual species cover in slickspots (i.e., *Bromus tectorum, Lepidium perfoliatum, Ranunculus testiculatus,* and/or *Sisymbrium altissimum).* Vegetation around monitoring transects had also been invaded by introduced species; only 5 of the 71 transects sampled lacked introduced annual species. Cover by soil crusts (absolute) in slickspots averaged 21%, and was at comparable levels (18%) in the associated vegetation transects. The majority of transects still had sagebrush in the surrounding habitat, with average (relative) cover at 44%. Native perennial grasses also persisted as about 19% of total vascular plant cover. Most native perennial grass cover was from *Poa secunda*, with smaller contributions form *Elymus elymoides* and *Pseudoroegneria spicata.* Bare ground cover (absolute) was an average of 32%.

Analysis Questions

The data analysis reported here is a continuation of the 1998-2001 HII data analysis (Menke and Kaye 2006), that integrates additional data from 2002 (when possible) and 2004. As with earlier analyses, we use data taken at the level of individual *L. papilliferum* EOs to explore range-wide trends in *L. papilliferum* and its habitat.

1) Are *L. papilliferum* population trends correlated with weather, alterations in slickspot condition, or disturbance?

2) What factors degrade slickspots?

3) What factors degrade the habitat surrounding slickspots?

ANALYSIS METHODS

Multi-Year Analyses

We used transects sampled in 1998-2002 (HII monitoring) and in 2004 by HIP monitoring to evaluate multi-year trends in *Lepidium papilliferum* plant abundance and its relationship with climate and disturbance. We also examined patterns in plant community functional groups across multiple years. As discussed earlier, community data were taken with a different method in 2004, making rigorous statistical comparisons unattainable, but trends can still be described.

Lepidium papilliferum habitat experiences frequent fire, and thus in some cases, it was difficult to classify transects as either unburned or burned since 1998. Fires in sagebrush steppe often occur in a mosaic pattern; often portions of transects were burned in one year, while other portions were burned in following years. The borders of past fires, especially if patchy and cool-burning, were also difficult to pinpoint in the field after several years' time (Colket, personal communication). To look at long term fire effects, we only used transects that could be classified as clearly unburned or clearly previously burned during the entire six years of monitoring. A caveat to this classification is that many of these areas, even those we consider "unburned" may have burned in the past 50 years.

We did not use grazing animal unit month (AUM) data to indicate livestock use or intensity since the correlation between BLM grazing records of AUM/acre and HII tallies of livestock sign in areas with *L. papilliferum* was not statistically significant or consistent between 1998 and 2001 (Menke and Kaye 2006). Most areas with *L. papilliferum* have experienced some degree of livestock use since 1998, as indicated by HII and HIP monitoring tallies of livestock signs in and around slickspots. Therefore, we did not have a reasonable sample of consistently "ungrazed" transects, and could not evaluate the influence of grazing on trends in *L. papilliferum* abundance or plant community characteristics between 1998 and 2004. Influences of same-year livestock use (as indicated by livestock tracking and feces in transects) were evaluated in the 2004 HIP data analyses.

Lepidium papilliferum *Trends*

To analyze trends in *L. papilliferum* abundance, we evaluated transects with six years of data (1998-2002, 2004) and five years of data (1998-2001, 2004). Both the five-year and six-year datasets are useful; the six-year dataset provides longer-term information for a smaller sample size of EOs (n=9), while the five-year dataset includes a greater number of EOs (n=21), and may reflect trends in a larger proportion of *L. papilliferum* sites. We excluded transects (in four EOs) with zero plants in all years of monitoring.

To address how overall *L. papilliferum* population trends correlate with weather (monthly precipitation, maximum and minimum temperature), we obtained climate data for each HII transect from PRISM (Parameter-elevation Regressions on Independent Slopes Model). PRISM is a system that uses point data and a digital elevation model to generate estimates of climate parameters (Daly et al. 1994). We pooled all transects with available climate data and with *L. papilliferum* present for at least one year during the study (n=12), and calculated average *L. papilliferum* abundance per transect in each year (1998-2002, 2004). We used this as the dependent variable in a linear regression, with precipitation, maximum and minimum temperature (summed or averaged bimonthly or trimonthly) as the independent variable.

To evaluate possible influences of past fires, we compared yearly average *L. papilliferum* abundance between burned and unburned transects with five and six years of data using non-parametric Kruskal-Wallis tests. We compared proportional changes in abundance between burned and unburned transects using one-way ANOVA.

Plant Community Trends

We evaluated overall plant community trends in 25 transects with plant community data consistently taken in 1998, 2001 and 2004 using one-way ANOVA or non-parametric Kruskal-Wallis tests. Attributes evaluated included species richness and Shannon Diversity, along with absolute cover by bare soil, soil crust, plant litter and vascular plants, and relative cover by several plant functional groups.

We examined differences in plant community attributes (see above) in 1998, 2001, and 2004 between plots that were clearly unburned (n=8) or clearly previously burned (n=11) for the entire period of monitoring using one-way ANOVA or non-parametric Kruskal-Wallis tests. We excluded transects that had patchy burn patterns or that were classified as burned in some years and unburned in others.

Analysis of 2004 Data

Lepidium papilliferum

We compared *L. papilliferum* abundance and the proportion of *L. papilliferum* plants flowering between HIP transects with and without grazing evidence in 2004 using Kruskal-Wallis tests. We made similar comparisons between burned and unburned HIP transects, using fire history assessments made immediately adjacent to the slickspots for classification. OHV use was seen only in 3 transects of the 71 sampled, therefore we did not evaluate its influence. We also evaluated the correlations (Spearman-rank) of abundance and the proportion of reproductive plants with soil crust cover, weedy species cover, and livestock track cover in slickspots.

2004 Slickspot condition
We compared slickspot soil crust cover and weedy species cover between HIP transects with and without grazing or past fire history using Kruskal-Wallis tests. We also evaluated the relationship of soil crust cover and weedy species cover with livestock track cover using Spearman-rank correlation. To better describe the patterns in slickspot weedy species composition, we also used MRPP (Multi-Response Permutation Procedures) to test for multivariate differences in species composition relating to fire or grazing, then described any differences using ISA (Indicator Species Analysis).

Surrounding Plant Community in 2004
We compared basic plant community functional groups (total native and exotic cover, native and exotic grass cover, native and exotic forb cover, and shrub cover) between HIP transects with and without grazing or past fires using Kruskal-Wallis tests. Again, to better describe the patterns in species composition between transects, we also used MRPP (Multi-Response Permutation Procedures) to test for multivariate differences in species composition between transects, then described any differences using ISA (Indicator Species Analysis).

RESULTS

Multi-year analyses of *Lepidium papilliferum* trends

Overall Trends
In the areas monitored by HII and HIP transects, *L. papilliferum* abundance decreased between 1998 and 1999, remained low through 2002, and increased somewhat in 2004 (Figure 1). Average plant abundance per transect in 2004 was approximately 50% lower than in 1998.

Influence of climate
Spring (March-May) precipitation explained the 89% of the variation in *L. papilliferum* abundance in 1998-2001, 2002 and 2004 in the slickspots sampled by HII and HIP transects (Figure 2). Years with greater spring precipitation generally had greater numbers of *L. papilliferum.* Regressions of maximum and minimum temperature values were not statistically significant, suggesting they are less important in driving the variation in *L. papilliferum* abundance.

Influence of fire
Within transects with six years of data (n=8), previously burned and unburned transects were similar in average *L. papilliferum* abundance in each year (all P>0.24; Figure 3). Proportional change in abundance was also similar between burned and unburned transects; both groups of transects decreased approximately 45% in plant abundance between 1998 and 2004 (P=0.90). When transects with five years of data (n=20) were compared, burned and unburned transects were also similar in average plant abundance in each year (Figure 3). These transects also had statistically similar trends in proportional abundance, although on average, burned areas had less negative population trends.

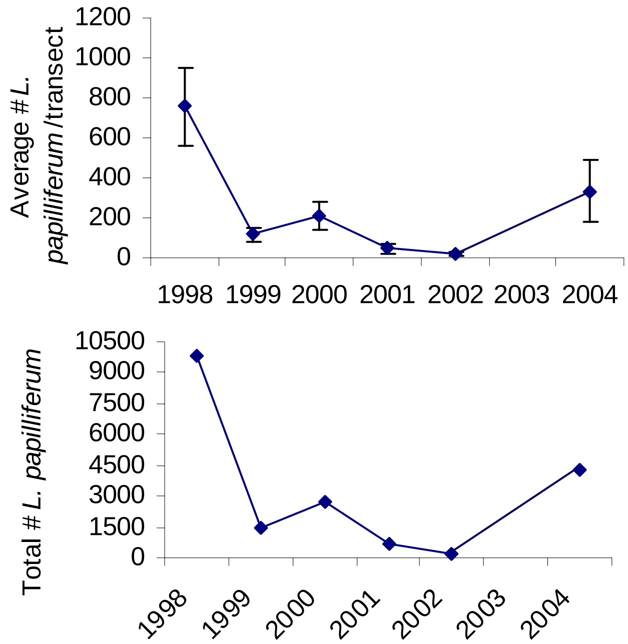

Figure 1. Total number *Lepidium papilliferum* plants monitored and average (± SE) abundance per transect in 1998-2001, 2002 and 2004. Data are from 13 transects that were consistently sampled in these years. These transects were not sampled in 2003.

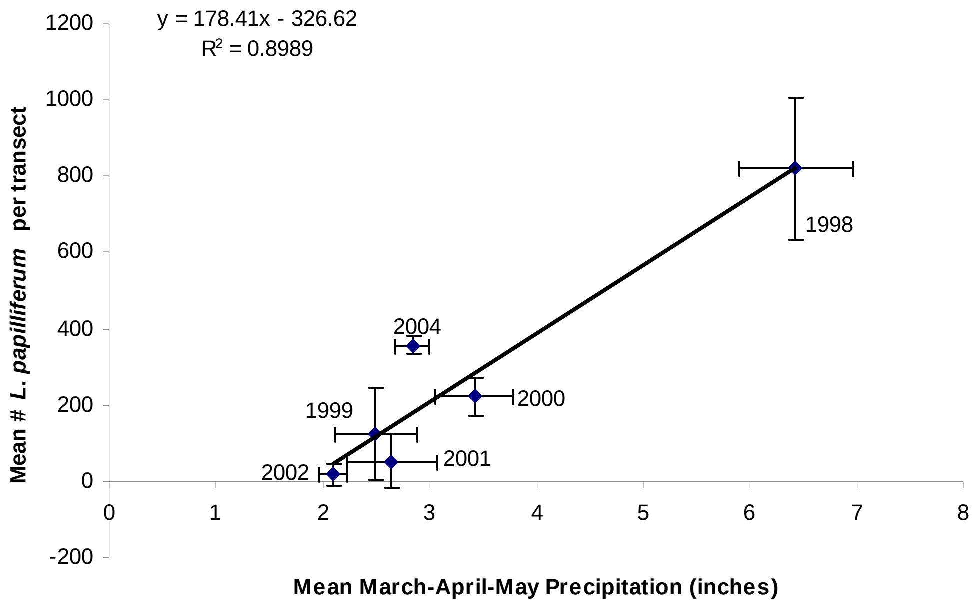

Figure 2. Linear regression of average (± SE) *L. papilliferum* abundance (n=12 transects/year) with mean (± SE) cumulative spring precipitation (March, April, May) 1998-2002 and 2004. Variation in precipitation explained 89% of the variation in plant abundance, with a statistical significance of *P*=0.004.

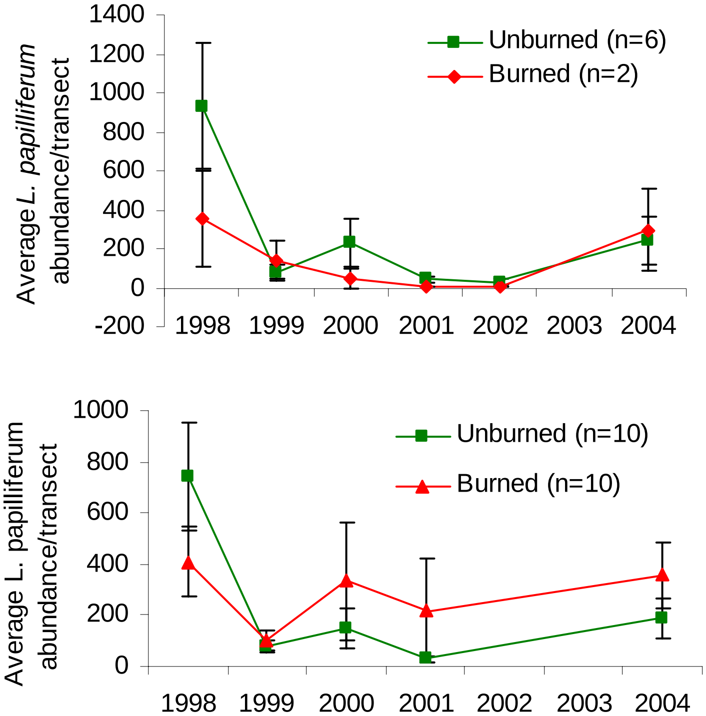

Figure 3. Average *Lepidium papilliferum* abundance (± SE) in transects with six years data (top, n=8) and with five years data (bottom, n=20). Only transects that were clearly burned in the past or were clearly unburned were included. Plant abundance was statistically similar between burned and unburned transects in all years. Data were not recorded in 2002 or 2003.

Multi-year Analyses of Plant Community

Overall Trends

In all transects (regardless of fire history) with three years of plant community sampling (1998, 2001 and 2004; n=25), bare soil cover changed very little (*P*=0.32; Figure 4) and soil crust cover also remained relatively constant (*P*=0.08). Total vascular plant cover declined (*P*<0.001), while plant litter cover increased (*P*=0.03). Species diversity (Shannon index) and species richness also declined (both *P*<0.0001) in this time period. Total (relative) native and exotic species cover remained similar to each other between 1998 and 2004, with burned and unburned groups averaging around 50% relative cover (Figure 5). Exotic grass cover (~40%) and exotic forb cover (~16%) also remained similar over time (both *P*>0.19). Native perennial grass cover was similar in 1998 and 2004 (*P*=0.085), while average native forb cover declined from an average of more than 8% to approximately 2% during this time (*P*<0.0001). Shrub cover remained similar over time (*P*=0.21).

Influence of fire

To evaluate possible persistent effects of past fires, we compared unburned transects (n=8) and previously burned transects (n=11). Transects with mosaic burns that were classified as burned in some years and unburned in others were excluded. Total vascular plant cover and bare soil cover were similar in burned and unburned transects in 1998, 2001 and 2004 (all *P*>0.24; Figure 4). Soil crust cover was consistently lower in burned areas (all *P*<0.015). Plant litter

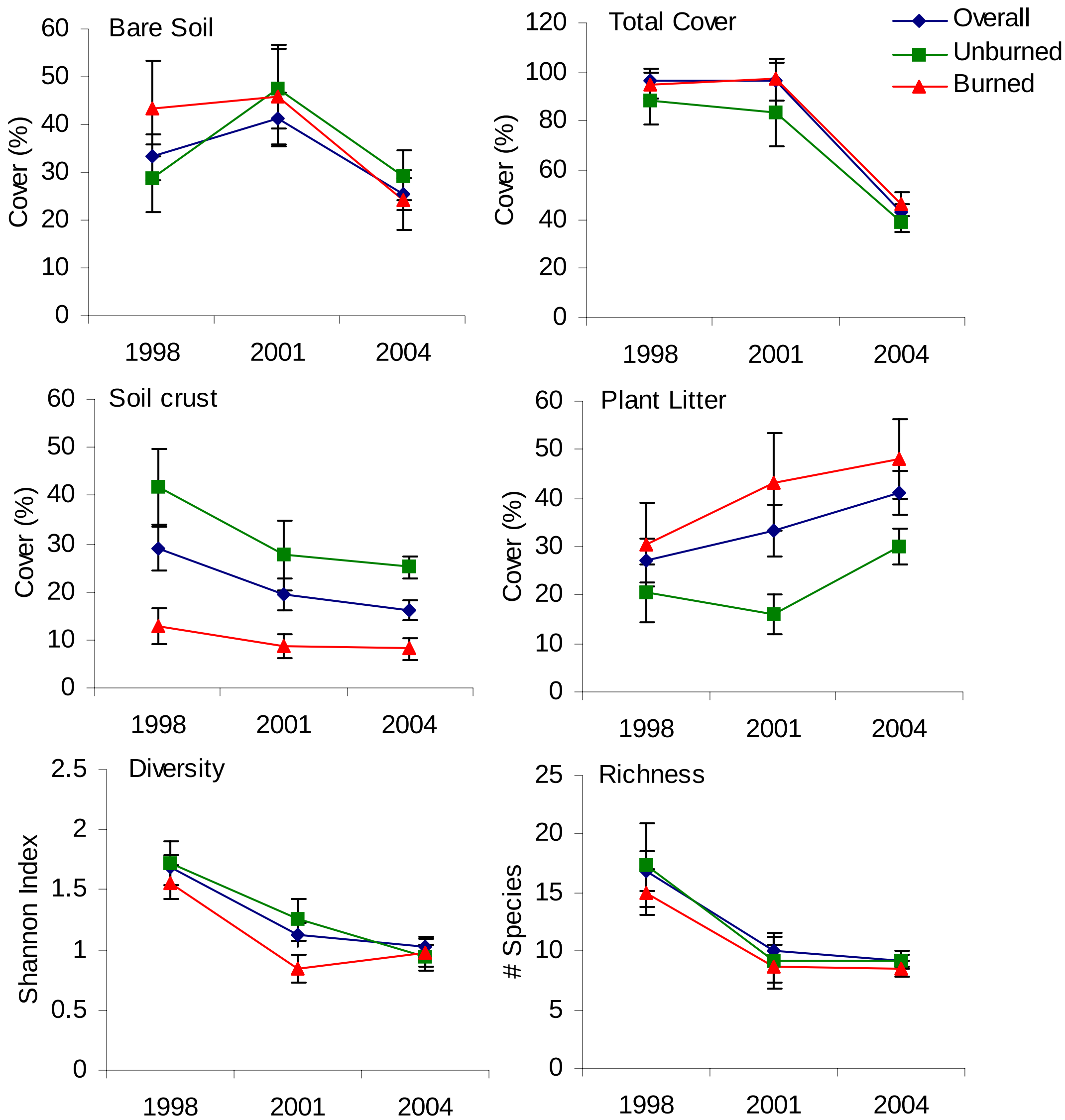

Figure 4. Average (± SE) species richness and diversity values, and absolute cover by soil crusts, litter, bare soil and vascular plants. The "Overall" group includes all transects with data (n=25). The "Unburned" group includes transects which remained unburned (n=8). The "Burned" group includes transects that were classified as previously burned in 1998-2004 (n=11).

cover was similar in burned and unburned transects in 1998 and 2004, but was slightly greater in burned transects in 2001 (P=0.04). Species richness was similar between burned and unburned transects in all sample years (all P>0.59). Species diversity was similar in burned and unburned transects in 1998 and 2004 (both P>0.50), but diversity was slightly lower in burned transects in 2001 (P=0.03).

In terms of plant functional groups, total native species cover and shrub cover was lower in burned transects in all years (all P<0.002; Figure 5). Conversely, total exotic species

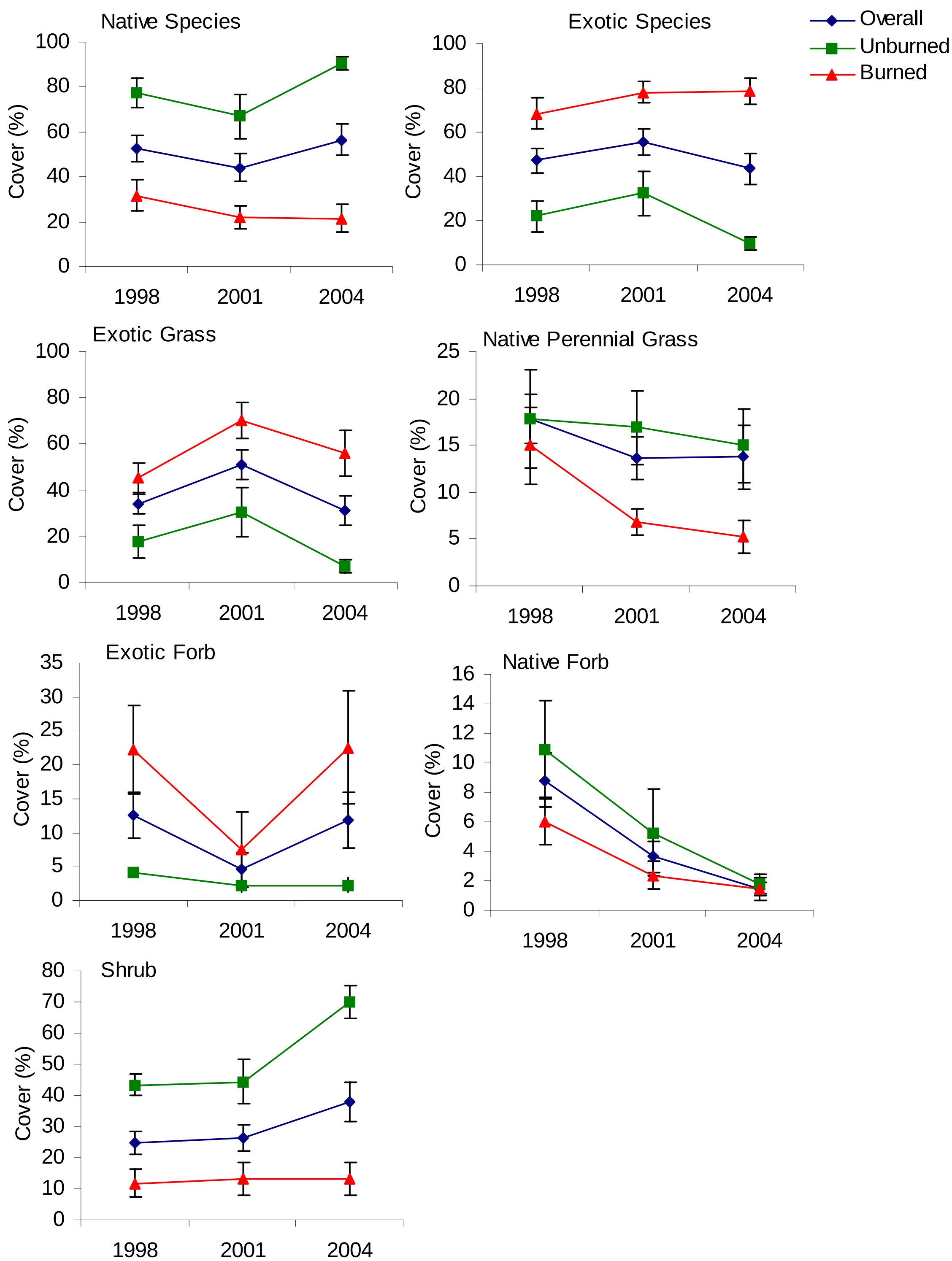

Figure 5. Average (± SE) relative cover by plant functional groups. The "Overall" group includes all transects (n=25) with plant community data taken in 1998, 2001, and 2004. The "Unburned" group includes transects (n=8) that remained unburned between 1998 and 2004. The "Burned" group includes transects (n=11) that were clearly classified as previously burned in all years.

cover and exotic grass cover were higher in burned transects in all years (all *P*<0.008). Native perennial grass cover was similar between burned and unburned transects in 1998 (*P*=0.19), then decreased to significantly lower levels in burned transects in 2001 (*P*=0.02) and 2004 (*P*=0.008). Exotic forb cover was greater in burned transects in 1998 and 2004 (both *P*<0.013), but was similar between burned and unburned transects in 2001 (*P*=0.93). Native forb cover was similar between burned and unburned transects in all sample years (all *P*>0.16).

2004 HIP Data

***Dynamics of* Lepidium papilliferum**

In 2004, *L. papilliferum* plant abundance was not strongly influenced by disturbance from livestock grazing or fire. Average plant abundance per slickspot was similar between currently grazed and currently ungrazed transects (*P*=0.58) and was also similar between burned and unburned transects (*P*=0.64). The proportion *L. papilliferum* plants flowering was also similar between grazed and ungrazed transects (*P*=0.80) and burned and unburned transects (*P*=0.07).

L. papilliferum abundance was not significantly correlated with slickspot soil crust cover (R=0.17; *P*=0.16) or with weedy species cover in slickspots (R=-0.01; *P*=0.93). *L. papilliferum* abundance was not significantly correlated with total livestock print cover (R=-0.19; *P*=0.10) or with cover of prints penetrating to the slickspot clay layer (R=-0.17; p=0.15). The proportion of *L. papilliferum* plants flowering had a positive correlation with soil crust cover (R=0.27; *P*=0.04), but was not significantly correlated with livestock print cover (R=-0.14, *P*=0.28) or weedy species cover (R=-0.18; *P*=0.17).

Slickspot Condition

We evaluated the influence of fire and grazing on 2004 slickspot condition in terms of soil crusts and weedy species cover in slickspots. Slickspots in burned transects had lower soil crust cover (approximately 17%) than those in unburned transects (24%; *P*=0.04). Total weedy species cover was higher in burned slickspots (about 16% cover) than unburned slickspots (~ 6% cover; *P*=0.0001). Weedy grasses and forbs both had greater cover in burned areas (both *P*<0.01).

Soil crust cover was significantly greater in ungrazed slickspots (approximately 42% cover) than in slickspots of grazed areas (approximately 17% cover; *P*<0.0001). Total weedy species cover (approximately 10-12%), weedy grass and weedy forb cover were similar between grazed and ungrazed transects (all *P*>0.29).

MRPP analysis suggested that the composition of the weedy plant community in slickspots differed between burned and unburned areas (*P*<0.0001), but that weedy community composition was similar in grazed and ungrazed slickspots (*P*=0.09). Species (indicators) with higher cover and frequency in burned area slickspots included several annual, exotic forbs: *Sisymbrium altissimum* (tall tumblemustard), *Salsola kali* (Russian thistle), *Halogeton glomeratus* (saltlover), and the exotic perennial grass *Agropyron cristatum* (crested wheatgrass).

Surrounding Plant Community

Burned and unburned transects had similar species richness, diversity (Shannon), bare ground cover, plant litter cover and total vascular plant cover in 2004 (Table 1). Soil crust cover was significantly lower in previously burned areas. Grazed and ungrazed transects had similar species richness, diversity and soil crust cover. Total vascular plant cover and plant litter cover were significantly lower in grazed transects (Table 2).

Several apparent effects of past fires on functional groups were evident in 2004. Transects in burned areas had higher total exotic species cover, and higher cover of both exotic grasses and exotic forbs (Table 3) than those in unburned transects. Unburned HIP transects had higher shrub cover and native species cover than burned transects. Native perennial grass and native forb cover were not influenced by fire (Table 3). Grazed and ungrazed transects had similar cover of all functional groups in 2004 (Table 4).

Table 1. Absolute cover (%), species richness and diversity in burned and unburned HIP transects in 2004. Chi-square and *P*-values from Kruskal-Wallis tests.

	UNBURNED			BURNED				
	n	Mean	SE	n	Mean	SE	Chi-Square	*P*-value
Bare Ground (%)	41	30.90	2.62	30	31.38	3.06	0.00	0.972
Soil Crust (%)	41	24.54	1.62	30	9.46	1.89	25.64	<0.001
Plant Litter (%)	41	27.04	2.95	30	38.39	3.44	2.56	0.109
Species Richness	41	9.10	0.47	30	9.80	0.55	0.65	0.422
Shannon Diversity	41	1.03	0.06	30	1.15	0.07	1.640	0.200
Total Vascular Plants (%)	41	37.69	2.33	30	34.32	2.72	1.15	0.284

Table 2. Absolute cover (%), species richness and diversity in currently grazed and ungrazed HIP transects in 2004. Chi-square and *P*-values from Kruskal-Wallis tests.

	Ungrazed			Grazed				
	n	Mean	SE	n	Mean	SE	Chi-Square	*P*-value
Bare Ground (%)	11	17.69	4.75	60	33.56	2.03	8.14	0.004
Soil Crust (%)	11	19.47	3.86	60	17.93	1.65	0.12	0.727
Plant Litter (%)	11	50.92	5.39	60	28.34	2.31	12.50	<0.001
Species Richness	11	9.64	0.92	60	9.35	0.39	0.13	0.719
Species Diversity	11	1.02	0.11	60	1.10	0.05	0.792	0.374
Total Vascular Plants (%)	11	52.45	3.99	60	33.30	1.71	8.93	0.003

Table 3. Relative cover (%) by plant functional groups in previously burned and unburned HIP transects in 2004. Chi-square and *P*-values from Kruskal-Wallis tests.

	Relative Cover (%)							
	UNBURNED			BURNED				
	n	Mean	SE	n	Mean	SE	Chi-Square	*P*-value
Total Exotic Species	41	8.60	3.31	30	51.64	3.87	34.97	<0.001
Total Native Species	41	91.24	3.31	30	48.26	3.87	34.97	<0.001
Native Perennial Grasses	41	22.45	2.77	30	19.93	3.23	2.19	0.14
Native Forbs	41	2.70	0.70	30	3.79	0.82	0.00	0.94
Exotic grasses	41	4.15	3.35	30	36.73	3.91	28.69	<0.001
Exotic forbs	41	4.45	2.37	30	14.91	2.77	5.17	0.02
Shrubs	41	66.08	3.41	30	24.54	3.99	29.10	<0.001

Table 4. Relative cover (%) by plant functional groups in currently grazed and ungrazed HIP transects in 2004. Chi-square and *P*-values from Kruskal-Wallis tests.

	Relative Cover (%)							
	Ungrazed			Grazed				
	n	Mean	SE	n	Mean	SE	Chi-Square	*P*- value
Total Exotic Species	11	29.72	9.11	60	26.24	3.90	0.35	0.557
Total Native Species	11	69.79	9.10	60	73.68	3.90	0.63	0.427
Native Perennial Grasses	11	18.80	5.34	60	21.86	2.29	2.09	0.148
Native Forbs	11	1.96	1.36	60	3.38	0.58	0.45	0.503
Exotic grasses	11	26.70	8.04	60	16.30	3.44	2.93	0.087
Exotic forbs	11	3.03	4.78	60	9.94	2.05	2.96	0.086
Shrubs	11	49.03	9.10	60	48.44	3.90	0.00	1.000

Multivariate analyses found that overall plant community composition in 2004 differed between burned and unburned areas (*P*<0.0001). Significant indicator species for burned plant communities around slickspots (Figure 6) were primarily exotic or annual species, whereas unburned areas were indicated by native species. Multivariate plant community composition also differed between currently grazed and ungrazed areas (*P*<0.0001). Significant indicator species (Figure 6) for both currently grazed and ungrazed areas included many exotic or annual species.

DISCUSSION

Lepidium papilliferum Trends

L. papilliferum plant abundance in 1998 through 2001, 2002 and 2004 was strongly correlated with spring (March-April-May) precipitation. This relationship is consistent with patterns seen in the earlier analyses of the 1998-2001 HII data (Menke and Kaye 2006). Similar observations were made on the Idaho National Guard Orchard Training Area (OTA) by Meyer et al. (2005). In that intensive three year study, growing season precipitation (Feburary-March-April-May) was critical in determining the size of the recruited cohort. In the case of the HII and HIP monitoring, six years of data are minimal for establishing long term trends, but continued monitoring efforts will further clarify the relationship between overall population trends and precipitation.

How does *L. papilliferum* respond to disturbances from fire or grazing? Past fire disturbance does not appear to significantly alter longer-term trends in plant abundance. However, without controlled experiments, this is only based on observational data that is retrospective to past fires. Competition from weedy annual species (which may be promoted by fire) does not appear to influence abundance of *L. papilliferum* plants in a given year, but may influence reproductive output other plant traits and other life history stages.

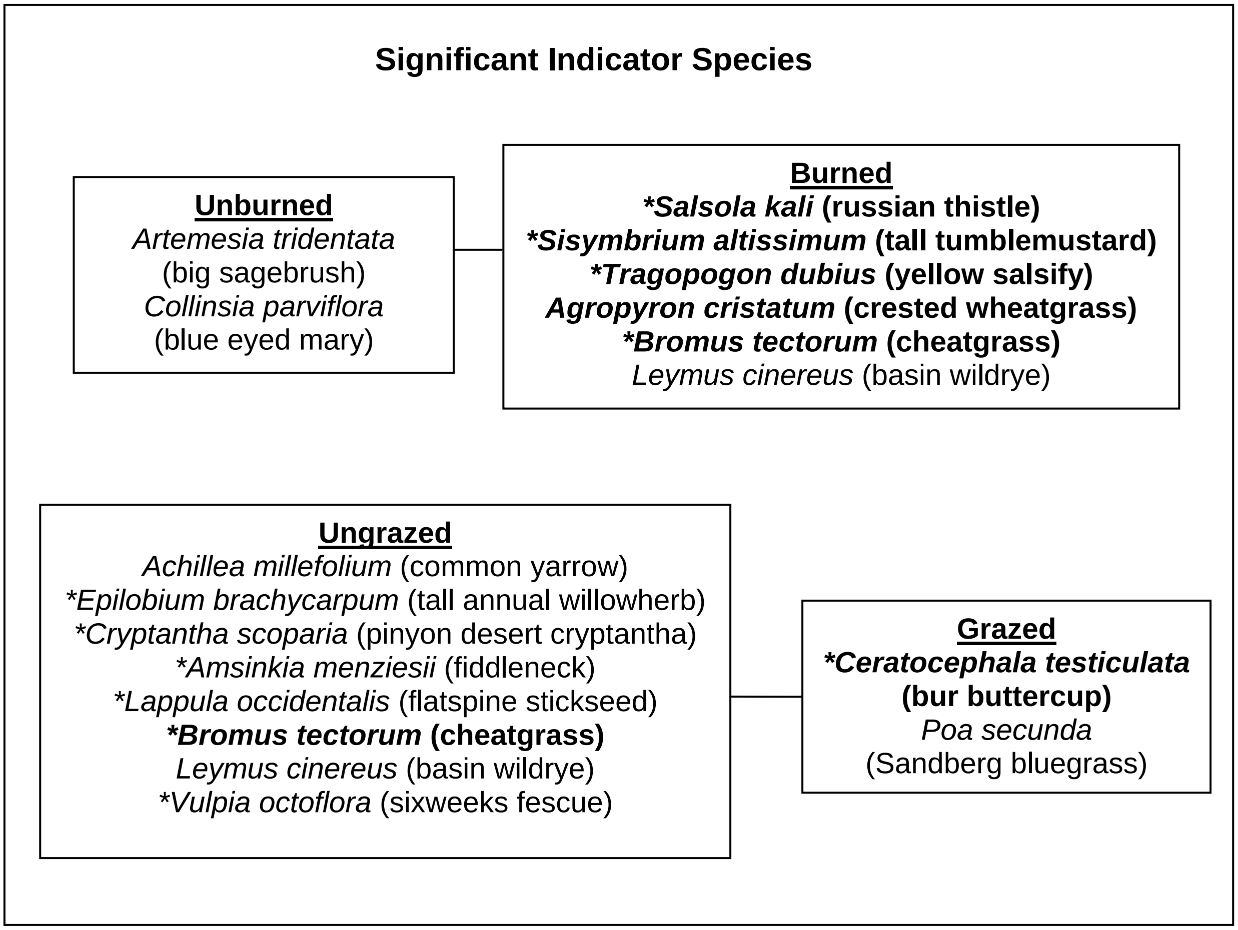

Figure 6. Significant indicator species ($p<0.05$) that differentiate burned/unburned plant communities around slickspots, and recently grazed/ungrazed plant communities around slickspots. Species in bold are non-native, and species preceded by an * are annual or occasionally biennial. Data are from 2004 only.

We were unable to evaluate the long-term influence of livestock grazing or different seasons of use on *L. papilliferum* trends since complete and detailed data regarding site utilization were not available. Also, few sites were truly free of historical livestock use, which limited our analysis. On a short term scale, using data from 2004, livestock print cover did not significantly influence *L. papilliferum* abundance.

Slickspot Condition

The 2004 HIP data suggest that past fires have been a factor in degrading slickspot condition. Slickspots in burned areas had lower soil crust cover and greater exotic species cover. This is in agreement with analysis of the 1998-2001 HII data, which found slickspots in burned areas had more dense weedy annual species cover, and also tended to have more frequent compromise of slickspot perimeter boundaries and greater organic debris accumulation than slickspots in unburned areas (Menke and Kaye 2006).

Livestock grazing, as measured by trampling in slickspots, did have some effects on slickspot condition in 2004. Soil crust cover in slickspots was significantly lower in transects with evidence of livestock grazing. Slickspot cover of exotic species was similar in areas with and without grazing. The previous HII monitoring (1998-2001) did not measure soil crust cover or exotic cover by species in slickspots, but found grazing had neutral effects on slickspot perimeter integrity, weedy species density, perennial forb/grass establishment and organic debris accumulation in slickspots (Menke and Kaye 2006).

Surrounding Habitat Condition

Evaluation of plant community data taken in 1998, 2001, and 2004 implies that overall, several aspects of *L. papilliferum* habitat have become increasingly degraded over time. Total vascular plant cover, species richness and species diversity all declined between 1998 and 2004. Across all transects and in each year, exotic species and native species each occupied about 50% of the vascular plant community, and this ratio has remained fairly consistent even as total vascular plant cover has decreased.

Past fires appear to have lasting effects on the composition and structure of plant communities surrounding slickspots; these fire events were likely a major agent of degradation. Total native species cover and shrub cover were consistently lower in burned transects, while total exotic species cover and exotic grass cover (including that by *Bromus tectorum)* were consistently higher in burned transects. This is consistent with substantial research on the dynamics of ecosystems invaded by *B. tectorum* (Young and Evans 1978; Melgoza et al. 1990; Peters and Bunting 1994). Soil crust cover also appears to decrease with fire, which has been observed in several arid systems (Evangelista et al. 2004; Hilty et al. 2004).

CONCLUSIONS

L. papilliferum populations generally decreased during 1998-2004 and these trends appeared to be strongly influenced by spring precipitation, with substantially larger numbers of plants of this ephemeral annual measured in wet years. This species depends on the availability of slickspot habitats in the sagebrush steppe environment. The quality of these habitats, in terms of plant cover, species richness and diversity, has declined since 1998. Factors that affect the quality of this habitat include wildfire and livestock grazing. Past fires have had persistent effects on the slickspots and the surrounding sagebrush-steppe landscape, resulting in reductions of shrub cover in the surrounding vegetation, degradation of soil crusts and increases in weedy vegetation in and around slickspots. Grazing also appears to degrade soil crusts in slickspots, and reduce overall vascular plant cover. Current monitoring efforts include the majority of areas that support *L. papilliferum,* and continued evaluation of these habitats will provide greater insight into dynamics of this species and associated plant communities.

LITERATURE CITED

Colket, B. 2005. 2004 Habitat integrity and population monitoring of slickspot peppergrass (*Lepidium papilliferum*). Idaho Conservation Data Center, Idaho Department of Fish and Game. 79 pp.

Daly, C., R.P. Neilson, and D.L. Phillips. 1994. A statistical-topographic model for mapping climatological precipitation over mountainous terrain. Journal of Applied Meteorology 33:140-158.

Dufrene, M. and P. Legendre. 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. Ecological Monographs 67:345-366.

Evangelista, P., T.J. Stohlgren, D. Guenther and S. Stewart. 2004. Vegetation response to fire and postburn seeding treatments in juniper woodlands of the Grand Staircase-Escalante National Monument, Utah. Western North American Naturalist 64:293-305.

Hilty, J.H., D.J. Eldridge, R. Rosentreter, M C. Wicklow-Howard and M. Pellant. 2004. Recovery of biological soil crusts following wildfire in Idaho. Journal of Range Management 57: 89-96.

Melgoza, G., R.S. Nowak, and R.J. Tausch. 1990. Soil water exploitation after fire: competition between *Bromus tectorum* (cheatgrass) and two native species. Oecologia 83:7-13.

Menke, C.A. and T.N. Kaye. 2006. *Lepidium papilliferum* (Slickspot peppergrass): Habitat Integrity Index Data Analysis (1998-2001). Institute for Applied Ecology. 27pp.

Meyer, S.E., D. Quinney and J. Weaver. 2005. A life history study of the Snake River Plains endemic *Lepidium papilliferum* (Brassicaceae). Western North American Naturalist 65: 11-23.

Meyer, S.E., D. Quinney and J. Weaver. 2006. A stochastic population model for *Lepidium papilliferum* (Brassicaceae), a rare desert ephemeral with a persistent seed bank. American Journal of Botany 93: 891-902.

Peters, E. F., and S. C. Bunting. 1994. Fire conditions and pre-and postoccurence of annual grasses on the Snake River Plain. Pages 31-36 *In* S.B. Monsen and S.G Kitchen (compilers), Proceedings– Ecology and Management of Annual Rangelands. USDA Forest Service General Technical Report INT-313. Intermountain Research Station, Odgen, Utah.

Robertson, I.C. and D. Klemash. 2003. Insect-mediated pollination in slickspot peppergrass, *Lepidium papilliferum* L. (Brassicaceae), and its implications for population viability. Western North American Naturalist 63: 333-342.

US Fish and Wildlife Service. 2004. 50 CFR 17. Endangered and threatened wildlife and plants; review of species that are candidates or proposed for listing as endangered or threatened; annual notice of findings on resubmitted petitions; annual description of progress of listing actions; Notice of Review; Proposed Rule. Federal Register 69(86):24876-24904.

Young, J.A. and R.A. Evans. 1978. Population dynamics after wildfires in sagebrush grasslands. Journal of Range Management 31:283-289.