Analysis of Slickspot Peppergrass (*Lepidium papilliferum*) Population Trends On Orchard Training Area and Rangewide Implications

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Executive Summary

The United States Fish and Wildlife Service has proposed to list slickspot peppergrass (*Lepidium papilliferum*) as endangered and is in the process of reviewing the best available scientific and commercial data in preparation of a new listing determination. Slickspot peppergrass occurs in the semiarid, sagebrush-steppe ecosystem of southern Idaho on the volcanic plains of the Snake River Plain and Owyhee Plateau, and Boise Foothills. Within the sagebrush-steppe communities, slickspot peppergrass occurs in a unique microenvironment variously termed slickspots, mini-playas, or natric sites.

Four programs exist that monitor the status of slickspot peppergrass populations on the Idaho Army National Guard Orchard Training Area (OTA). Three programs are conducted solely on the OTA. Two of these programs have been monitoring the same locations annually since the early 1990's. The third program searches new areas for unknown populations of slickspot peppergrass. A fourth program is the Habitat Integrity Index (HII) and Habitat Integrity and Population (HIP) monitoring that has been performed annually since the late 1990's. The HII/HIP monitoring transects occur throughout the range of slickspot peppergrass in southwestern Idaho. We describe and analyze data from each these programs.

Slickspot peppergrass data from "rough census" area and special use plot surveys conducted between 1990 and 2008 on the OTA provide limited evidence for declining populations in that trends were negative but only statistically significant for the "rough census" survey. Both surveys provided evidence that slickspot peppergrass numbers were positively related to mean monthly precipitation in winter and spring. Evidence from the "rough census" survey (though not the special use plots) indicated a negative relationship between slickspot peppergrass numbers and mean monthly precipitation in the fall (October – December). When we consider temperature in combination with precipitation, predicted slickspot peppergrass numbers are greatest following a fall or early winter when temperature or precipitation is high and the other is low. High mid- to late winter and spring precipitation produces an increase in slickspot peppergrass numbers, and either temperature is unimportant or is beneficial when temperatures are low. Finally, based on a shorter time series (2000 – 2008) of data from the special use plots, abundance of blooming plants depended on both precipitation in the current year and abundance of non-blooming plants in the previous year.

Questions have been raised in the past regarding why the surveys conducted by URS in 2005 recorded higher numbers of slickspot peppergrass than had been observed previously. The large number of slickspot peppergrass plants counted by URS resulted from searching a larger area and searching that area more intensively.

The habitat composition differs among the many areas monitored for slickspot peppergrass as part the different programs on the OTA. When the three extant slickspot peppergrass EOs on the OTA are considered together, the habitat consists of approximately 65% big sagebrush with the remainder split fairly evenly between cheatgrass and rabbitbrush.

Since EO 27 on the OTA accounts for 60% of all the area of EOs with a B rank rangewide, it suggests that much of the best remaining habitat for slickspot peppergrass exists on the OTA.

Only a single EO in the Boise Foothills qualified for a B rank and was only 0.84 hectares in size. Five EO's on the Snake River Plain qualified for B ranks, totaling 3875 hectares with EO 27 contributing 75% of that area. The EOs with B ranks on the Snake River Plain constitute 74% of the area of all EOs on the Snake River Plain. Seven EOs on the Owyhee Plateau have a rank of B, but these seven constitute 88% of the area of all the EOs on the Owyhee Plateau. The Snake River Plain has the majority of the area with the highest rank of B with most of that being on the OTA.

In an effort to assess whether the monitoring programs conducted on the OTA could be used to evaluate rangewide changes in slickspot peppergrass numbers, we compared three different monitoring programs. The "rough census" area and special use plot programs focus only on slickspot peppergrass numbers on the OTA. The HIP program monitors abundance rangewide. We found that the three programs all track annual changes similarly, so each can act as an index and shows similar fluctuations from year to year. The comparison of the HIP program on the OTA with that off the OTA suggests that the fluctuations observed on the OTA are similar to those seen off the OTA. Although the rangewide monitoring has not been conducted for as long as the monitoring on the OTA, the trend observed on the OTA is likely representative of the trend across the entire range. Because the data from the "rough census" areas are slightly less variable, the trend from the "rough census" areas can be considered slightly more reliable.

We also conducted an analysis of many of the factors measured within the slickspots or in the plant community surrounding the slickspots monitored as part of the HIP program. Very few of the factors we analyzed for relationships with slickspot peppergrass abundance demonstrated a consistent pattern across the Boise Foothills, Snake River Plain and Owyhee Plateau. The annual abundance counts for slickspot peppergrass are highly variable making it difficult for regression analyses to identify significant relationships. Numerous differences were identified among the regions, complicating analyses across the entire range.

The abundance of slickspot peppergrass differs among regions and across years. Regional differences are apparent with the Boise Foothills having the highest abundance, followed by the Snake River Plain and the Owyhee Plateau. Slickspot peppergrass abundance was lower within those slickspot that had previously burned. Only the amount of cheatgrass in the plant community surrounding HIP transects showed a consistent relationship with slickspot peppergrass abundance across all regions, and it was negative. No factor showed a consistently positive impact on slickspot peppergrass. From this, we conclude that managing slickspot peppergrass across the three regions might require region-specific approaches. As more years of HIP data become available, these analyses can be refined.

Since the special use plots and "rough census" areas as well as the HIP transects were subjectively located in areas where slickspot peppergrass was known to occur, any inferences regarding slickspot peppergrass abundance outside these locations should be made cautiously. The long-term nature of the data from the OTA makes these data the best available data when attempting to model trends through time. However the restricted geographic range creates limitations when attempting to extrapolate to areas away from this one section of the OTA.

Acknowledgements

Many organizations and individuals contributed data and provided expert knowledge in support of this project. In addition to the professional staff of the United States Fish & Wildlife Service, staff at the Idaho National Guard Orchard Training Area and the Natural Heritage Program within the Idaho Department of Fish and Game contributed valuable expertise and data. Dana Quinney and Jay Weaver at the OTA enabled us to better understand how the long-term abundance data on the OTA were collected and provided insights into the biology of slickspot peppergrass. Beth Colket was extremely helpful regarding how to interpret the Habitat Integrity and Population data. Without the assistance provided by these individuals, in particular, this project would not have been possible.

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Chapter 1: Project Background

Project Description

On July 15, 2002 (67 FR 46441), the U.S. Fish and Wildlife Service (USFWS) published a proposed rule to list slickspot peppergrass (*Lepidium papilliferum*) as endangered. On January 22, 2004, the USFWS withdrew the proposed ruling based on the conclusion that "there is a lack of strong evidence of a negative population trend, and the conservation efforts contained in formalized plans have sufficient certainty that they will be implemented and will be effective such that the risk to the species is reduced to a level below the statutory definition of endangered or threatened" (Federal Register Volume 69, No. 14, Pp. 3094-3116). However, in 2006, the USFWS reinstated the proposed rule from July 15, 2002 (Federal Register Vol. 71, No. 204, Pp. 62078-62079). The USFWS is in the process of reviewing the best available scientific and commercial data in preparation of a new listing determination. As part of the effort to review existing data, and to incorporate more recent information, we have been asked to:

A. Better document data collection methods at the Idaho Army National Guard Orchard Training Area

B. Statistically analyze data

The Idaho Army National Guard (IDARNG) data has not been statistically analyzed. The wide fluctuations in slickspot peppergrass numbers tend to be correlated with precipitation, therefore our statistical analysis will consider precipitation effects on abundance.

C. Compare methods from the "rough census" to other survey efforts at the Orchard Training Area

The collection methods utilized in the "rough census" will be compared with other survey efforts at the Orchard Training Area.

D. Better illustrate habitat quality at the Orchard Training Area

Based on Element Occurrence (EO) rankings, slickspot peppergrass habitat at the Orchard Training Area is thought to represent the highest quality habitat for the species on the Snake River Plain. EO ranks need to be summarized range Rangewide and, if possible, quantified to compare habitat quality to the Orchard Training Area.

E. Compare OTA data with HIP monitoring

Based on graphical representations, declines in numbers of slickspot peppergrass individuals at the OTA, not consistent with precipitation, occurred starting in 1996. The only data set available to assess the status of slickspot peppergrass range wide is the Habitat Integrity Index (HII) 1998-2002, followed by Habitat Integrity and Population (HIP) 2004-2008 monitoring. We will compare the HIP data to the data collected by IDARNG on the OTA.

Literature Review

Slickspot peppergrass was originally thought to be strictly biennial. It is described as densely papillose-pubescent, especially the stems; intricately branched, forming compact spherical clumps (Nelson and McBride 1913). However, more recently it has been established that it is an annual/biennial that grows from a taproot (Meyer and Quinney 1993, Moseley1994). Slickspot peppergrass is an ephemeral monocarpic plant displaying two life cycle types. Emergence takes place in the early spring for both types. The annual type sets fruit the summer following germination. The biennial type persists as a basal rosette and sets fruit the following spring. Occasionally, biennial plants flower both years (Meyer 1995). The stem leaves are sparse, most of the plant being comprised of a mass of inflorescences with many white flowers. When in flower, the plant is quite noticeable growing in the interstices of sagebrush and bunchgrasses on small, barren slickspots (Moseley1994).

Slickspot peppergrass grows on visually distinct microsites with remnant communities of relatively undisturbed Wyoming big sagebrush (*Artemisia tridentata* ssp. *Wyomingensis*). Its known range is southwestern Idaho where rapid habitat alteration is occurring. Typical slickspot peppergrass microsites contain sparse vegetation and often exhibit low water permeability. Typically, the habitat with vigorous slickspot peppergrass populations has not been recently burned, is not heavily grazed, has an understory of native bunchgrasses, and a well-developed microbiotic soil crust. Cheatgrass (*Bromus tectorum*) and clasping peppergrass (*Lepidium perfoliatum*), both exotic annuals, are invading slickspots in otherwise intact shrub communities (Fisher *et al.* 1996).

Range

Slick spot peppergrass is restricted to unique microsites of small-scale openings of the sagebrush-steppe on and adjacent to the western Snake River Plains (Moseley1994). The main portion of the range of slickspot peppergrass is the western Snake River Plain and adjacent northern foothills in Payette, Gem, Canyon, Ada and Elmore counties, Idaho (Moseley 1994). This portion of the range is separated into the Boise Foothills and the Snake River Plain for discussion purposes in this report. There is also a disjunct population on the Owyhee Plateau of Owyhee County, approximately 50 miles south of the Snake River Plain.

Habitat

Slickspot peppergrass occurs in the semiarid, sagebrush-steppe ecosystem of southern Idaho on the volcanic plains of the Snake River Plain and Owyhee Plateau, and adjacent foothills. Within the sagebrush-steppe communities, slickspot peppergrass occurs in a unique microenvironment created by unusual soil conditions. It occurs in microsites variously termed slickspots, mini-playas, or natric sites, with soils significantly higher in sodium and especially clay content than adjacent, unoccupied habitat.

Slickspot peppergrass microsites are small-scale run-on sites characterized by some clay and salt enrichment in the surface horizon, but without abnormally high levels of exchangeable sodium. Their soils show reduced levels of organic matter and bound nutrients as a consequence of lower biomass production relative to the surrounding shrubland vegetation. The exclusion of seedlings of species of the surrounding vegetation is probably more related to consequences of small-scale flooding and associated disease problems than to the differences in soil characteristics (Moseley1994, Meyer 1995).

Slickspots in good or excellent condition, where slickspot peppergrass was generally present have a surface silt layer varying from a few millimeters to 3 cm thick, and the hardpan varied from 1 to 3 cm. A red clay layer was consistently found beneath the hardpan (Meyer and Allen 2005). Unoccupied slickspots tended to have a thinner hardpan and thicker silt layer. The layer of silt might be too thick to allow germination (Meyer and Allen 2005).

Sodium (Na) concentrations inside slickspots are higher compared with areas outside the slickspots, and greater electrical conductivity (EC) values with depth are an indication of water storage inside the slickspots. Because slickspots are essentially areas that accumulate water, the increased Na and EC values may be related to the deeper depth or water-holding capacity of the slickspot. The increase in these soil parameters may reduce growth and competition of other plants within the slickspots (Palazzo *et al.* 2008).

Life History

Slickspot peppergrass is essentially restricted to intercoppice spaces that are bare of other vegetation. These small areas are visually distinct from both vegetated intercoppice areas and shrub coppices. They appear to be run-on areas where water is redistributed after either rainfall events or snowmelt. It appears that the exclusion of the typical perennial plant species results from an intolerance of recurring periods of flooding, whereas slickspot peppergrass can tolerate the flooding, whether as seeds or rosettes. The adaptation to recurrent flooding either prevents slickspot peppergrass from occurring outside of the slickspots, or prevents it from successfully competing with the existing vegetation (Meyer and Quinney 1993).

Seeds germinate in late winter or early spring (Meyer 1996), and plants emerge as seedlings in the early spring as slickspots are beginning to dry. Some individuals flower and set seed in early summer following the spring of emergence (*i.e.*, annuals). However, many other individuals do not flower the first summer, but instead persist as vegetative rosettes until the following spring, when they flower and set seed with the annual cohort in the following year (*i.e.*, biennials). The trigger that determines whether an individual becomes an annual or biennial is at least partly related to rosette size. Larger rosettes of first-year plants are more likely to flower than are smaller rosettes (Meyer 1995). Field observations made on the Orchard Training Area, south of Boise, in 1990–1992 revealed that those plants that survived until June either flowered and set seed immediately, functioning as summer annuals, or remained vegetative. Vegetative individuals that survived functioned as biennials, flowering and setting seed with the annual cohort of the subsequent year (Meyer *et al.* 2005). A few individuals, possibly as a response to floral herbivory will flower out of season or will flower during the first and second summers (Meyer 1995).

Successful biennials appeared to have higher reproductive output than the annuals that set seed with them, but their chances of surviving to reproduction seemed greatly reduced. Seedlings of the dominant perennial species are usually excluded from slick spots, presumably because of their inability to tolerate winter flooding (Meyer *et al.* 2005).

The number of individuals adopting the annual strategy fluctuates from year to year, with as few as approximately 20% flowering in their first year to as many approximately 60% doing so.

More plants might flower as first-year plants following wet springs (Meyer 1996). The numbers of potential biennial plants ranged between less than 20% of a year's cohort to over 50%. In dry years, most plants fail to grow large enough to flower during their first year. Of the individuals existing as rosettes through July, roughly 80% might die by mid-October. Of the remaining individuals, approximately 50% (12% of the original overwinter cohort) survive to set seed in the following summer (Meyer 1995, Meyer *et al.* 2005). In dry years, it is possible that none of the potential biennial plants will survive their first summer to reproduce as biennials (Meyer 1996). The individuals adopting the annual strategy were over six times more likely to survive to seed set than the biennial individuals (Meyer *et al.* 2005). Meyer (1995) concludes that the chances for survival of biennials are fair in good years, and very poor in bad years. In some years, the biennial strategy might 'pay-off' since the biennials are larger and produce more seeds than do the annuals.

Factors Affecting Seed Production

Damage to flowers by herbivorous insects can reduce the number of seed produced. Leavitt and Robertson (2006) found that when flowers had holes chewed in petals by chrysomelid beetles (*Phyllotreta* sp.), those flowers produced fewer fruit and seeds than undamaged flowers. More seeds were set on average per unit of plant mass in 1993, the wet year, than in 1994, the dry year. Overwintering biennials of the 1992 cohort on the Orchard Training Area had an average seed output of 787, six times higher than the average annual (Meyer *et al.* 2005). Outcrossing with plants from greater distances also increased the number of seeds produced (Robertson and Ulappa 2004).

Effects of Precipitation

Late winter precipitation appeared most important in mediating the size of the recruited cohort, with a large increase in the number of seedlings recruited with increased February–March precipitation. Survival of potential biennials was tied primarily to summer precipitation, with increased survival in years with substantial summer rainfall. But it was also influenced negatively by early winter precipitation. Heavy early winter precipitation tends to maintain the microsites in a flooded condition, with subsequent mortality the following spring, particularly of rosettes located in microsite centers where water stands longer (Quinney personal observation) (Meyer *et al.* 2005). The dry summers in southwestern Idaho have apparently applied strong selection pressure in the direction of the annual habit. Even in years when biennials are successful, their contribution to the seed rain may be small, and in some years, such as 1995, they make no contribution at all (Meyer *et al.* 2005). Meyer *et al.* (2005) think it is likely that (1) mean plant size is positively related to growing season precipitation, (2) overwintering biennials grow larger in response to high growing season precipitation than annuals, and (3) flowering as an annual is based primarily on achieving a minimum resource status and consequent threshold size, as non-flowering individuals are consistently concentrated in the smallest classes (Meyer *et al.* 2005).

Population Viability

Slickspot peppergrass is dependent upon a persistent seed bank. Meyer *et al.* (2006) created a stochastic model based on a long-term artificial seed bank and found that the viability of the local population depends on variable annual germination and seed production. If all viable seeds germinate annually, the risk of extinction was greater since many years are unfavorable for good seed production. However, the seed bank could be replenished following exceptional years that more than compensate for intervening years with poor or even ‘average’ seed production. Their model also showed that catastrophic trampling by livestock greatly increased the risk of extinction, even over periods as short as 15 years.

Seeds buried deeply remain viable, but are unlikely to germinate. Nearly all seeds remaining near the surface remain viable for up to about 12 years (Meyer *et al.* 2005). Seeds can germinate and emerge from depths of 30 mm, but depths of 2 mm appear optimal under laboratory conditions (Meyer and Allen 2005).

Description and Location of the Idaho Army National Guard Orchard Training Area

The Orchard Training Area (OTA) is a 56, 217 ha (138,912 acre) area located south of the City of Boise, ID (Figure 1-1) in the southeast corner of Ada County. Two raster-based dataset were used to analyze vegetation across the slickspot peppergrass range. One dataset was created by and available from the OTA. The second dataset was created as GAP Ecological Systems, USGS Mapping Zone 18 and available from Institute for Natural Resources, Oregon State University, Corvallis, Oregon for the USGS GAP Program.

The OTA’s vegetation dataset was created using Landsat images from throughout the calendar year during 1999 to 2001. The peak month for each vegetation type was selected to map that particular vegetation class (N. Nydegger, pers. comm.). The metadata for this dataset, as well as the vegetation class descriptions, are provided in Appendix 1. An accuracy assessment was performed using the OTA’s Land Condition Trend Analysis data from the 2000 survey. The results of the accuracy assessment are provided in Table 1-1.

Mapping Zone 18 was completed in November 2007 using multi-season satellite imagery (Landsat ETM+) from 1999-2001 in conjunction with digital elevation model (DEM) derived datasets (e.g. elevation, landform, aspect, etc.) to model natural and semi-natural vegetation. The minimum mapping unit for this dataset is approximately 1 hectare. Landcover classes are drawn from NatureServe's Ecological System concept. For the majority of classes, a decision tree classifier was used to discriminate landcover types, while a minority of classes (e.g. urban classes, burn scars, etc.) were mapped using other techniques (Kagen *et al.* 2008). The metadata for this dataset, including the vegetation class descriptions, are provided in Appendix 2. No ground-truthing and subsequent accuracy assessment was performed on Mapping Zone 18 vegetation classification (A. Davidson, pers. comm.).

Table 1-1. Accuracy assessment of the vegetation classification for the Orchard Training Area vegetation GIS layer (provided by N. Nydegger).

Vegetation Classification	%Correct
OverallX	73(N=274)
Overall	72(N=286)
Artemisia tridentata – Big Sagebrush	90 (N=54)
Atriplex confertifolia - Shadscale	79 (N=21)
Bromus tectorum – Cheatgrass	76 (N=29)
Ceratoides lanata – Winterfat	61 (N=32)
Chrysothamnus visidiflores – Rabbitbrush	81 (N=26)
Poa Sandbergii – Sandberg's Bluegrass	60 (N=57)
Exotic Annuals – Exotic invader	68 (N=33)
Miscellaneous Water	No Sample
Primary Agriculture	No Sample
Secondary Agriculture	(N=1)
Snake River proper	No Sample
Cindered Areas (volcanic)	(N=11)
Bare Ground Areas	68 (N=22)
Playa areas	No Sample

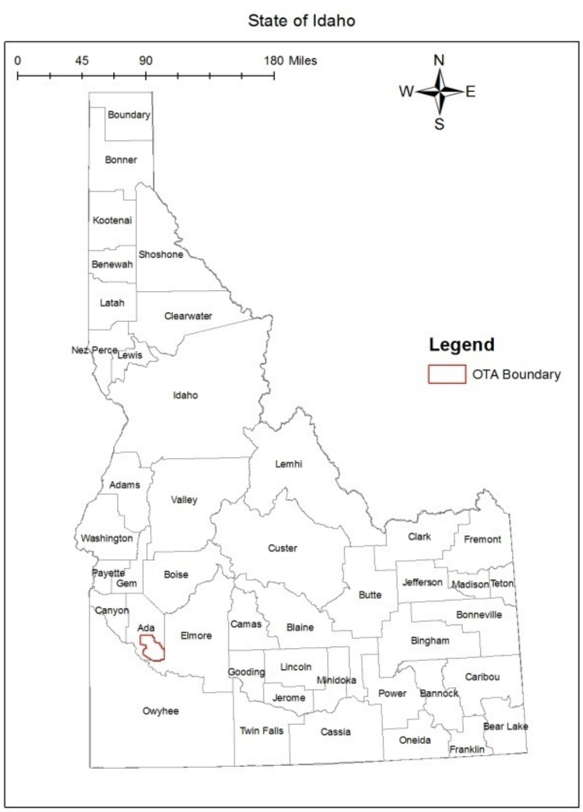

Figure 1-1. Map of Idaho showing location of the Orchard Training Area.

Using these data, the vegetation classes across the OTA were identified and the amounts of each class determined. The OTA has seven vegetation classes within its borders and six additional landcover classes (Table 1-1,) and is dominated by Sandberg's bluegrass (29%) and big sagebrush (21%) (Table 1-2) using the OTA's classification or Introduced Upland Vegetation - Annual Grassland (33%) and Inter-Mountain Basins Big Sagebrush Shrubland (32%) (Table 1-3) using the GAP classification. However, the area within 10 or 20 miles of the OTA includes a considerably more varied land cover. The OTA should not be considered truly representative of the local area (Tables 1-4 and 1-5). Although the area within 10 or 20 miles of the OTA and including the OTA is still dominated by Introduced Upland Vegetation - Annual Grassland (35% including the area within 10 miles or 25% including the area within 20 miles) and Inter-Mountain Basins Big Sagebrush Shrubland (25% including the area within 10 miles or 19% including the area within 20 miles), Cultivated Cropland contribute to a much greater extent making up 8% or 11% of the entire area, respectively. Large areas devoted to agriculture exist to the northwest and southeast of the OTA. There are also scattered areas directly to the east and west of the OTA with a number of agricultural areas just outside the OTA.

The OTA is a contiguous area with little development or agricultural lands. Moving away from the OTA, there is an increase in the amount of agricultural lands, urban areas, or lands otherwise disturbed. Therefore, the OTA represents a relatively undisturbed area consisting mostly of native vegetation types.

Table 1-2. Vegetation classes on the Orchard Training Area based on Orchard Training Area vegetation GIS layer

Class	Hectares	Acres	Percent of Area
Sandberg's Bluegrass (*Poa sandbergii*)	16,048.88	39,656.77	28.55
Big Sagebrush (*Artemisia tridentata*)	11,652.13	28,792.40	20.73
Cheatgrass (*Bromus tectorum*)	7,083.88	17,504.26	12.60
Exotic Annuals	5,827.19	14,398.98	10.37
Shadscale (*Atriplex confertifolia*)	4,911.69	12,136.78	8.74
Rabbitbrush (*Chrysothamnus visidiflores*)	4,865.94	12,023.73	8.66
Winterfat (*Ceratoides lanata*)	2,486.63	6,144.45	4.42
Bareground	2,280.63	5,635.42	4.06
Cindered Areas (volcanic)	1,019.00	2,517.95	1.81
Secondary Agriculture (inactive but previously farmed)	22.25	54.98	0.04
Playa areas (ephemeral ponds)	14.50	35.83	0.03
Primary Agriculture (active during the analysis)	2.94	7.26	0.01
Miscellaneous Water	1.25	3.09	0.00
	56,216.88	138,911.90	100.00

Table 1-3. Vegetation classes on the Orchard Training Area based on GAP Ecological Systems, USGS Mapping Zone 18 GIS layer.

Class	Hectares	Acres	Percent of Area
Introduced Upland Vegetation - Annual Grassland	18772.91	46387.87	33.37
Inter-Mountain Basins Big Sagebrush Shrubland	17802.21	43989.26	31.65
Columbia Plateau Steppe and Grassland	8092.83	19997.38	14.39
Inter-Mountain Basins Mixed Salt Desert Scrub	5809.06	14354.18	10.33
Inter-Mountain Basins Semi-Desert Shrub-Steppe	2920.06	7215.47	5.19
Inter-Mountain Basins Semi-Desert Grassland	1815.33	4485.68	3.23
Inter-Mountain Basins Big Sagebrush Steppe	363.15	897.33	0.65
Columbia Plateau Ash and Tuff Badland	347.41	858.46	0.62
Developed, Low Intensity	134.72	332.88	0.24
Developed, Open Space	133.70	330.38	0.24
Developed, Medium Intensity	27.20	67.22	0.05
Inter-Mountain Basins Greasewood Flat	27.10	66.97	0.05
Developed, High Intensity	4.44	10.98	0.01
Cultivated Cropland	4.20	10.38	0.01
Open Water	0.63	1.57	0.00
Introduced Upland Vegetation - Annual and Biennial Forbland	0.08	0.20	0.00
	56255.04	139006.20	100.00

Table 1-4. Vegetation classes within 10 miles of and including the Orchard Training Area based on GAP Ecological Systems, USGS Mapping Zone 18 GIS layer.

Class	Hectares	Acres	Percent of Area
Introduced Upland Vegetation - Annual Grassland	106,211.16	262,447.78	35.44
Inter-Mountain Basins Big Sagebrush Shrubland	74,152.06	183,229.75	24.74
Columbia Plateau Steppe and Grassland	23,820.29	58,859.93	7.95
Cultivated Cropland	22,601.46	55,848.21	7.54
Inter-Mountain Basins Mixed Salt Desert Scrub	16,683.39	41,224.65	5.57
Inter-Mountain Basins Semi-Desert Shrub-Steppe	15,044.88	37,175.89	5.02
Pasture/Hay	12,040.12	29,751.14	4.02
Inter-Mountain Basins Semi-Desert Grassland	4,952.95	12,238.74	1.65
Developed, Open Space	4,595.81	11,356.24	1.53
Inter-Mountain Basins Greasewood Flat	4,183.66	10,337.83	1.40
Inter-Mountain Basins Big Sagebrush Steppe	4,161.80	10,283.82	1.39
Columbia Plateau Ash and Tuff Badland	4,002.55	9,890.31	1.34
Open Water	1,716.69	4,241.95	0.57
Columbia Basin Foothill and Canyon Dry Grassland	1,414.78	3,495.91	0.47
Developed, Low Intensity	1,350.29	3,336.56	0.45
Recently burned grassland	856.53	2,116.49	0.29
Columbia Basin Foothill Riparian Woodland and Shrubland	565.14	1,396.45	0.19
Developed, Medium Intensity	549.29	1,357.29	0.18
Inter-Mountain Basins Cliff and Canyon	253.39	626.13	0.08
Developed, High Intensity	221.14	546.45	0.07
Introduced Upland Vegetation - Annual and Biennial Forbland	164.90	407.48	0.06
North American Arid West Emergent Marsh	55.56	137.28	0.02
Columbia Plateau Western Juniper Woodland and Savanna	38.18	94.35	0.01
Inter-Mountain Basins Montane Sagebrush Steppe	33.65	83.14	0.01
Unconsolidated Shore	11.39	28.15	0.00
Rocky Mountain Lower Montane Foothill Shrubland	2.36	5.84	0.00
Rocky Mountain Aspen Forest and Woodland	1.94	4.80	0.00
	299,685.38	740,522.57	100.00

Table 1-5. Vegetation classes within 20 miles of and including the Orchard Training Area based on GAP Ecological Systems, USGS Mapping Zone 18 GIS layer.

Class	Hectares	Acres	Percent of Area
Introduced Upland Vegetation - Annual Grassland	172,329.22	425,825.51	24.61
Inter-Mountain Basins Big Sagebrush Shrubland	131,911.10	325,952.33	18.84
Cultivated Cropland	76,267.97	188,458.16	10.89
Columbia Plateau Steppe and Grassland	50,701.85	125,284.28	7.24
Inter-Mountain Basins Big Sagebrush Steppe	49,128.85	121,397.40	7.02
Inter-Mountain Basins Mixed Salt Desert Scrub	47,455.23	117,261.87	6.78
Pasture/Hay	34,030.51	84,089.39	4.86
Developed, Open Space	27,260.29	67,360.17	3.89
Inter-Mountain Basins Montane Sagebrush Steppe	16,315.68	40,316.03	2.33
Inter-Mountain Basins Semi-Desert Shrub-Steppe	16,009.14	39,558.59	2.29
Developed, Low Intensity	15,699.00	38,792.23	2.24
Columbia Plateau Ash and Tuff Badland	14,836.71	36,661.52	2.12
Inter-Mountain Basins Greasewood Flat	6,653.14	16,439.92	0.95
Open Water	6,354.38	15,701.68	0.91
Inter-Mountain Basins Semi-Desert Grassland	5,704.99	14,097.04	0.81
Columbia Basin Foothill Riparian Woodland and Shrubland	4,722.14	11,668.41	0.67
Developed, Medium Intensity	3,887.44	9,605.86	0.56
Recently burned grassland	3,478.49	8,595.36	0.50
Columbia Basin Foothill and Canyon Dry Grassland	3,348.19	8,273.38	0.48
Columbia Plateau Western Juniper Woodland and Savanna	1,351.46	3,339.47	0.19
Middle Rocky Mountain Montane Douglas-fir Forest and Woodland	1,277.55	3,156.84	0.18
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	677.40	1,673.85	0.10
Inter-Mountain Basins Cliff and Canyon	656.58	1,622.41	0.09
Developed, High Intensity	644.67	1,592.98	0.09
Columbia Plateau Low Sagebrush Steppe	497.74	1,229.92	0.07
Northern Rocky Mountain Lower Montane, Foothill, and Valley Grassland	308.43	762.13	0.04
Northern Rocky Mountain Subalpine-Upper Montane Grassland	246.00	607.86	0.04
Introduced Upland Vegetation - Annual and Biennial Forbland	206.74	510.86	0.03
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	191.84	474.04	0.03
Columbia Plateau Scabland Shrubland	157.30	388.69	0.02
North American Arid West Emergent Marsh	154.49	381.75	0.02
Rocky Mountain Aspen Forest and Woodland	132.38	327.11	0.02
Great Basin Xeric Mixed Sagebrush Shrubland	51.14	126.37	0.01
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	37.99	93.88	0.01
Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland	20.71	51.19	0.00
Inter-Mountain Basins Active and Stabilized Dune	13.20	32.62	0.00

Table 1-5 (Continued)

Class	Hectares	Acres	Percent of Area
Unconsolidated Shore	11.39	28.15	0.00
Rocky Mountain Subalpine-Montane Mesic Meadow	9.34	23.07	0.00
Rocky Mountain Lower Montane Foothill Shrubland	9.15	22.62	0.00
Columbia Plateau Silver Sagebrush Seasonally Flooded Shrub-Steppe	3.57	8.82	0.00
Inter-Mountain Basins Aspen Mixed Conifer Forest-Woodland	1.67	4.14	0.00
Inter-Mountain Basins Playa	1.37	3.37	0.00
Rocky Mountain Lodgepole Pine Forest	0.27	0.67	0.00
Northern Rocky Mountain Subalpine Deciduous Shrubland	0.15	0.37	0.00
Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	0.12	0.29	0.00
Inter-Mountain Basins Juniper Savanna	0.09	0.22	0.00
(blank)	7,520.89	18,584.13	1.07
	700,278.01	1,730,386.96	100.00

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Chapter 2: Monitoring Methods on the Idaho Army National Guard Orchard Training Area

Four programs exist that monitor the status of slickspot peppergrass (*Lepidium papilliferum*) populations on the Idaho Army National Guard Orchard Training Area (OTA). Three of the programs are conducted solely on the OTA, by the staff or hired consultants of the OTA. Two of these programs have been monitoring the same locations annually since the early 1990's. The third program searches new areas for unknown populations of slickspot peppergrass. A fourth program is the Habitat Integrity Index (HII) and Habitat Integrity and Population (HIP) monitoring that has been performed annually by the Idaho Natural Heritage Program in the Idaho Department of Fish and Game since the late 1990's. The Idaho Natural Heritage Program was formerly known as the Idaho Conservation Data Center and is cited in this report. The HII/HIP monitoring transects occur throughout the range of slickspot peppergrass in southwestern Idaho.

Each of these programs is described in the following sections. The OTA has the longest monitoring efforts for slickspot peppergrass, and the objective of this chapter is to document each of the different programs and describe the methods used in each monitoring program.

"Rough Census" Areas

The methods of the annual "rough census" have not been previously published. The methods presented are based on personal communications from Dana Quinney, a biologist at the OTA. "Rough census" areas are located in the northeastern portion of the OTA (Figure 2-1).

Each year between mid-May and 1 July, certain areas of OTA are sampled for relative numbers of slickspot peppergrass plants by walking transects. The program began in 1990 by monitoring 5 areas (Figure 2-1) and expanded to a total of 15 areas through 1994. In 1992, the Red Tie area was broken up into four separate areas: South Standifer, Alamo, North Fork Road, and East Alamo. The combined area of the 15 "rough census" areas totals 350.50 hectares (866.09 acres). At least some of the "rough census" areas have been monitored annually since 1990, with a single exception during 1999. Since 2001, all 15 "rough census areas have been surveyed annually.

Each "rough census" area is delineated by easily discernible landmarks, such as roads or fences, so the areas searched remains constant over the years. Some portions of "rough census" areas occur outside the boundaries of the OTA because a fenceline thought to be the boundary turned out to be well outside the OTA. Each "rough census" area is walked by trained technicians in parallel lines approximately 20 m apart searching for slickspots. When a slickspot is noted, technicians walk to it and, if slickspot peppergrass is present, count all the plants. The reproductive status of plants is not recorded; only total numbers of plants were recorded. Although the lines walked are not marked, each "rough census" area is search in a similar pattern each year, so the search lines are likely similar each year. These data are statistically analyzed in Chapter 3.

Technicians are trained to walk along as straight a line as possible, and to go to each slick spot they can see from their line, and if slickspot peppergrass occurs, count them, return to the line they were walking and continue. The lines walked are not permanently marked, so slight changes could occur regarding the specific locations of the lines walked from year to year. Over the years, the total time it takes to count the "rough census" areas has been pretty constant, but in years with many plants present, it takes longer to do the counts than in years with few plants. Dozens of technicians have been involved in the "rough census" over the years. Jay Weaver and Dana Quinney, permanent staff at the OTA, have trained all the technicians that have been involved in the rough census, and have done much of the monitoring themselves.

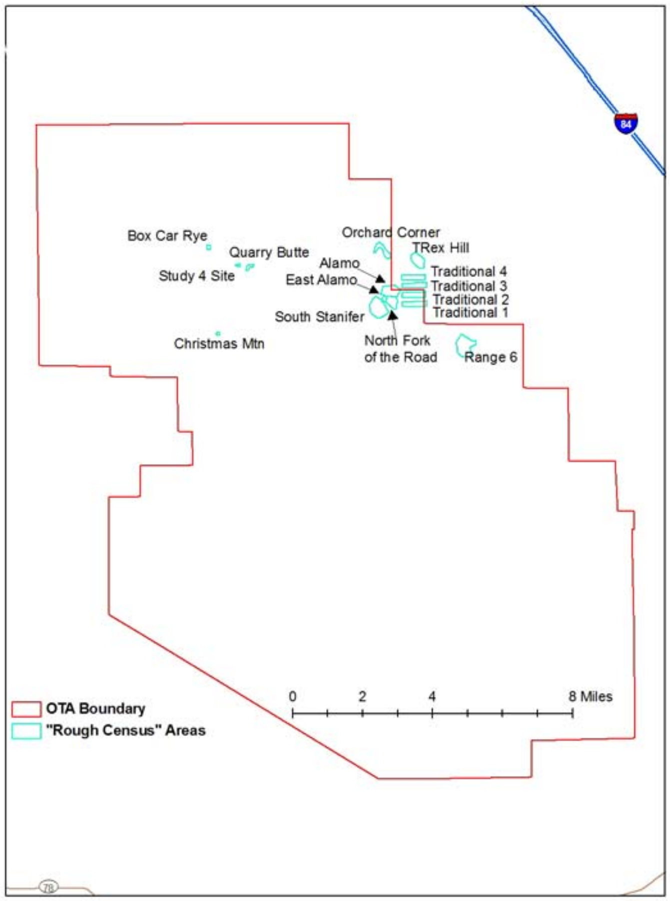

Figure 2-1. Locations of "rough census" areas at the Orchard Training Area.

Special Use Plots

Slickspot peppergrass special use plots on the OTA are monitored according to the methods developed for monitoring programs on military lands (Diersing *et al.* 1989, Tazik *et al.* 1992). A total of 16 plots have been monitored for the condition of the habitat of slickspot peppergrass since 1990 or 1991.

The Land Condition Trend Analysis (LCTA) core plot allocation was done using geographic information systems analysis, based on overlaying an unsupervised reflectance category satellite image, upon a digitized soils map, and mapping all resulting polygons that were over 5 acres in size. 279 LCTA core plots were allocated by random means, within these polygons (Figure 2-2). The OTA slickspot peppergrass population was discovered in 1989 while LCTA core plots were being established (pers. comm. D. Quinney). Tazik *et al* (1992) refer to these locations as 'plots,' but they should be considered belt transects measuring 6 m x 100 m. Each plot consists of five permanent metal stakes, 25 m apart, along the central transect line. Each year, a photograph of record is taken of the plot by a person standing at the 0-m mark. On each plot, the following information is recorded at each meter on a line-point transect 100 m long (100 points): the disturbance, if any, affecting the ground; the ground cover (bare ground, plant species, cryptogamic cover, etc.); and the aerial plant cover, by species, for each decimeter above ground. This allows analyses of species diversity, ground cover by species, aerial cover by species, soil disturbance, cryptogamic cover, bare ground, and so on.

LCTA on and around the Orchard Training Area

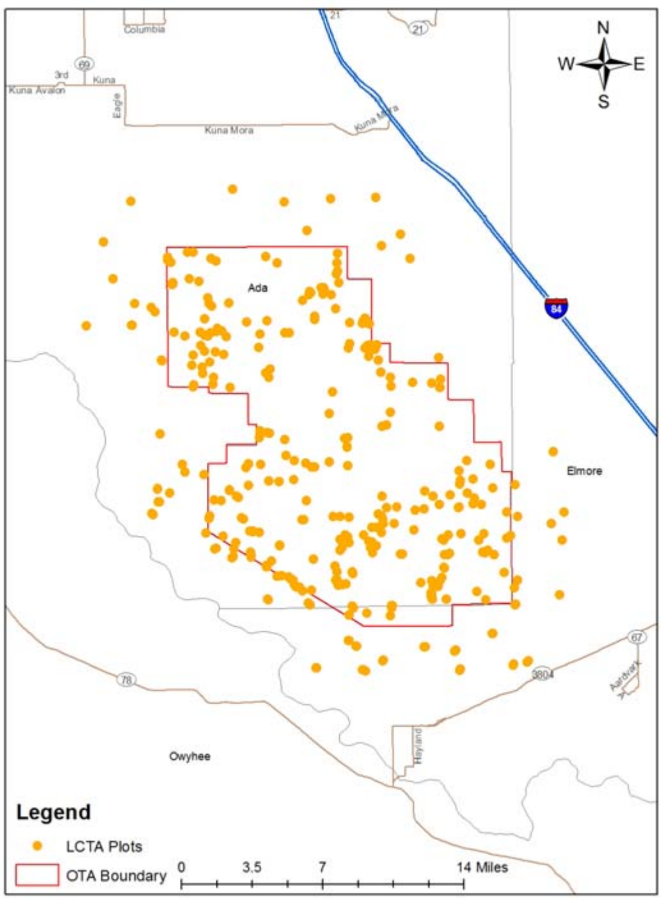

Figure 2-2. Location of the LCTA plots on and around the Orchard Training Area.

In the 100 x 6-m belt transect, each individual of each woody species present (if any) is counted and its height in decimeters recorded. This gives shrub density and height, and is useful in determining trends in shrub species.

In 1990, 15 slickspot peppergrass special use plots (Plots 280 to 294) were established in areas where slickspot peppergrass had been found. In the following year, a 16th plot (Plot 296) was established in an area that extended the OTA range of slickspot peppergrass. These 'special use plots' are very similar to the LCTA plots, and again would be more accurately described as belt transects. The differences between core LCTA plots and the special use plots are described below. The location for each of the 16 permanent slickspot peppergrass special use plots was determined simply by finding a slick spot that had slickspot peppergrass. The slickspot is permanently marked and becomes the 50-m point along the 6 m x 100 m belt transect. The plots are monitored each year in early to mid-June, when mature slickspot peppergrass plants are in bloom and young seedlings are still green. The special use plots all occur in the northern half of the OTA and are mostly along the eastern border (Figure 2-3). The special use plots all occur in the same vicinity as the "rough census" areas (Figure 2-4).

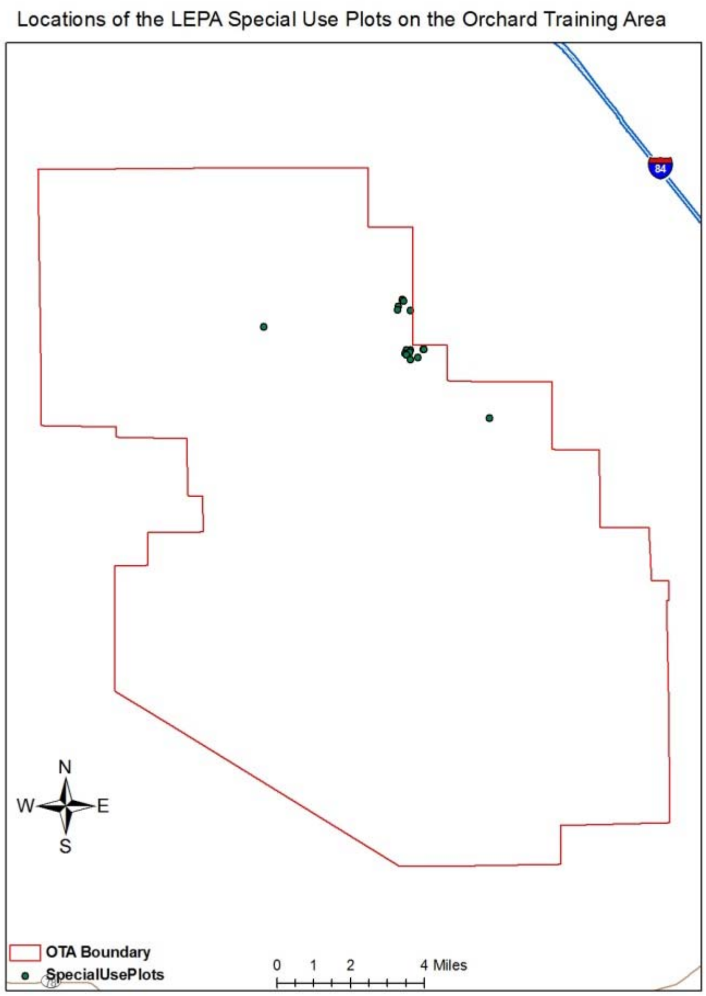

Figure 2-3. Location of the special use plots at the Orchard Training Area.

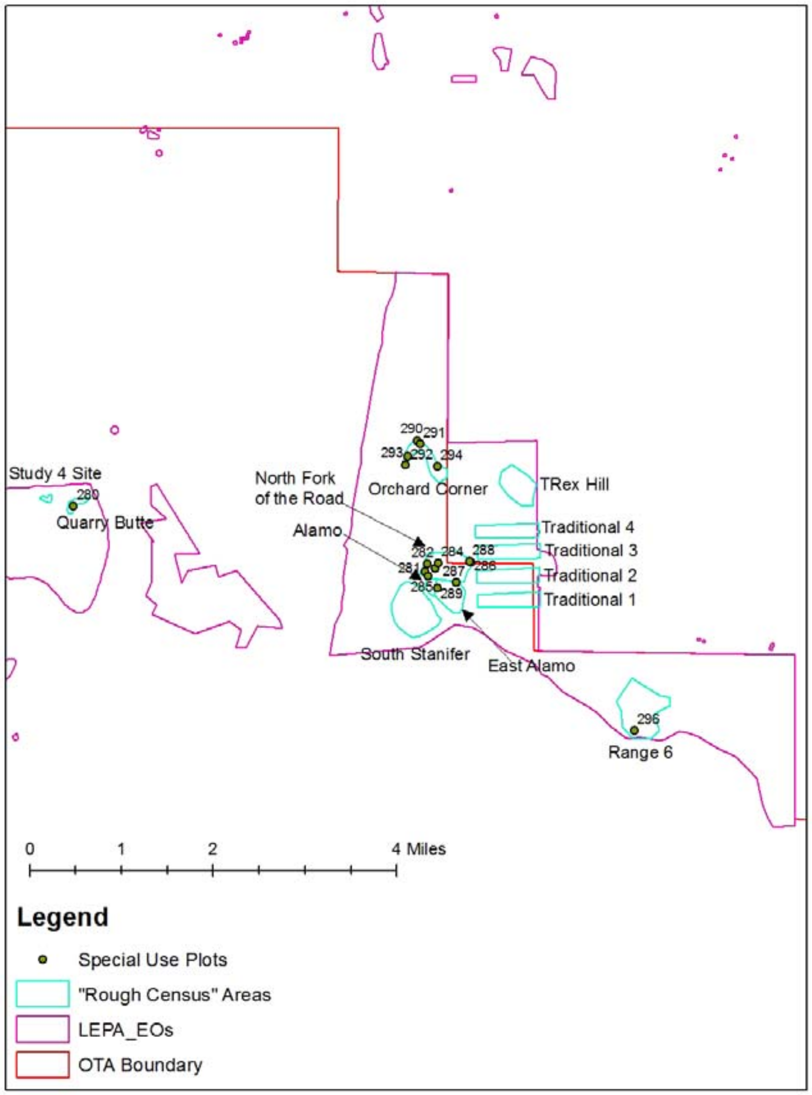

Figure 2-4. Detailed View of labeled special use plots on the Orchard Training Area shown in relation to the "rough census" areas.

Slickspot peppergrass special use plots are monitored like LCTA plots (Tazik *et al.* 1992), with a few additions to the basic LCTA method (pers. comm. D. Quinney):
a. The 50-m stake of each plot is centered within a slickspot peppergrass microsite. A random number table was used to align the belt transect on a random azimuth that crosses this point, and a coin was flipped to determine which end became the point of origin of the belt transect. The woody vegetation within the 6 x 100-m belt transect and vegetation present at each meter along the center line transect was recorded in the same manner as the LCTA plots.
b. An additional 10-m diameter circular plot was implemented to count slickspot peppergrass only (Figure 2-5). These plots centered on the 50-m stake. Within the circular plot, all slickspot peppergrass are counted, and beginning in 2000, technicians recorded how many plants are reproductive and how many are nonreproductive (Figure 2-4). The recorded counts consist of only those slickspot peppergrass plants in the circular area around the 50-m stake. Since

herbaceous vegetation is only recorded every meter along the central transect, slickspot peppergrass has rarely been recorded outside the central circular area, and would not be included in the total slickspot peppergrass count for that special use plot (J. Weaver and D. Quinney, pers. comm.).
c. Two additional plot photos are taken at each plot: one at the 45-m stake looking toward the 50-m stake, and one at the 55-m stake looking toward the 50-m stake.

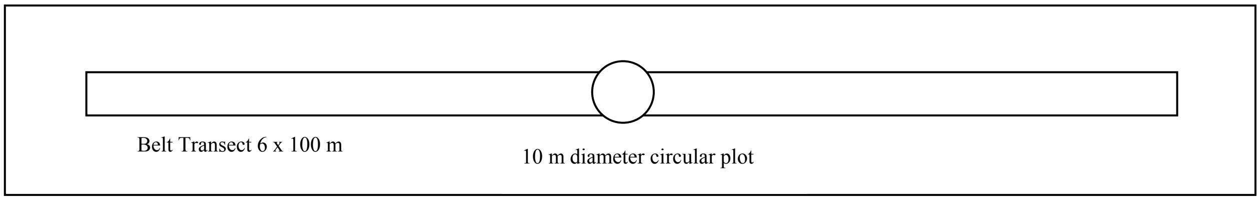

Figure 2-5. Sketch of Special Use Plot showing 6 x 100 m belt transect with a central 10-m diameter circular plot encompassing the slickspot.

Annual Block Search

The following methods are based on personal communications from D. Quinney. As a signatory to the slickspot peppergrass Candidate Conservation Agreement (2003), IDARNG agreed to continue doing a slickspot peppergrass "block search." Each year, a different polygon is delineated to be searched, and the contractor would walk 10-m parallel lines all the way across the polygon, recording slickspots and slickspot peppergrass plants observed. The size and number of the areas searched vary from year to year depending on available funding and on locations of recognizable landmarks that will readily delimit a search area. Block sizes varied from 16 to approximately 345 hectares (40 to 850 acres). Searches are conducted from late spring through mid-summer. The task of the block searches is to search previously unsearched areas to identify new areas supporting slickspot peppergrass.

Habitat Integrity Index (HII) and Habitat Integrity and Population (HIP)

The final monitoring program conducted on the OTA is not restricted to the OTA, but is a program conducted by the Idaho Natural Heritage Program across the southwestern Idaho range of slickspot peppergrass. Fourteen of the approximately 80 HII/HIP transects exist on the OTA or along its borders (Figure 4-2). Habitat Integrity Index (HII) monitoring and Habitat Integrity and Population (HIP) monitoring for slickspot peppergrass applied different methodologies but are still useful for tracking abundance at transects across the two monitoring efforts. The HII/HIP transects occur in roughly the same areas as the "rough census" areas and the special use plots.

The Habitat Integrity Index monitoring protocol consists of four interrelated parts: the HII scorecard; an Occurrence Viability Rank scorecard; vegetation sampling; and photo points. HII transects were subjectively located in areas known to support slickspot peppergrass and in areas thought to be representative of the vegetation throughout the Element Occurrence (EO). There is no preset length of each transect. Rather, each transect was established to include 10 slickspots (Mancuso *et al.* 1998). Monitoring of HII transects occurred from 1998 through 2003. A detailed description of the HII methods can be found in Mancuso *et al.* (1998).

In 2004, the habitat integrity and population (HIP) monitoring protocol was developed to monitor and assess slickspot peppergrass population, habitat integrity, and disturbance trends, for the purpose of evaluating and improving management actions implemented by the Candidate Conservation Agreement (2003). The HIP monitoring protocol replaces the habitat integrity index (HII) monitoring protocol (Mancuso and Moseley 1998, Mancuso *et al.* 1998, Mancuso 2000, 2001, 2002, 2003) to provide more replicable data specific to the needs of the Candidate Conservation Agreement. HIP monitoring has been annually conducted during 2004-2008 and consists of the following procedures: 1) establish and permanently mark HIP transects, 2) record location information, 3) take photographs, 4) measure population, habitat and disturbance attributes at selected slickspots, 5) measure plant community attributes, and 6) analyze and describe the results (Colket 2005).

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Chapter 3: Analysis of Slickspot Peppergrass Abundance on the Idaho Army National Guard Orchard Training Area

Slickspot peppergrass (*Lepidium papilliferum*) is an herbaceous plant occurring in the sagebrush steppe of southwestern Idaho. Concerns regarding the population status prompted the Habitat Integrity Index (HII) rangewide survey program in 1998 which was succeeded by the similar Habitat Integrity and Population (HIP) monitoring program in 2004. Previous analyses of the HII and HIP survey data necessarily have been limited by the relatively short time series of 4 – 5 years and by changes in monitoring protocols. In contrast, surveys for slickspot peppergrass have been conducted on the Idaho Army National Guard Orchard Training Area (OTA) for nearly 2 decades from 1990 through 2008. Furthermore, these surveys have maintained relatively consistent protocols. Two separate surveys have been conducted in most years – these are the "rough census" area and special use plot surveys. Analysis presented here addresses whether there is any evidence of decline in slickspot peppergrass on the OTA, but does not address range-wide population trends.

Menke and Kaye (2006) and others have argued that slickspot peppergrass abundance is positively correlated with amount of spring precipitation based on an analysis of the HII/HIP data. Furthermore, they found some evidence of negative association with late fall/early winter precipitation. We have analyzed the OTA data to identify any increasing or decreasing trend over time and to determine whether there is a statistical relationship between abundance and precipitation.

Slickspot peppergrass has a complicated life history with 2 alternative reproductive strategies. Some individuals are annuals, germinating in the early spring, then flowering and setting seed in June. Other individuals are biennials that pass the first year in a vegetative state, and those that survive reproduce in the second year. The OTA surveys were not designed to distinguish annuals and biennials. However, beginning in 2000, the special use plot survey did conduct separate counts of non-blooming plants (presumably biennials in their first year) and blooming plants (an unknown mixture of annuals and biennials). For slickspot peppergrass distinguished by reproductive status, we conducted additional analyses of association with precipitation and dependence of blooming plant abundance on abundance of non-blooming plants in the previous year.

Methods

"Rough census" survey data consisted of estimated slickspot peppergrass abundance within 15 census areas. Statistical analyses were conducted on 14 of the "rough census" areas. The Boxcar Rye area was excluded from analyses because of the predominance of zero values; only one non-zero value occurred during the study period. Because different areas were surveyed in different years (in particular, early in the study) and because rough census areas differ in size, abundance was standardized as density. For convenience in estimation, density was expressed as number of individuals per 10 hectares. Special use plot data consisted of abundance estimates within each of central circular plots described early for each year in the period 1991 – 2008. From 2000 onward special use plot counts included separate estimates of number of blooming and non-blooming individuals (see Chapter 2 for a detailed description of field methods). All special use plots were the same size and, furthermore, all plots were surveyed in all years. Therefore, there was no need to re-express abundance as density.

In all analyses, the response variable was either slickspot peppergrass density (number of individuals per unit area) or abundance (total number of individuals). In general, count data are not normally distributed. Rather, count variables are naturally represented by the Poisson or the Negative Binomial distribution. Preliminary examination of the slickspot peppergrass data indicated that the Negative Binomial distribution was more appropriate than the Poisson because it better accounted for the large variances. Therefore, Negative Binomial regression was used to model density or abundance as a function of year (for trend analysis) or precipitation. The general regression equation had the form

$$\log(Count) = \beta_0 + \beta_1 X$$

where *Count* represented the density or abundance estimated in the survey and *X* represented the covariate of interest (year or precipitation). All models were fit using SAS Proc Genmod.

A notable feature of the OTA surveys is the annual repetition of measurements on the same areas or plots. A consequence of this repeated measures design is that values of the response (density or abundance) on the same subject (area or plot) tend to be more highly correlated with each other than is the case for measurements among different subjects. The repeated measures design is frequently employed in human drug trials. For instance, blood pressure might be measured at weekly intervals in subjects that were assigned to either a control group receiving a placebo or a treatment group receiving a new blood pressure medicine. Irrespective of treatment, successive blood pressure measurements within a patient are likely to be more similar to each other than to measurements made on other patients. For the slickspot peppergrass analyses, we addressed these potential dependencies using the Generalized Estimating Equation approach (Diggle et al. 1994), which is available through the *Repeated* statement in Proc Genmod. We specified an autoregressive order 1 correlation structure, which seemed appropriate for these data – measurements made close in time ought to be more similar to each other than measurements separated by longer periods.

Monthly precipitation data were available from 3 stations near the survey sites. These included the OTA Range 2 station and two Agricultural Research Service (ARS) stations. The OTA Range 2 data were most complete, covering the entire period from June 1990 through April 2008. For the periods in common, weather observations among the 3 stations were highly correlated. OTA Range 2 data were used in preference to data from either of the ARS stations or the average of all 3 stations because the Range 2 station had data covering the entire period and the high inter-station correlation indicated little would be gained by including the ARS stations. Additionally, all plots were closer to the OTA Range 2 station than to either of the ARS weather stations.

Three-month running averages of precipitation were calculated for the period from fall of the preceding calendar year through spring (i.e., by calculating mean monthly precipitation for

October – December, November – January, …, March – May). We explored a range of potential relationships by regressing slickspot peppergrass abundance on mean precipitation for each of these 3-month periods. Because precipitation data were not available for 1990, these analyses were restricted to the period 1991 – 2008 for both the rough census and special use data.

Reproductive Status, Special Use Plots

For the years 2000 – 2008, inclusive, surveys at special use plots included separate tallies of blooming and non-blooming plant numbers. Non-blooming plants were assumed to be biennials in their first year. As such, we reasoned that they might show dependence on precipitation in the current year. Therefore, abundance of non-blooming plants was regressed on current-year precipitation as described above for all plants.

Blooming plants were considered to be an unknown mixture of annuals and biennials. We conducted 2 separate analyses of abundances. First, we regressed abundance on precipitation in both the current and previous years, using individual coefficients for each year. For simplicity, we only considered the same three-month period in both years (though, any combination of periods might be postulated). The general equation for all these models was

$$\log(Blooming) = \beta_0 + \beta_1(Precip, current\ year) + \beta_2(Precip, previous\ year)$$

In the second analysis, abundance of blooming plants was regressed on both precipitation in the current year and numbers of non-blooming plants in the previous year. Regression models had the form

$$\log(Blooming) = \beta_0 + \beta_1(Precip, current\ year) + \beta_2(Nonblooming, previous\ year)$$

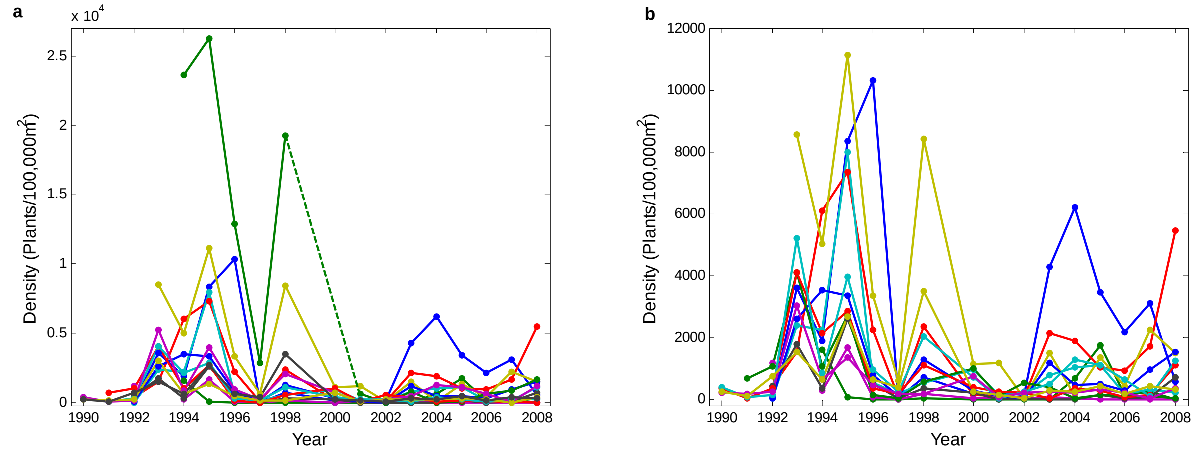
Data for the non-blooming term was the same in all models, while data for the precipitation term depended on the chosen three-month period.

Results

"Rough Census" Areas

Slickspot peppergrass density on most "rough census" areas was low in the early 1990's when the survey was initiated, reached a peak in the mid-1990's, and since that time has been at lower levels (Figure 3-1). Some "rough census" areas have had smaller peaks in the late 1990's, early 2000's, and most recently in 2007 and 2008 (Figure 3-1). In general, the dynamics are complicated and show no evidence of a smooth temporal pattern. Nonetheless, we modeled density as a linear function of time. This relatively simple model was not intended to describe (nor explain) the details of the temporal pattern, but rather to determine whether there was any overall trend and, if so, whether it indicated a decline in slickspot peppergrass numbers. This trend was modeled using Negative Binomial regression with Year as the only covariate and assuming autoregressive order 1 correlation structure. As noted in Methods above, the Negative Binomial model is appropriate for count data, and can account for the large variances that are characteristic of such data. The fitted equation for the mean response was log(*LEPA count*) = 178.3 – 0.086(*Year*)

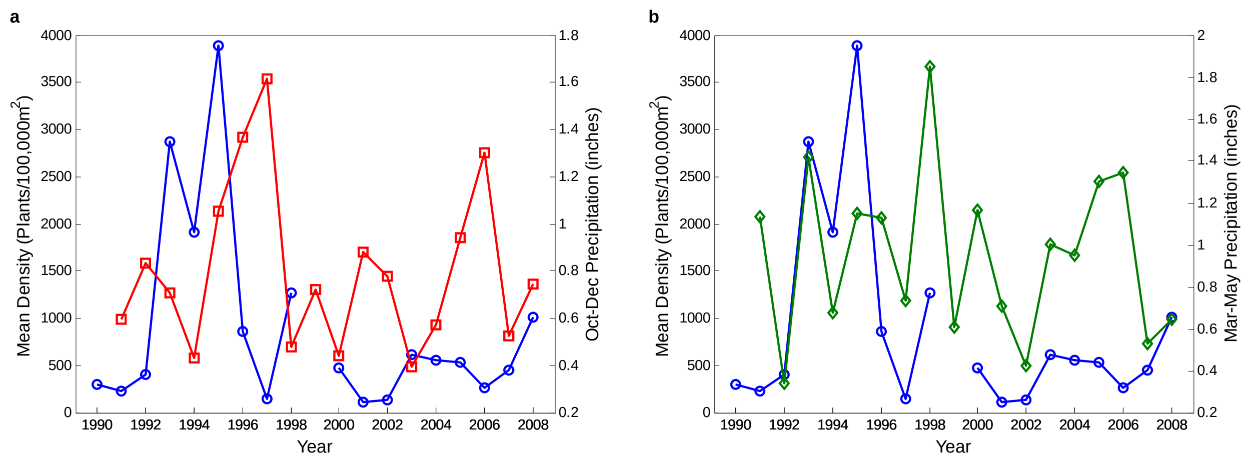
with $p = 0.0087$ (two-sided p-value) for the *Year* effect. That is, results indicated a negative trend with a slope of -0.086. Inspection of Figure 3-1a reveals that densities were unusually high in one area (the Study 4 Site). Large values in that area could drive much of the trend since they occur relatively early in the time series of available data. Excluding Study 4 Site (Figure 3-1b) from the analysis led to shallower slope (-0.059) but also lower p-value (0.0046) due to lower overall variance.



Each line represents an individual "rough census" area. Note that no data were collected in 1999 in any area. Study 4 Site represented by green line in (a); dashed segment indicates that no data were collected in this area in 2000.

Figure 3-1. Annual slickspot peppergrass density on "rough census" areas with Study 4 Site (a) included and (b) excluded.

"Rough census" area densities were also regressed against 3-month running averages of precipitation. Density was negatively associated with fall and early winter precipitation (Figure 3-2a, Table 3-1). Note that the estimated slope is negative for the October – December, November – January, and December – February periods. In contrast, slickspot peppergrass density was positively associated with mean monthly precipitation in each of the January – March, February – April, and March – May periods (Figure 3-2b). Each of these regressions was highly significant (Table 3-1). As an example, the data and the fitted regression line for March – May are shown in Figure 3-3. Note that the observed annual density from each area (represented by black dots) exhibit considerable scatter around the regression line (red line), though that line essentially represents a fit to the mean density across all areas (blue squares).



Blue line = "Rough census" area mean density
Red line = October – December precipitation

Blue line = "Rough census" area mean density
Green line = March - May precipitation

Note that density tends to be negatively associated with fall precipitation and positively associated with spring precipitation.

Figure 3-2. Mean annual slickspot peppergrass density from the "rough census" and precipitation in (a) October – December and (b) Mar – May.

Table 3-1. Results for "rough census" areas: univariate negative binomial regression models for relationship between slickspot peppergrass density and precipitation.

Period	Slope Estimate	SE	*Z*-statistic	*p*-value
Oct – Dec	-0.9455	0.1177	-8.03	<0.0001
Nov – Jan	-0.7464	0.1172	-6.37	<0.0001
Dec – Feb	-0.7462	0.1384	-5.39	<0.0001
Jan – Mar	1.0509	0.1204	8.73	<0.0001
Feb – Apr	1.3229	0.1522	8.69	<0.0001
Mar – May	1.2542	0.0991	12.66	<0.0001

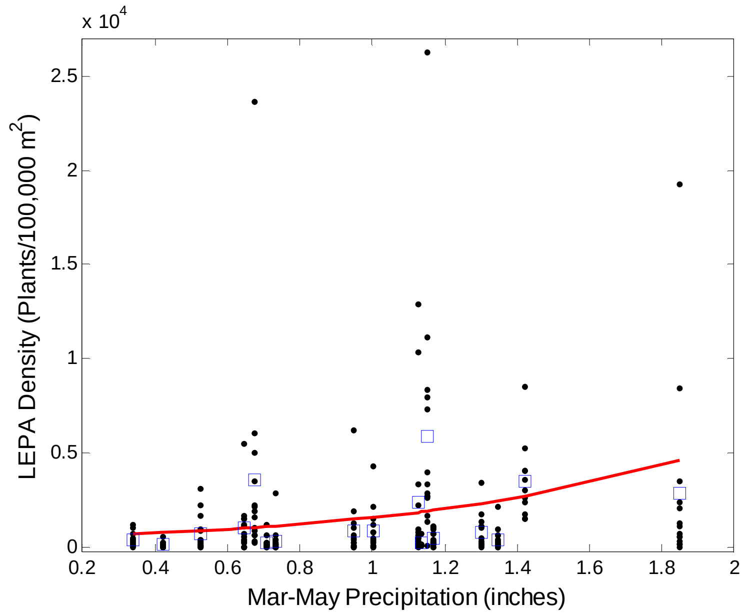
Data analyzed starting in 1991 through 2008 since weather data were not available for late 1989 and early 1990.

Special Use Plots

Slickspot peppergrass abundances in the special use plots displayed an alternating pattern such that a year of high abundance was typically followed by a year of low abundance and subsequently another year of high abundance (Figure 3-3). Generally, abundances were greatest in the early- to mid-1990's, as in the "rough census" data. The fitted equation for the negative binomial regression was

$$\log(LEPA\ count) = 71.55 - 0.0332(Year)$$

While the coefficient for the *Year* effect (*i.e.*, slope) was negative, it was not significant (p = 0.2857). Thus, there was insufficient evidence to conclude that slickspot peppergrass abundance declined in the special use plots in the period from 1991 – 2008.



Black dots = Density for each area, Blue squares = Mean density across all areas,
Red line = Predicted density based on the negative binomial

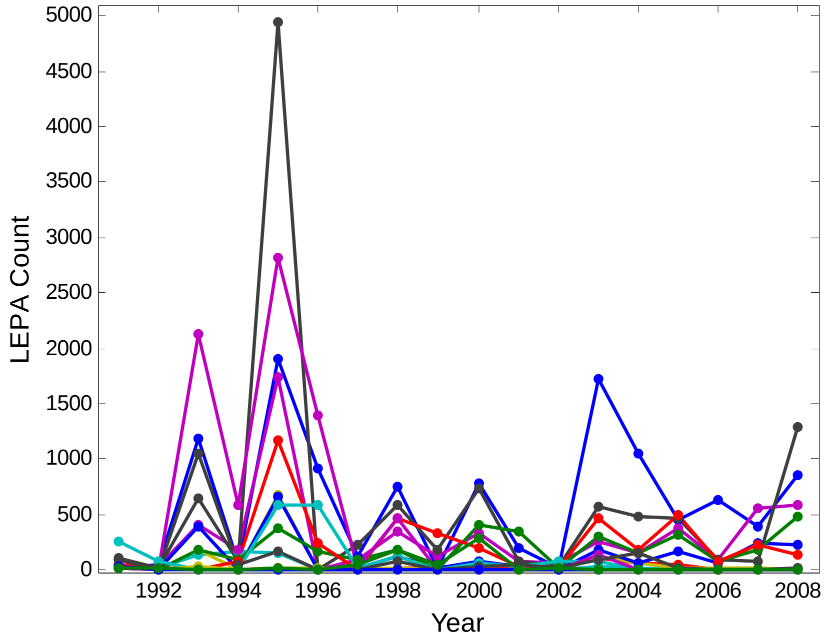
Figure 3-3. Slickspot peppergrass density on "rough census" areas versus mean monthly precipitation for March – May.

The relationship between abundance and precipitation generally was similar to that seen in the "rough census" areas. In particular, abundance was positively associated with mean precipitation in January – March, February – April, and March – May (Table 3-2). Furthermore, the relationship for each of these periods was highly significant. Typical results are shown in Figure 3-5, which depicts abundance as a function of mean monthly precipitation for the January – March period. There was no evidence of negative relationships with the previous fall and early winter; estimated slope coefficients were positive and non-significant (Table 3-2).

Table 3-2. Results for special use plots: univariate negative binomial regression models for relationship between slickspot peppergrass abundance and precipitation.

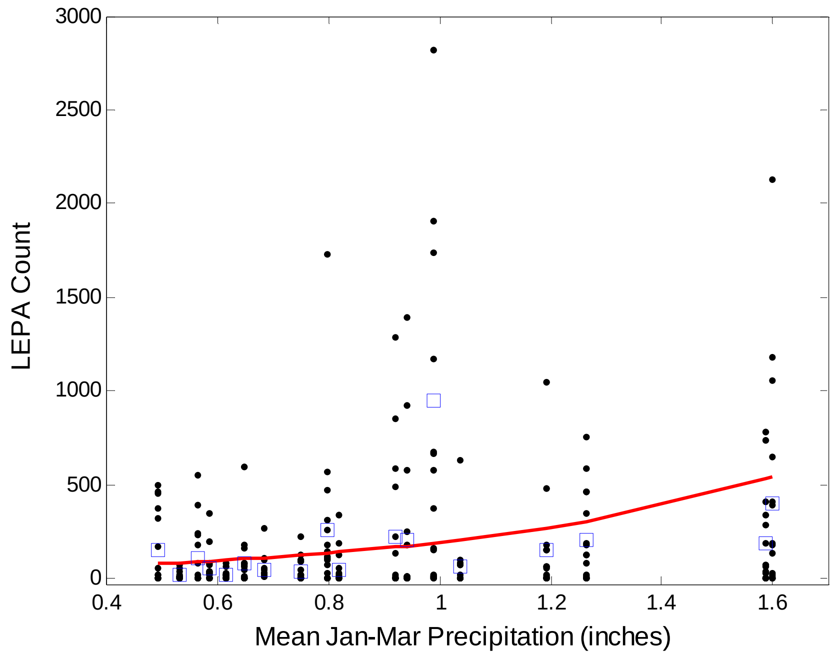
Period	Slope Estimate	SE	*Z*-statistic	*p*-value
Oct – Dec	0.0763	0.4392	0.17	0.8620
Nov – Jan	0.3135	0.3467	0.90	0.3658
Dec – Feb	0.0798	0.4008	0.20	0.8421
Jan – Mar	1.7387	0.3826	4.54	<0.0001
Feb – Apr	2.0608	0.4440	4.64	<0.0001
Mar – May	2.0698	0.2949	7.02	<0.0001

Data analyzed for 1991 through 2008



Each line represents an individual plot.

Figure 3-4. Annual slickspot peppergrass abundance in special use plots.



Black dots = Abundance for each special use plot, Blue squares = Mean abundance across all special use plots, Red line = Predicted abundance based on the negative binomial

Note that the Y-axis has been scaled for greater clarity, but one observation corresponding to approximately 0.98 inches precipitation and a count of 5000 is not shown.

Figure 3-5. Slickspot peppergrass abundance in special use plots versus mean monthly precipitation for March – May.

Reproductive Status

Abundance of non-blooming plants had a negative linear association with precipitation in both the October – December and November – January periods for the 9 years 2000-2008 though only the former was significant at the 5% level (Table 3-3). Abundance was positively related to mean monthly precipitation in the other 3-month periods examined. None of these relationships was significant, though the regressions for the January – March and February – April periods were nearly so ($p = 0.0621$ and $p = 0.0605$, respectively).

Table 3-3. Results for special use plots, non-blooming plants only: univariate negative binomial regression models for relationship between slickspot peppergrass abundance and precipitation.

Period	Slope Estimate	SE	*Z*-statistic	*p*-value
Oct – Dec	-1.2376	0.5175	-2.39	0.0168
Nov – Jan	-0.4659	0.4001	-1.16	0.2443
Dec – Feb	0.2960	0.3246	0.91	0.3618
Jan – Mar	0.7138	0.3826	1.87	0.0621
Feb – Apr	0.9047	0.4819	1.88	0.0605
Mar – May	0.9034	0.5166	1.75	0.0804

Data analyzed for 2000 through 2008

In the first analysis for blooming plants, there were no cases in which abundance was significantly related to precipitation in both the current and previous years simultaneously (Table 3-4). Indeed, only the March – May regression model had a term significant at the 5 % level. The March – May slope estimate (for precipitation in the previous year) was negative, an outcome counter to other results for spring precipitation, though consistent with the alternating pattern in abundances (Figure 3-4).

Table 3-4. Results for special use plots, blooming plants only: negative binomial regression models for relationship between slickspot peppergrass abundance and precipitation in both the current year and the previous year.

Period	Parameter	Slope Estimate	SE	*Z*-statistic	*p*-value
Oct – Dec	Current	-1.4747	0.7899	-1.87	0.0619
	Previous	-0.1924	0.7267	-0.26	0.7912
Nov – Jan	Current	-0.7664	0.7411	-1.03	0.3011
	Previous	0.0040	0.7377	0.01	0.9957
Dec – Feb	Current	-1.0167	0.6557	-1.55	0.1210
	Previous	-0.7692	0.6341	-1.21	0.2251
Jan – Mar	Current	-0.4877	1.0414	-0.47	0.6396
	Previous	-0.8123	0.6991	-1.16	0.2453
Feb – Apr	Current	2.3454	1.2165	1.93	0.0539
	Previous	-0.4359	0.6495	-0.67	0.5021
Mar – May	Current	0.4306	0.5806	0.74	0.4583
	Previous	-1.1648	0.5517	-2.11	0.0347

The second analysis showed that abundance of blooming plants was associated with both precipitation and numbers of non-blooming plants. For the models including the October –

December and November – January periods, both terms were highly significant (Table 3-5). Abundance of blooming plants was negatively associated with precipitation in these periods and positively associated with the numbers of non-blooming plants in the previous year. Otherwise, none of the models examined had significant effects of both precipitation and non-blooming abundance (Table 3-5). On the other hand, the model including mean monthly precipitation for February – April did have a significant, positive precipitation effect (p = 0.0245) and nearly significant (p = 0.0582) positive effect of non-blooming abundance. In general, whether statistically significant or not, non-blooming plant abundance in the previous year was positively associated with abundance of blooming plants in the current year.

Table 3-5. Results for special use plots, blooming plants only: negative binomial regression models for relationship between slickspot peppergrass abundance and both current-year precipitation and the number of non-blooming plants in the previous year.

Period	Parameter	Slope Estimate	SE	*Z*-statistic	*p*-value
Oct – Dec	Precipitation	-4.7760	0.7865	-6.07	<0.0001
	Non-bloom	0.0118	0.0015	7.97	<0.0001
Nov – Jan	Precipitation	-2.7319	0.7726	-3.54	0.0004
	Non-bloom	0.0088	0.0019	4.64	<0.0001
Dec – Feb	Precipitation	-1.0225	0.6728	-1.52	0.1285
	Non-bloom	0.0045	0.0020	2.28	0.0226
Jan – Mar	Precipitation	0.9752	1.1958	0.82	0.4147
	Non-bloom	0.0038	0.0020	1.90	0.0581
Feb – Apr	Precipitation	3.4359	1.5281	2.25	0.0245
	Non-bloom	0.0037	0.0019	1.89	0.0582
Mar – May	Precipitation	0.5041	0.8608	0.59	0.5581
	Non-bloom	0.0036	0.0020	1.82	0.0682

Summary

We analyzed slickspot peppergrass data from 2 long-term surveys conducted between 1990 and 2008 on the OTA. We used a repeated measures implementation of the general Negative Binomial regression model to examine trend in slickspot peppergrass numbers (density or total abundance) as well as the relationship between numbers and precipitation. For both surveys, we found limited evidence for declining populations based on models assuming a simple linear trend. In particular, trends were negative but only statistically significant for the rough census survey. Both surveys provided evidence that slickspot peppergrass numbers were positively related to mean monthly precipitation in winter and spring (3-month running averages of monthly precipitation from January through March). Evidence from the "rough census" survey (though not the special use plots) indicated a negative relationship between abundance and mean monthly precipitation in the fall (October – December). Finally, based on a shorter time series (2000 – 2008) of data from the special use plots, abundance of blooming plants depended on both precipitation in the current year and abundance of non-blooming plants in the previous year.

Caveats

As described in Methods, Generalized Estimating Equations (GEE's) were used to account for potential correlation arising from the repeated measures study design. A shortcoming of the

GEE approach is that alternative models (e.g., other correlation structures) cannot be compared via likelihood-based methods. That is, there are no objective criteria for assessing whether the chosen model is the best-fitting. Thus, interpretation hinges on the appropriateness of the model, including both the model component for the mean response (based on the covariates) and the model component for the correlation structure (whether auto-regressive, compound symmetric, or other). Furthermore, GEE-based models cannot handle certain complicated correlation structures. For instance, in this study, spatial correlation could arise due to the physical proximity among areas or plots. Other more general methods, particularly generalized linear mixed models, can address both temporal and spatial correlation, but GEE is not suited for such problems. On the other hand, GEE-based models are relatively easy to fit and are more likely to converge on a solution than are mixed models. For the latter reasons, our analysis focused on GEE-based models.

Literature Cited

Diggle, P.J., K.Y. Liang, and S.L Zeger. 1994. *Analysis of Longitudinal Data*. Clarendon Press, Oxford.

Menke, C.A. and T.N. Kaye. 2006. *Lepidium papilliferum* (slickspot peppergrass): evaluation of trends (1998-2004) and analysis of 2004 Habitat Integrity and Population Monitoring data. Institute for Applied Ecolog Ecology, Corvallis, OR.

Chapter 4: Relationship Between Slickspot Peppergrass Abundance and Weather on the Orchard Training Area

In this chapter, we expand one of the analyses were performed in Chapter 3. In Chapter 3, we looked at how precipitation by itself influenced the abundance of slickspot peppergrass. In this chapter, we include temperature to determine whether the combination of precipitation and temperature are important, or if temperature or precipitation is more important at influencing the abundance of slickspot peppergrass.

These analyses are restricted to two of the monitoring programs conducted on the Orchard Training Area (OTA), namely the 'rough census" area and special use plot monitoring programs. These programs are described in detail in Chapter 2.

Methods

Weather data for the period of interest (1990 – 2008) were obtained from the National Climatic Data Center for the Boise Air Terminal station. The OTA does not record temperature at their weather station, so we needed to get temperature data from the Boise Air Terminal. For consistency within this analysis, we used both the precipitation and temperature collected at the Boise Air Terminal. Variables considered for analysis included monthly summaries of heating degree days (relative to 65º F), mean minimum temperature (ºF), mean maximum temperature (ºF), mean temperature (ºF), and total precipitation (inches). Following the approach used in our previous analysis, we calculated 3-month running averages of the weather data for the period determined to be most relevant to the life history of slickspot peppergrass, i.e., for the period running from the fall through the spring prior to the annual survey. Averages were calculated for each of the periods October – December, November – January… March – May. Pairwise correlations were calculated among the variables for each of the 3-month periods. Because correlations among all the temperature-related variables (including heating degree days) were very high ($|r| > 0.95$ in most cases), only the running averages of mean temperature were retained for further analysis. Mean temperature had relatively low correlation with total precipitation ($|r| < 0.45$ in all cases) such that presence of both in the same model was judged unlikely to contribute to estimation problems. Thus, the candidate explanatory variables were mean temperature and total precipitation, each represented by six separate 3-month averages.

Slickspot peppergrass abundance data were available from two monitoring programs on the OTA. The "rough census" was conducted annually from 1990 through 2008, except in 1999, within 15 delineated areas. The survey of "special use" plots was similarly conducted every year from 1991 through 2008 within 16 plots. In these analyses, the 15 "rough census" areas and the 16 special use plots were treated as the sample units.

Abundance was treated as the response variable in negative binomial regression models. As in Chapter 3, potential temporal correlations (due to repeated measures on the same areas or plots) were modeled using the Generalized Estimating Equation (GEE) method; a first-order autoregressive correlation structure was assumed. A simple backwards stepwise model selection procedure was applied to each 3-month period. First, we examined a model with both the main effects of temperature and precipitation as well as the interaction between them. If the interaction term was significant at $\alpha = 0.05$, the interaction model was accepted as the best model. However, if the interaction term was not significant, it was removed and the model with additive main effects was examined. That model was accepted if both terms were significant, but if either or both terms were not significant, the least significant term was dropped and the model remaining with one main effect (either temperature or precipitation) was examined. Finally, either that model with a single term was accepted, or if the effect was not significant, then no model was deemed acceptable.

Results

Of the models examined, the best-fitting models for the October – December and November – January periods include the interaction between temperature and precipitation. This is true for both the "rough census" area (Table 4-1) and the special use plot surveys (Table 4-2). Estimated coefficients (Tables 4-1 and 4-2) and model predictions (Figures 4-1 and 4-5) show the same pattern in all cases. In particular, at lower temperatures during October through January, predicted abundance increases with increases in precipitation during October through January, while at higher temperatures, predicted abundance decreases with increases in precipitation.

In corresponding fashion, the best-fitting models for the December – February and January – March periods are similar for the rough census (Table 4-1) and the special use survey (Table 4-2). These models include only precipitation and the estimated coefficient is consistently positive. Thus, slickspot peppergrass abundance is predicted to increase during the ensuing growing season with increases in precipitation (Figures 4-2 and 4-6) during these two 3-month periods.

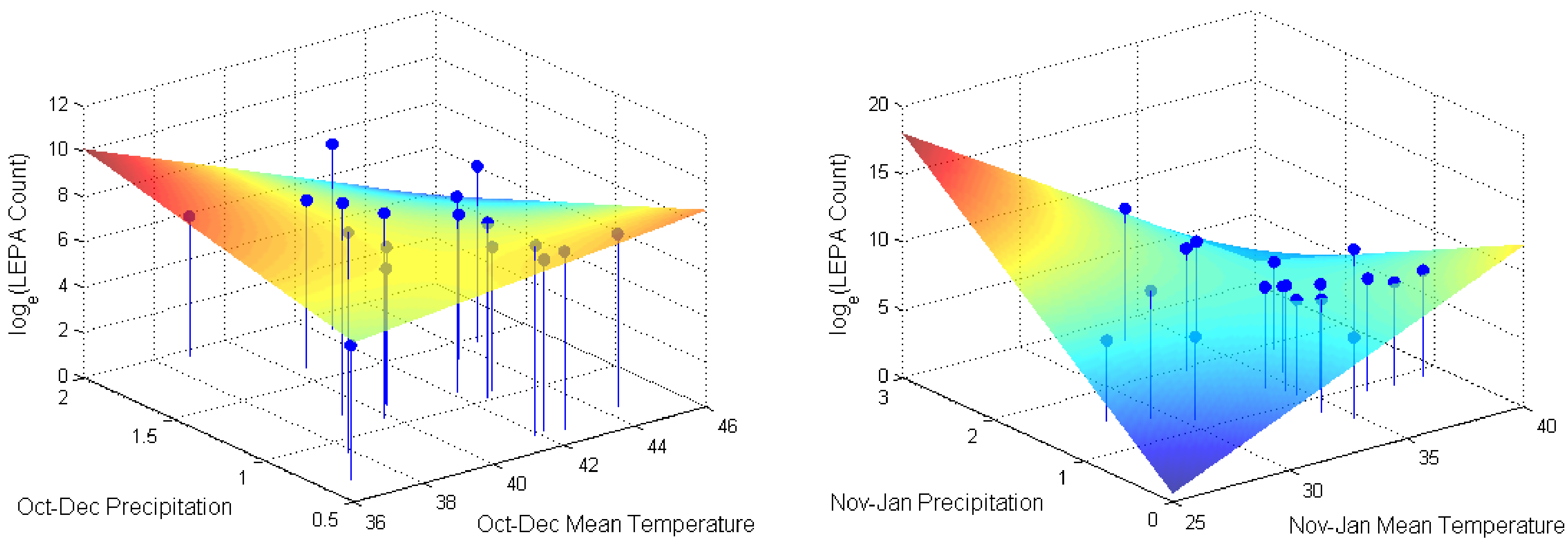
For the remaining 2 periods, February – April and March – May, results were different for "rough census" areas and special use plots. The best model for the "rough census" areas during the February – April period contains only temperature, with a negative coefficient (Table 4-1) and, thus, decreases in predicted abundance are expected with increases in temperature (Figure 4-3). For the "rough census" areas in the March – May period, the best model includes temperature and precipitation, but no interaction. Temperature has a negative coefficient while precipitation has a positive coefficient (Table 4-1) such that changes in precipitation have parallel effects on predicted abundance at all temperatures (Figure 4-4). Slickspot peppergrass abundance tends to be greater when precipitation is greater but temperatures during March through May are lower. In contrast, the best models for the special use plots in both February – April and March – May include only precipitation, which is predicted to have a positive effect on abundance (Table 4-2, Figure 4-7) as in the earlier periods (Figure 4-6).

In summary, interactions between temperature and precipitation appear to be important in the fall and early winter. Results indicate that later in the winter and in the spring, precipitation has a dominant, and positive, effect on abundance particularly for the special use plots, while temperature has a negative effect especially for the rough census in the spring.

Table 4-1. Negative binomial regression results for final models of slickspot peppergrass abundance from the rough census. Weather variables (monthly mean temperature and monthly total precipitation) were averaged over 3-month periods.

Parameter	Estimate	Std Error	*Z*	*p*-value
October – December				
Intercept	-9.3396	4.5514	-2.05	0.0402
Mean Temperature	0.4264	0.1095	3.89	<0.0001
Precipitation	20.9813	3.8313	5.48	<0.0001
Mean Temperature × Precipitation	-0.5266	0.0924	-5.70	<0.0001
November – January				
Intercept	-18.1951	3.2788	-5.55	<0.0001
Mean Temperature	0.7524	0.0944	7.97	<0.0001
Precipitation	21.1725	2.8172	7.52	<0.0001
Mean Temperature × Precipitation	-0.6157	0.0805	-7.65	<0.0001
December – February				
Intercept	6.7836	0.3115	21.78	<0.0001
Precipitation	0.6342	0.2194	2.89	0.0038
January – March				
Intercept	6.4902	0.2968	21.87	<0.0001
Precipitation	0.8963	0.2084	4.30	<0.0001
February – April				
Intercept	11.5812	1.8590	6.23	<0.0001
Mean Temperature	-0.0918	0.0421	-2.18	0.0290
March – May				
Intercept	12.0188	2.6676	4.51	<0.0001
Mean Temperature	-0.0974	0.0490	-1.99	0.0468
Precipitation	0.3917	0.1784	2.20	0.0281

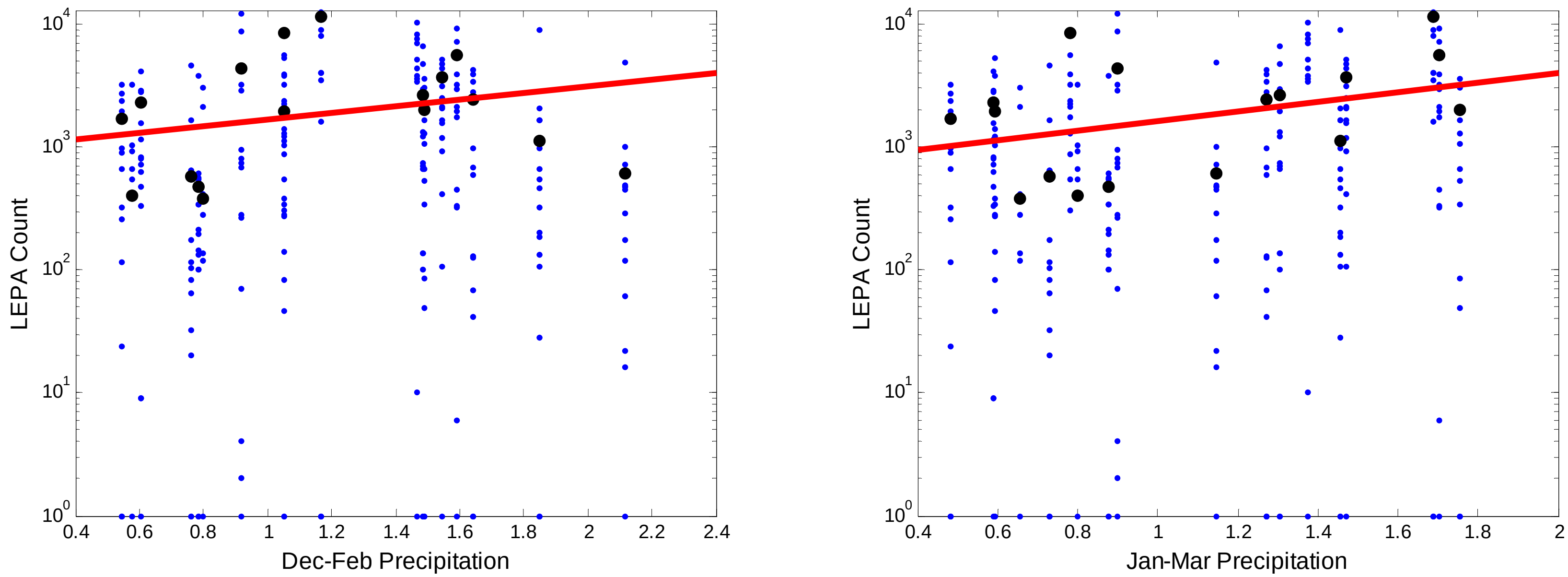
The initial model for each period included the interaction between temperature and precipitation.
Z is the standard normal statistic.



Filled circles represent mean abundance for each combination of temperature and precipitation. The colored surface shows predicted abundance based on negative binomial regression models with interaction terms significant at $\alpha = 0.05$ (Table 4-1). In both cases, predicted abundance increases with precipitation at lower temperatures, and decreases with precipitation at higher temperatures.

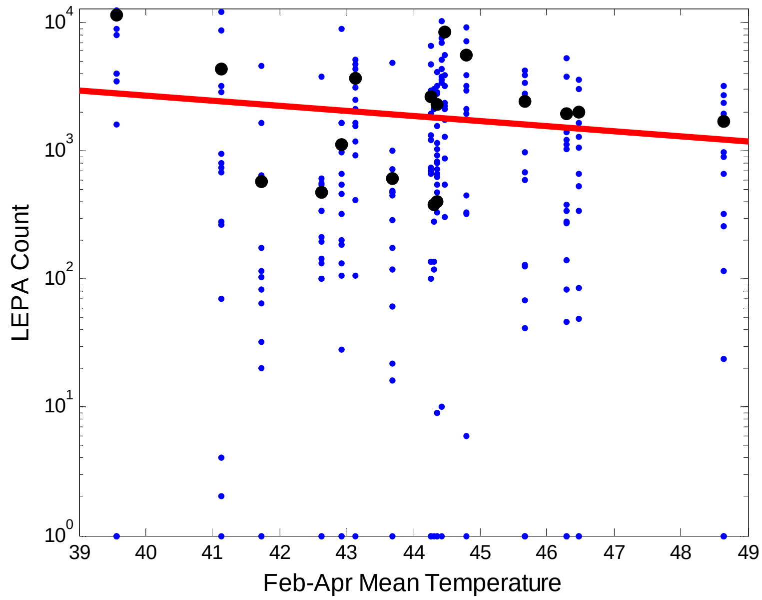
Figure 4-1. Slickspot peppergrass abundance from the rough census as a function of mean monthly temperature and total monthly precipitation, both averaged over 3-month periods.

Colors are used to represent predicted values (i.e., predicted slickspot peppergrass abundance). Red indicates highest abundance, yellow is somewhat lower, cyan/turquoise is lower yet, and blue is lowest. The colors indicate relative rather than absolute abundance, so that each figure shows gradations from red to blue, but red (or blue or whatever) does not indicate the same level of predicted abundance on all plots. Colors are redundant with the relative height (on the Z-axis) of the surface, intended to be a visual aid since it's sometimes difficult to determine height in a 2-d, black-and-white representation of a surface. Although these 3-dimensional representations appear to be triangular, they are more properly considered saddle-shapes that fall away on the far side away from the viewer. That is, predicted abundance is relatively low at the combination of high temperatures and high precipitation.



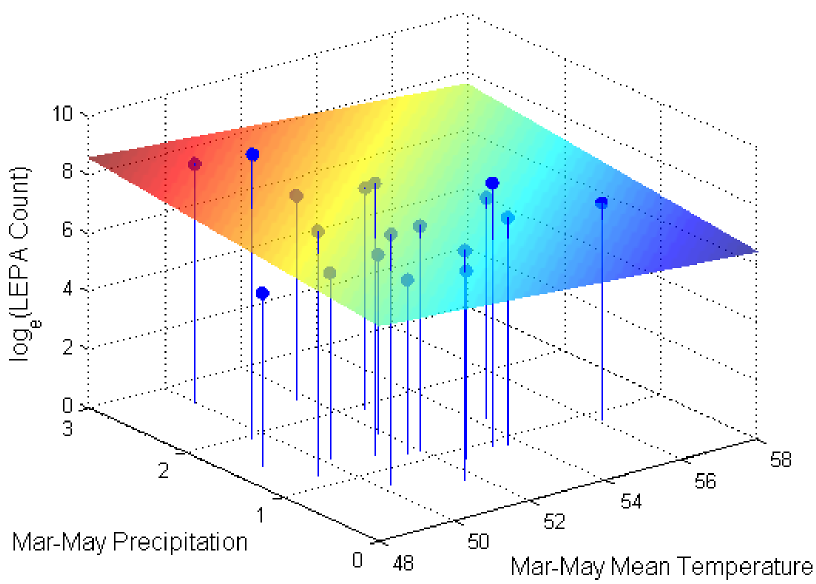
Blue dots represent observations, and filled circles represent mean abundance for each observed precipitation value. The red line shows predicted abundance based on negative binomial regression models with precipitation terms significant at $\alpha = 0.05$ (Table 4-1). In both cases, predicted abundance increases with increasing precipitation.

Figure 4-2. Slickspot peppergrass abundance from the rough census as a function of total monthly precipitation, averaged over 3-month periods.



Blue dots represent observations, and filled circles represent mean abundance for each observed temperature value. The red line shows predicted abundance based on negative binomial regression models with temperature term significant at α = 0.05 (Table 4-1). Predicted abundance decreases with increasing temperature.

Figure 4-3. Slickspot peppergrass abundance from the rough census as a function of mean monthly temperature, averaged over a 3-month period.



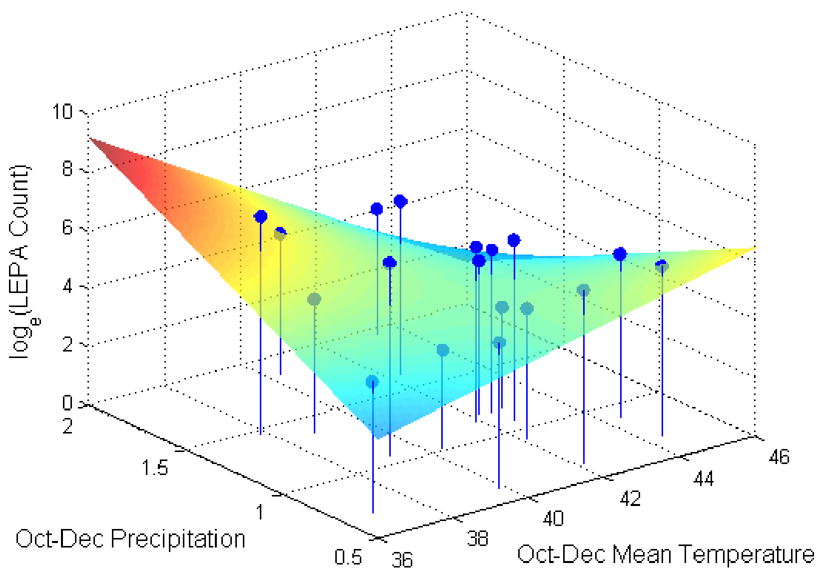
Filled circles represent mean abundance for each combination of temperature and precipitation. The colored surface shows predicted abundance based on an additive negative binomial regression model with both terms significant at α = 0.05 (Table 4-1). Predicted abundance increases with increasing precipitation and decreases with increasing temperature.

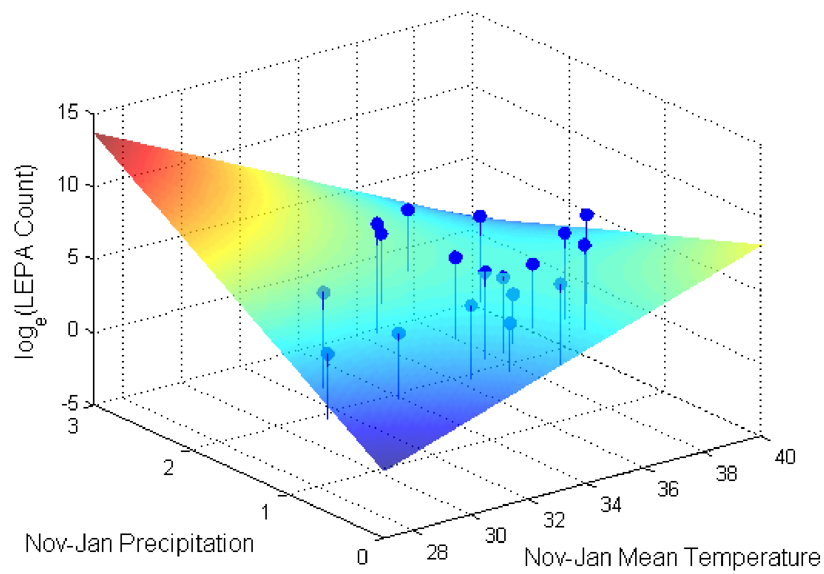
Figure 4-4. Slickspot peppergrass abundance from the rough census as a function of mean monthly temperature and total monthly precipitation, both averaged over 3-month periods.

Table 4-2. Negative binomial regression results for final models of slickspot peppergrass abundance from the survey of special use plots. Weather variables (monthly mean temperature and monthly total precipitation) were averaged over 3-month periods.

Parameter	Estimate	Std Error	*Z*	*p*-value
October – December				
Intercept	-22.6310	6.3371	-3.57	0.0004
Mean Temperature	0.6687	0.1529	4.37	<0.0001
Precipitation	29.9242	5.5121	5.43	<0.0001
Mean Temperature × Precipitation	-0.7240	0.1331	-5.44	<0.0001
November – January				
Intercept	-18.1572	4.7067	-3.86	0.0001
Mean Temperature	0.6558	0.1364	4.81	<0.0001
Precipitation	19.4519	3.9762	4.89	<0.0001
Mean Temperature × Precipitation	-0.5467	0.1136	-4.81	<0.0001
December – February				
Intercept	4.0754	0.4236	9.62	<0.0001
Precipitation	0.8544	0.3145	2.72	0.0066
January – March				
Intercept	3.3583	0.3631	9.25	<0.0001
Precipitation	1.5132	0.2911	5.20	<0.0001
February – April				
Intercept	3.9849	0.4705	8.47	<0.0001
Precipitation	1.0984	0.4187	2.62	0.0087
March – May				
Intercept	3.3443	0.3120	10.72	<0.0001
Precipitation	1.4102	0.2162	6.52	<0.0001

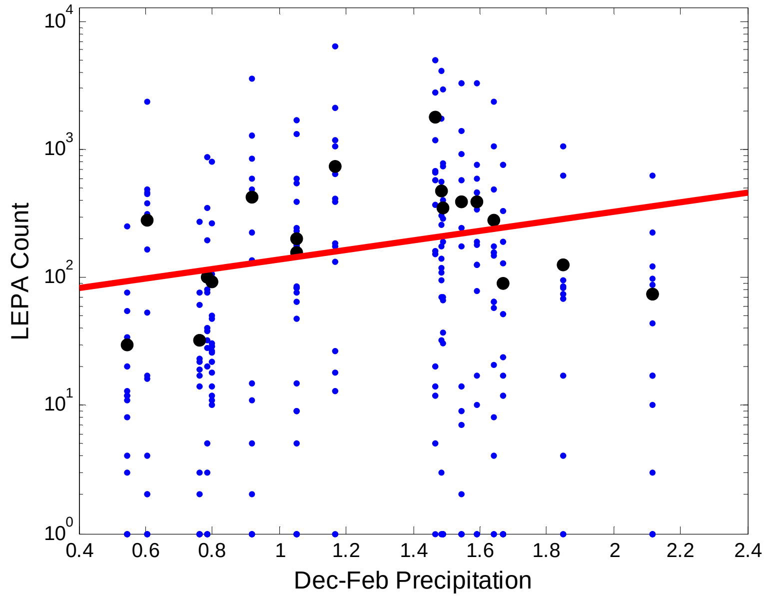
The initial model for each period included the interaction between temperature and precipitation.
Z is the standard normal statistic.

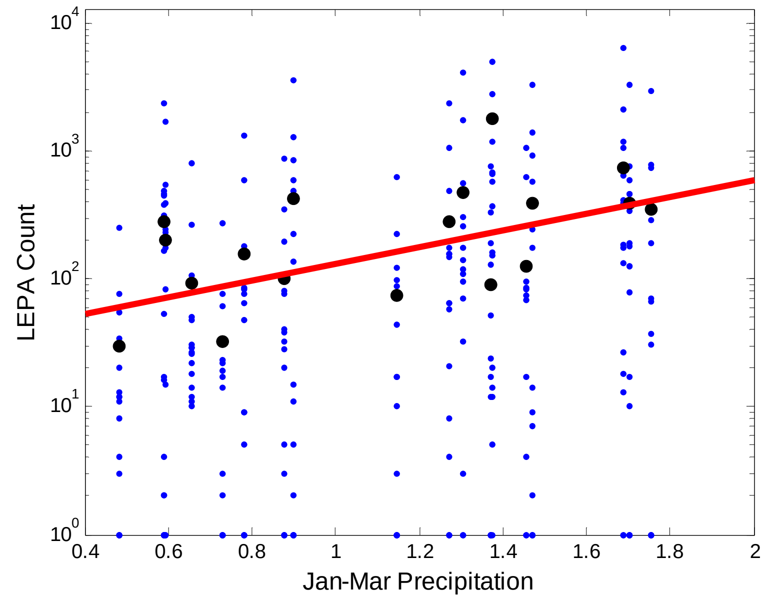




Filled circles represent mean abundance for each combination of temperature and precipitation. The colored surface shows predicted abundance based on negative binomial regression models with interaction terms significant at $\alpha = 0.05$ (Table 4-2). In both cases, predicted abundance increases with precipitation at lower temperatures, and decreases with precipitation at higher temperatures.

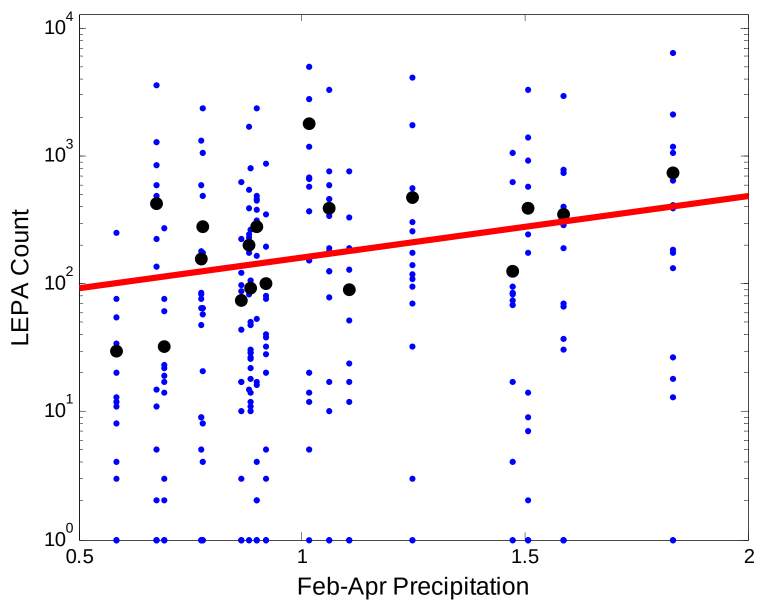
Figure 4-5. Slickspot peppergrass abundance from the survey of special use plots as a function of mean monthly temperature and total monthly precipitation, both averaged over 3-month periods.

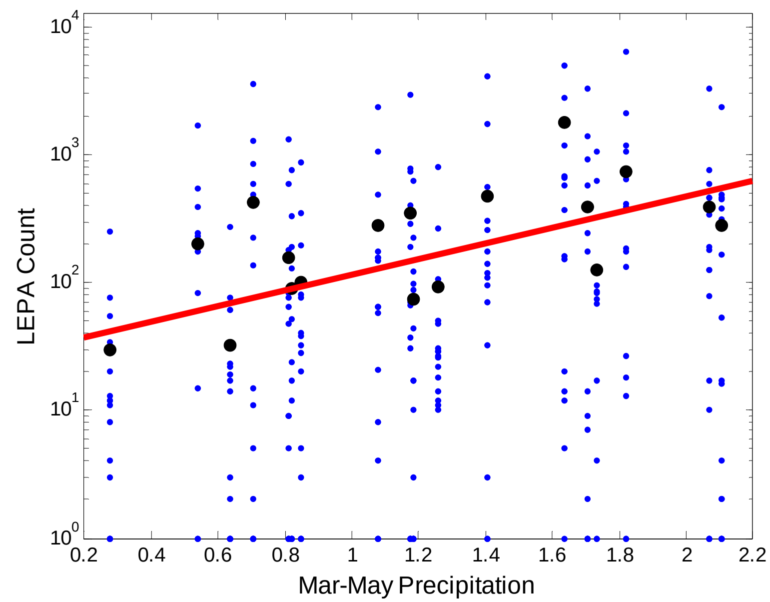




Blue dots represent observations, and filled circles represent mean abundance for each observed precipitation value. The red line shows predicted abundance based on negative binomial regression models with precipitation terms significant at $\alpha = 0.05$ (Table 4-2). In both cases, predicted abundance increases with increasing precipitation.

Figure 4-6. Slickspot peppergrass abundance from the survey of special use plots as a function of total monthly precipitation, averaged over 3-month periods.





Blue dots represent observations, and filled circles represent mean abundance for each observed precipitation value. The red line shows predicted abundance based on negative binomial regression models with precipitation terms significant at α = 0.05 (Table 4-2). In both cases, predicted abundance increases with increasing precipitation.

Figure 4-7. Slickspot peppergrass abundance from the survey of special use plots as a function of total monthly precipitation, averaged over 3-month periods.

Discussion

The analyses presented in this chapter do not indicate a simple relationship between temperature, precipitation, and slickspot peppergrass abundance. The analyses of "rough census" areas and special use plots provide similar results, but they differ somewhat. Where the results of the two monitoring programs agree, we feel confident stating the influences of precipitation and temperature are accurately portrayed in the outcomes of the analyses. Where the results differ, we place slightly greater confidence in the outcome of the "rough census" area analysis.

The special use plot monitoring program consists of counting the slickspot peppergrass on a single slickspot for each special use plot. Each special use plot falls within the borders of a "rough census" area, so although the methods differ among the two programs, the special use plots are to some degree a subset of the "rough census" areas. Also, since the special use plots consist of only a single slickspot, any local impacts could have greater influence over the counts at the one slickspot than across the larger area of the "rough census" areas.

The analyses of both monitoring programs agree that temperature and precipitation during the fall and early winter (from October through January) interact to influence the abundance of slickspot peppergrass. Predicted slickspot peppergrass abundance is greater following a fall or early winter when either precipitation or temperature is high and the other is low. The lowest predicted slickspot peppergrass abundance occurs following a fall or early winter when precipitation and temperature are low or both are high.

Temperature does not appear to be important according to the outcomes from the analysis of special use plots for the periods through the winter and spring (from December through May). However, the "rough census" area analysis indicates that only precipitation is important during the winter, but temperature and then temperature along with precipitation is important moving from winter into the spring. Whenever precipitation is important in any of the models with no interaction with temperature during the winter and into the spring, precipitation has a positive relationship with predicted slickspot peppergrass abundance. During late winter and the spring, temperature has a negative impact. These results suggest that slickspot peppergrass abundance is greater following a cool and wet late winter and spring than following a warm late winter and spring.

In an analysis of Habitat Integrity and Population (HIP) data, Unnasch (2008) thought there might be a threshold effect for precipitation, with a minimum amount of rainfall required for germination. Above that threshold, affects would be random. We do not see strong evidence of that in the OTA data, although our analysis did not directly address that question. However, only four years of HIP data were included in Unnasch's analysis. The HIP data also cover a broader geographic range extending from the Boise Foothills, through the Snake River Plain, and south to the Owyhee Plateau. Our analysis of the HIP dataset, even with the inclusion of a fifth year of data (2004 to 2008) failed to find as strong a relationship with precipitation as we see with the slickspot abundance data for 1990 to 2008 from the OTA (see Chapter 8). Menke and Kaye (2006a,b) analyzed Habitat Integrity Index (HII) data from 1998 through 2001 and HIP data from 2004 and did find that precipitation was important for predicting slickspot peppergrass abundance with a positive relationship. However, their analyses were strongly influenced the observations in 1998, without which the relationship is not significant. From this, it appears the specific time period as well as the number of years for the analysis is important.

Conclusions

Since the special use plots and “rough census” areas were subjectively located in areas where slickspot peppergrass was known to occur, any inferences to the relationship between precipitation and temperature with slickspot peppergrass abundance outside these areas should be made cautiously. The long-term nature of the data from the OTA makes these data the best available data when attempting to model trends through time. However the restricted geographic range creates limitations when attempting to extrapolate to areas away from this one section of the OTA.

The results of the analyses from this chapter indicate that both temperature and precipitation can be important to predict the abundance of slickspot peppergrass, but the nature of the importance changes from fall through winter and into spring. Predicted slickspot peppergrass abundance is greatest following a fall or early winter when temperature or precipitation is high and the other is low. High mid- to late winter and spring precipitation produces an increase in slickspot abundance, and either temperature is unimportant or is beneficial when temperatures are low.

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Menke, C.A. and T.N. Kaye. 2006b. *Lepidium papilliferum* (Slickspot peppergrass): Evaluation of Trends (1998 – 2004) and Analysis of 2004 Habitat Integrity and Population Monitoring Data. A Cooperative Project between the Bureau of Land Management, the Idaho Fish and Game Idaho Conservation Data Center and Institute for Applied Ecology. 21 pp.

Unnasch, R.S. 2008. *Lepidium papilliferum* (Slickspot peppergrass): Evaluation of Trends 2004 – 2007. Final Report prepared for Idaho Department of Fish and Game, Idaho Conservation Data Center. 17 pp.

Chapter 5: "Rough Census" and Other Monitoring Programs on the Idaho Army National Guard Orchard Training Area

As reported in Chapter 2, multiple monitoring programs exist on the Orchard Training Area (OTA). The methods used to monitor slickspot peppergrass on the OTA are described there. In this chapter, we compare the methods and assess how the methods used will impact how well the programs would be capable of detecting changes in the status of slickspot peppergrass.

Three extant slickspot peppergrass Element Occurrences (EOs) exist on the OTA (Figure 5-1). In the northern OTA, EO 27 is the largest with 2899 ha (7163 acres). The remaining two EOs in the OTA are EO 53 with 16 ha (40 acres) and EO 67 with 3.9 ha (9.6 acres). These area estimates are not precise because polygon EO features are often coarsely mapped, resulting in an EO that appears much larger and more continuously occupied by slickspot peppergrass than occurs in reality (Colket *et al.* 2006).

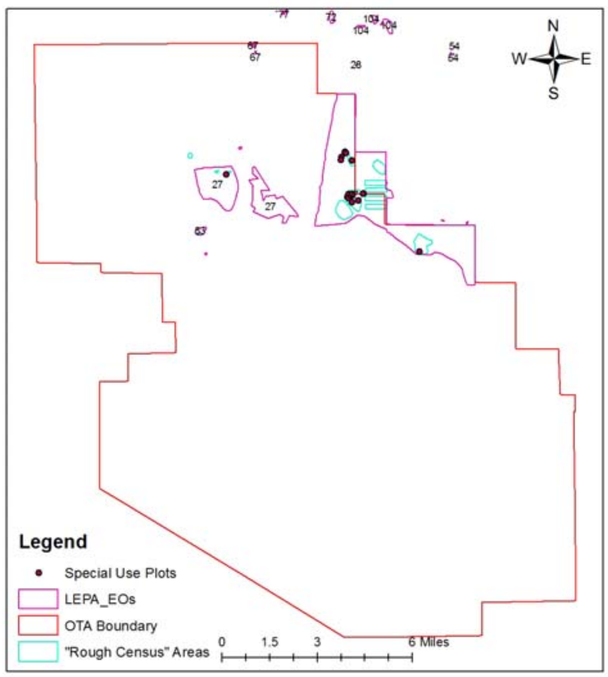

Figure 5-1. Slickspot peppergrass Element Occurrences, special use plots and "rough census" areas on the Orchard Training Area.

All monitoring for slickspot peppergrass on the OTA on permanent "rough census" areas and special use plots is restricted to the northern portion of the training area. The permanent monitoring locations reflect the known locations of slickspot peppergrass on the OTA. Almost all the monitoring has taken place in EO 27 in the northeastern portion of the OTA. EOs 53 and 67 have received much less attention in the monitoring efforts on the OTA. The majority of the OTA is outside any of the EOs and receives no annual monitoring for slickspot peppergrass, but these areas are routinely surveyed during the visits to the core LCTA plots and when areas are searched specifically for slickspot peppergrass during block searches. The “rough census” areas are mostly in EO 27, but a single “rough census” area falls within EO 53 (Figure 5-1). Special use plots are restricted to EO 27 (Figure 5-1). The vast majority of the HIP transects are in EO 27, but EOs 53 and 67 also have a few HIP transects (Figure 5-2).

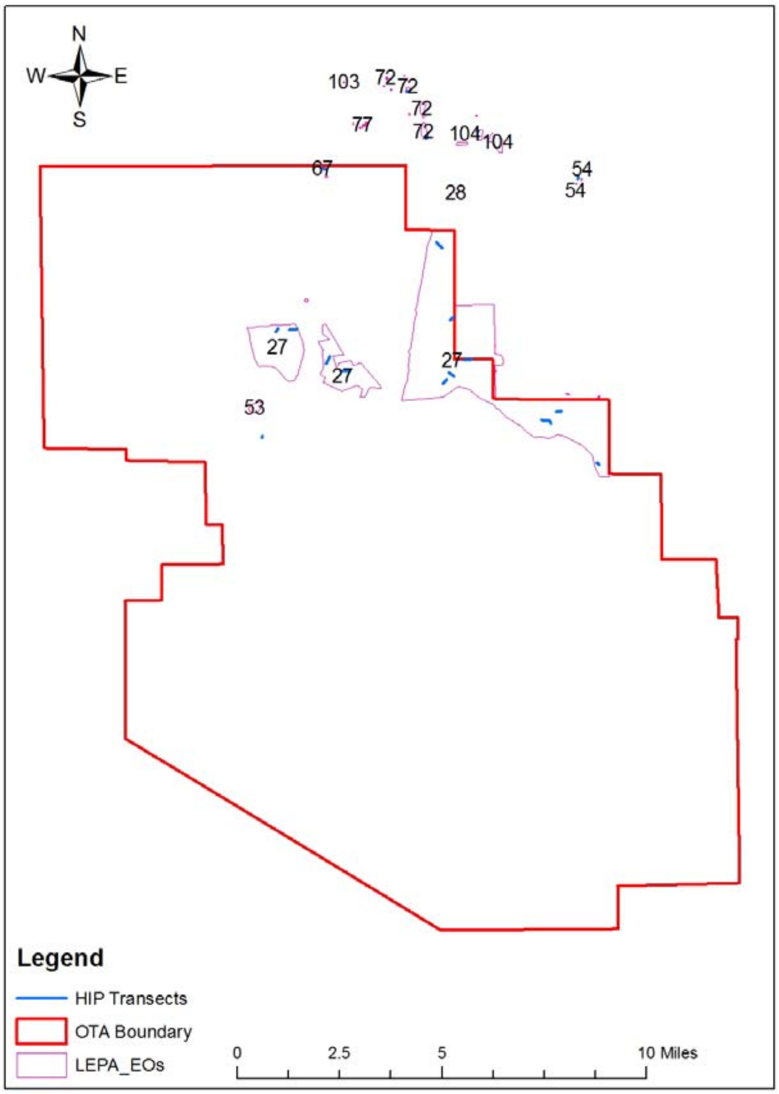

Figure 5-2. Locations of HIP Transects in relation to the Element Occurrences on the Orchard Training Area.

The total area of all the EOs known to still contain slickspot peppergrass on the OTA is 2919 ha (7213 acres). The total of all the “rough census” areas is 351 ha (867 acres). Therefore, the “rough census” program monitors 3.6% of the total land designated as EOs on the OTA. The “rough census” areas were intentionally located in areas with slickspots known to have slickspot peppergrass (D. Quinney, pers. comm.), so the “rough census” areas should not be considered representative of the entire EO where they are located. The “rough census” areas were not placed across the majority of the OTA, and no “rough census” areas have been added since the early 1990s. So, as new areas of slickspot peppergrass are identified, they are not incorporated into this long-term monitoring.

URS Corporation Monitoring in 2005 (2005a)

Additional monitoring efforts reported on the OTA include work performed by URS Corporation in 2005 (Figure 5-3) (URS 2005a). All these efforts again focused on EO 27. URS (2005a) sampled mostly in the section of EO 27 that runs along the eastern boundary of the OTA with a few slickspots (North Quarry area) monitored in the section of EO 27 in the north-central area of the OTA (Figure 5-3). The purpose of the inventory was to: 1) survey known locations of slickspot peppergrass within delineated areas of the OTA; 2) determine and record the location and number of reproductive (flowering) and non-reproductive (rosette) individuals present on populated slickspots, both historic and newly established; and 3) document historically populated slickspots that are no longer occupied by slickspot peppergrass.

The URS (2005a) program overlaps with many of the "rough census" areas (Table 5-1), but the names between the two programs do not always correspond. For example, the Emerald Wash region monitored by URS includes the "rough census" area named Orchard Corner, but the Orchard Corner region within the URS program includes the "rough census" area named Range 6.

URS 2005a Field Methods

URS used methods based on experience with the OTA staff performing similar slickspot peppergrass surveys, in combination with ongoing communication with OTA staff. The inventory was carried out from April 18 through July 8, 2005. Five separate areas (Figure 5-3) were targeted for inventory based on previous slickspot peppergrass observation and monitoring data completed by the OTA staff. URS staff visited previously identified slickspots as well as locating slickspots not previously monitored or had lost their permanent markers. The search areas existed both within and outside the "rough census" areas, and the methods represented a more intensive search of the area in an effort to locate as many slickspots and slickspot peppergrass plants as possible.

Field crews performed visual reconnaissance of the target areas to locate existing occurrences of slickspot peppergrass. The crews were trained to recognize slickspot habitat and the identification of slickspot peppergrass in its various growth forms. Field crews consisted of at least two members. One member performed navigation duties using a GPS receiver to properly direct the other crew member(s), in order to thoroughly grid the target area. Field crews searched the observation grid spaced at lateral intervals of no more than 20 m. GPS locations of slickspots containing slickspot peppergrass were recorded. Reproductive (flowering) and non-reproductive (rosette) slickspot peppergrass plants were counted and recorded separately at each populated slickspot. An aluminum ID-TAG was placed at the eastern corner of every slickspot containing slickspot peppergrass for the purpose of future reference and study (URS 2005a).

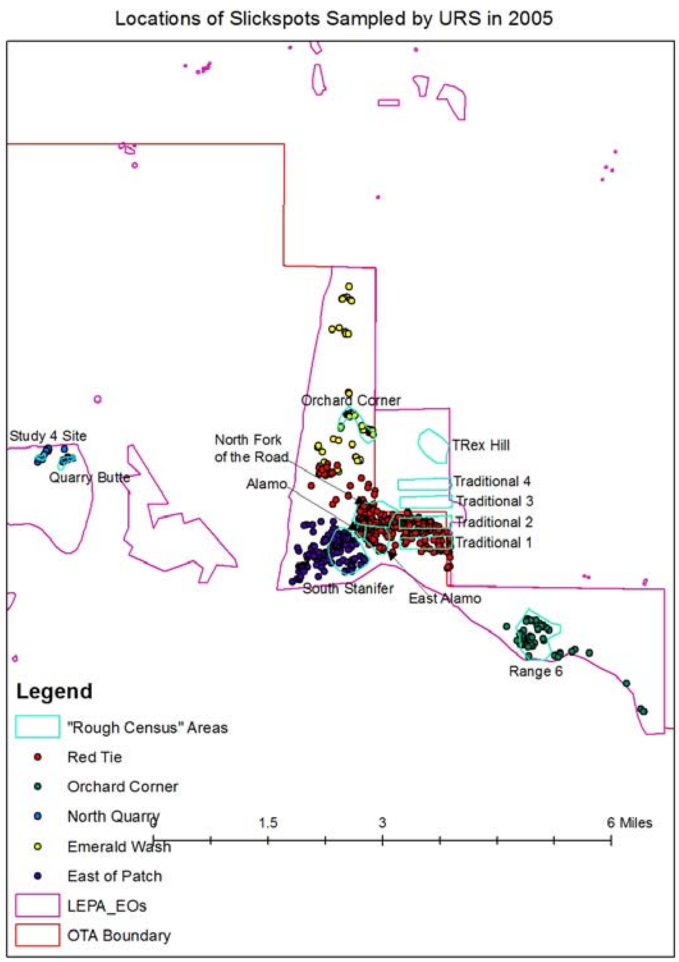

Figure 5-3. Locations of slickspots sampled during 2005 by URS Corporation (URS 2005a).

Table 5-1. The "rough census" areas and the corresponding slickspot regions sampled by URS Corporation (URS 2005a).

URS Slickspot Region	"Rough Census" Areas
East of Patch	South Stanifer
Emerald Wash	Orchard Corner
North Quarry	Quarry Butte Study Site 4
Orchard Corner	Range 6
Red Tie	Alamo East Alamo North Fork of the Road Traditional 1 Traditional 2
No corresponding URS region	BoxCar Rye Christmas Mountain TRex Hill Traditional 3 Traditional 4

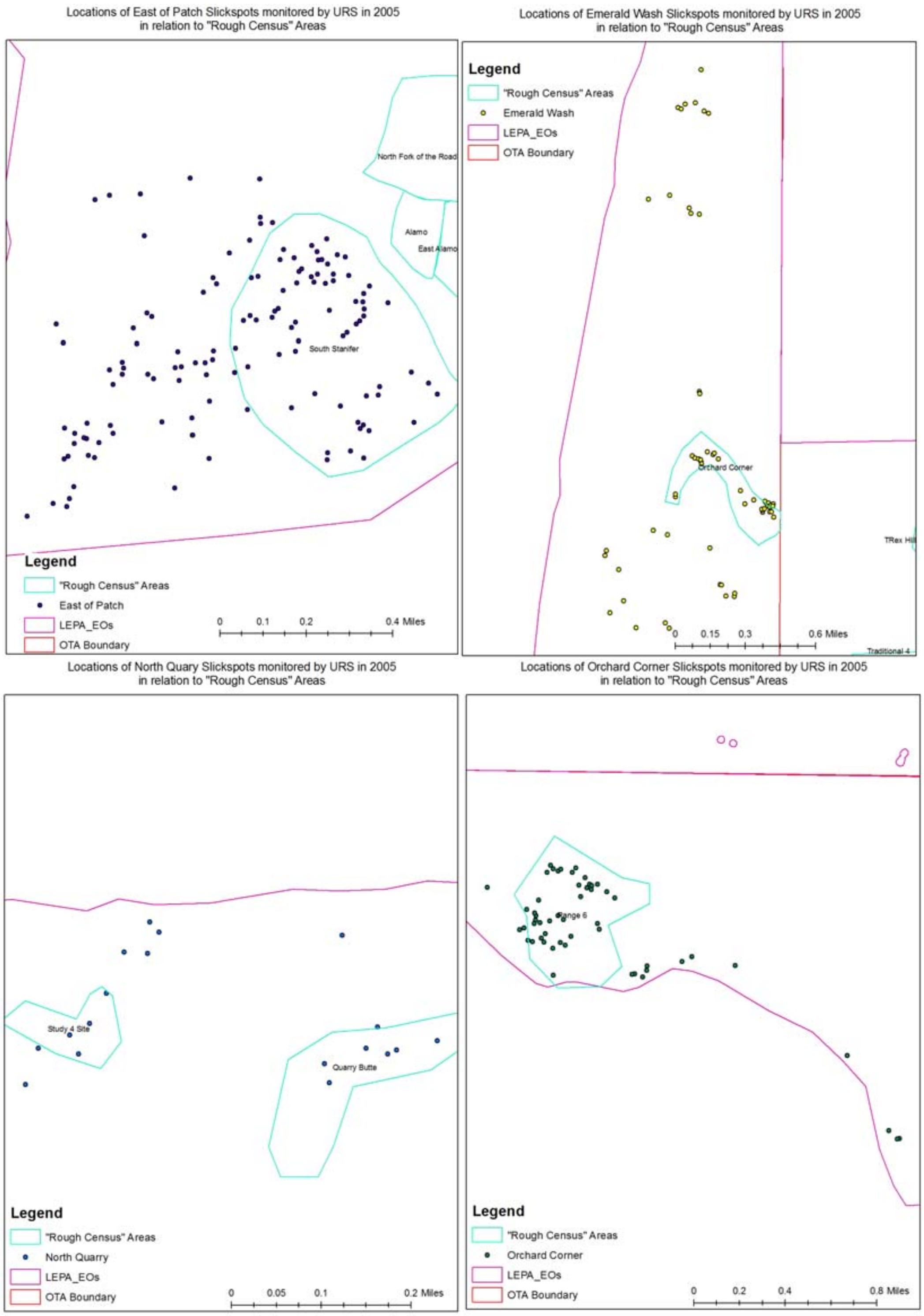

Figure 5-4. Locations of slickspots sampled during 2005 by URS Corporation showing the overlap between slickspots and "rough census" areas (URS 2005a).

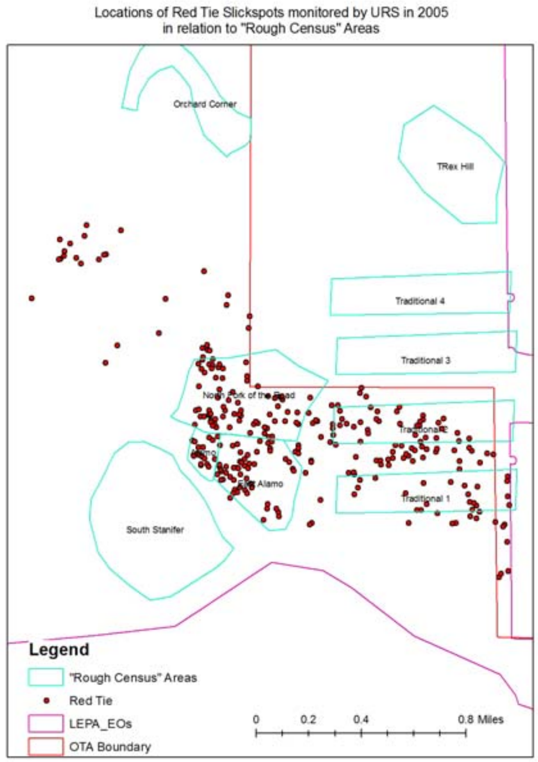

Figure 5-4. Continued

URS 2005a Findings

URS field crews identified 556 slickspots, roughly two-thirds (365) of which were new. However, the authors suggest some of the slickspots identified as new in 2005 might have been historic slickspots where the markers were missing or had not been marked previously. More than one-third of the historic sites had no slickspot peppergrass present.

URS field crews searched a larger area and used more intensive search methods (URS 2005a). The total number of slickspot peppergrass counted by URS was 43,925, whereas the total number of plants counted in 2005 in the "rough census" areas was only 18,599, and the total in the special use plots was 2360. The greater number of slickspot peppergrass counted by URS during this study is likely related to searching a larger areas more intensively, and identified many new slickspots. An estimate of the minimum area searched by URS determined by calculating the minimum convex polygon based on the locations of the slickspots is 882 ha (2179 acres) as compared to 351 ha (867 acres) of all the "rough census" areas combined. URS simply searched a larger area and searched more slickspots than searched annually.

Another aspect of the URS (2005a) program that makes it not comparable with the "rough census" program is even when "rough census" areas are included within the URS program, slickspots outside the "rough census" areas were also monitored (Figure 5-4). All of the regions monitored by URS (2005a) included many slickspots that were outside the boundaries of any “rough census” area. Therefore, abundance estimates from URS (2005a) would likely be greater than those from “rough census” areas.

URS Corporation Monitoring in 2005 (2005b)

The second URS program (URS 2005b) focused on the Crypt Basin which encompasses the middle section of EO 27. The second URS (2005b) monitoring program focused solely on the Crypt Basin (Figure 5-5). Most of the central section of EO 27 is included in the area monitored as part of URS’s monitoring of Crypt Basin. The digitized locations of the slickspots monitored in the Crypt Basin were not available for mapping. No special use plots or “rough census” areas occur within the Crypt Basin. However, two HIP transects occur in the Crypt Basin (Figure 5-6).

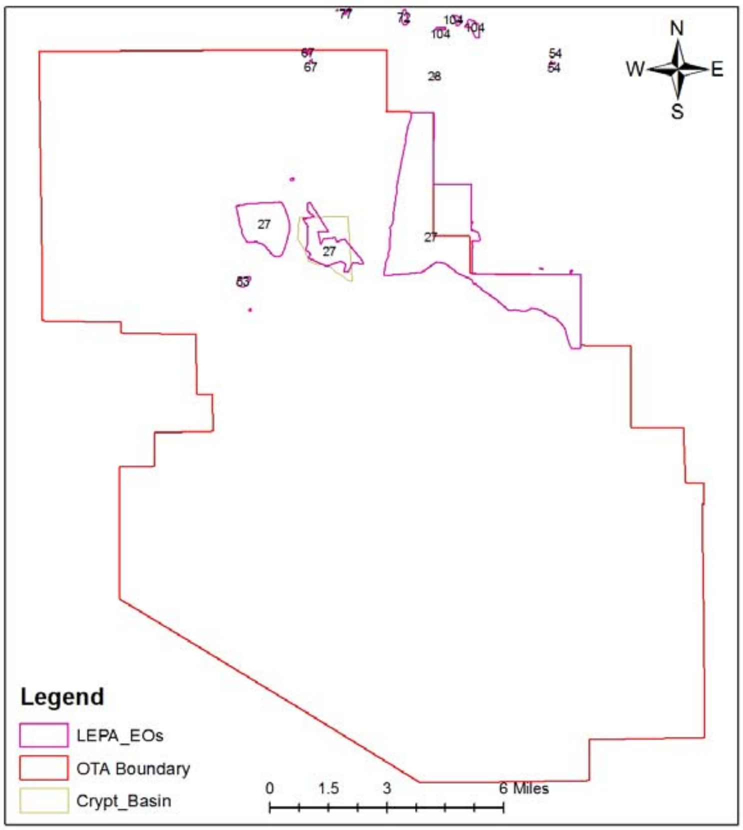

Figure 5-5. Location of the Crypt Basin monitoring area sampled during 2005 by URS Corporation (URS 2005b).

URS 2005b Methods

The methods used were the same as were used during the monitoring performed earlier in the spring/summer (URS 2005a). The surveys conducted in the Crypt Basin occurred from September 19 through October 14, 2005.

URS 2005b Findings

The number of slickspot peppergrass plants counted during this monitoring effort was much lower than reported for the areas monitored earlier in the year. The authors suggest the difference might be due, at least partially, to the time of year since the surveys were conducted in September and October. Slickspot peppergrass bloom in the late spring/early summer, and those plants that flower often do not survive to the fall.

It is possible that there has been a reduction in the number of slickspot peppergrass in the Crypt Basin because only about one-third of the historic slickspots known to previously have slickspot peppergrass had any plants during this monitoring effort. However, because all other monitoring efforts occurred earlier in the year, it is no possible to compare this effort with any others.

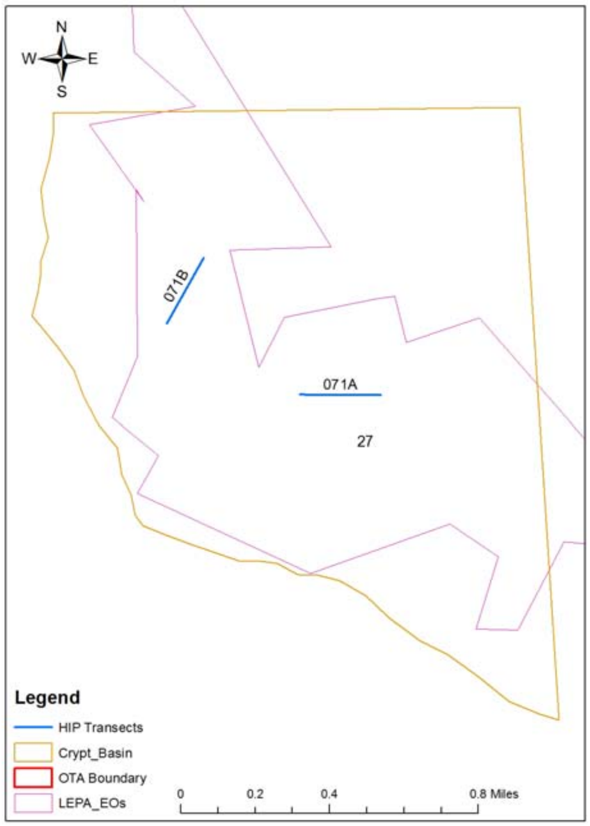

Figure 5-6. HIP transects located in the Crypt Basin monitoring area.

TRS Range Services Monitoring Program

The TRS Range Services program in 2006 focused on a similar area of EO 27, the Orchard Corner region that was surveyed by URS (2005a), but in the TRS program, this area is referred to as The States region. TRS Range Services also surveyed the Christmas Mountain area of EO 53 (Figure 5-7).

TRS Range Services Methods

TRS used methods for this survey based on TRS staff experience with the OTA staff performing similar slickspot peppergrass surveys, in combination with ongoing communication with IDARNG staff. The inventory was completed during the month of July 2006. The field methods used in this monitoring effort were the same methods used in 2005 by URS Corporation (URS 2005a,b).

TRS Range Services Findings

TRS identified more slickspots in The States area than URS did in the area referred to in that project as Orchard Corner. However, TRS found fewer slickspot peppergrass plants than did URS. TRS found a total of 879 on 67 slickspots in 2006, whereas URS counted a total of 3600 on 54 slickspots. A possible explanation for the difference between the two monitoring efforts is the difference between the two years. The total number of plants counted during "rough census" monitoring program in 2005 was 18,599, but in 2006, the total was only 8986. A similar difference occurred in the counts on the special use plots. In 2005, the total count was 2360, but in 2006, the count was 1062. The most likely explanation for the difference between the counts seen in the URS (2005a) effort and the TRS (2006) effort is simply a difference in the local conditions or other factors which produce the population fluctuations often seen with slickspot peppergrass.

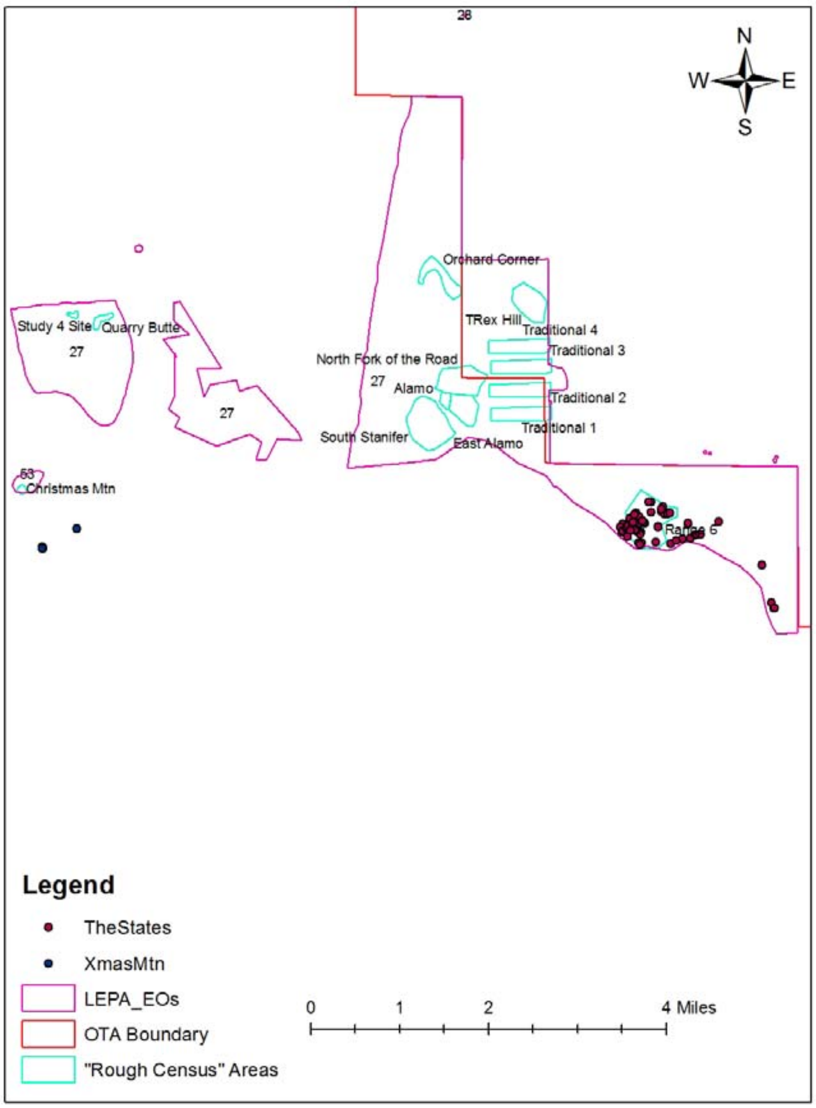

Figure 5-7. Locations of slickspots sampled during 2006 in The States (in EO 27) and Christmas Mountain (in EO 53) areas by TRS Range Services (TRS 2006).

Comparison of Long-Term Monitoring Programs

Monitoring “rough census” areas consists of searching the same 15 areas since approximately 1990. The searches do not provide complete counts of the slickspot peppergrass within those areas for each year, i.e., they are not true censuses. Furthermore, the sampling design does not permit specification of inclusion probability and, therefore, it is not possible to know how many slickspots may have been missed. However, because the methods and level of effort have been similar over the years, we assume that inclusion probabilities have remained constant. That is, we assume that a constant, but unknown, proportion of the slickspot peppergrass population within the surveyed area has been sampled. As such, the reported abundances more properly represent an index of population size within the survey area, rather than absolute abundance. Under these assumptions, the abundance data are adequate for the analyses of trend and relationship with precipitation (Chapter 3).

Special use plot monitoring consists of monitoring 15 individual slickspots that occur within the “rough census” areas along with monitoring the vegetation in the nearby habitat. Since the special use plot monitoring has relied on constant methodology applied over essentially the same time period as the monitoring of the “rough census” areas, the data are also adequate for trend and precipitation analyses. However, since only a single slickspot is monitored for each special use plot, a localized impact to that one slickspot could have an exaggerated impact on the subsequent abundance estimate. The annual variability of the special use plot data would be expected to be greater than that at the “rough census” areas, making the comparison between the special use plot data and any environmental factor looser than might be expected for the “rough census” area data. Indeed, that appears to be the case. We expressed the year-to-year variability in abundance within each plot or area as the coefficient of variation ($CV = sd$/mean, where sd is the standard deviation in abundance). Among “rough census” areas CV ranged from 1.20 to 2.32 with an average value of 1.55, while among special use plots, CV ranged from 0.80 to 3.14 with an average of 1.84. Thus, on average, annual variability was somewhat greater for the special use plots than for the rough census areas.

Currently the HIP data collection has not occurred over a long enough time period to allow reliable long-term trend analyses. However, since the HIP transects all include 10 slickspots, they will be less susceptible to localized impacts than the special use plots. The monitoring methods are more rigorous than the “rough census” area methods, so the abundance estimates should be more reliable. Finally, the HIP transects occur throughout the range of slickspot peppergrass, so it will be possible to evaluate the trend across the entire range.

Conclusions

The methods used by URS during 2005 in its spring/summer survey (URS 2005a) or its fall survey (URS 2005b), and the methods used by TRS during 2006 were more intensive throughout the search area than the methods used by OTA staff when monitoring the “rough census” areas. The large number of slickspot peppergrass plants counted by URS (2005a) resulted from searching a larger area and searching that area more intensively. Since many of the areas surveyed by URS and TRS are outside the “rough census” areas, special use plots, and HIP transects, they are not included in any long-term monitoring programs. Many areas recently determined to have slickspot peppergrass are outside any monitoring program, and all programs selected locations based on pre-existing knowledge of where slickspot peppergrass occurred. Therefore, it is not possible to assess whether slickspot peppergrass is shifting it range on the OTA, expanding, or contracting. The existing programs will assess the status of slickspot peppergrass on the current monitored sites, but are not well-designed to determine long-term changes across the entire OTA or throughout southwestern Idaho.

Literature Cited

URS. 2005a. Final Report: July 26, 2005 *Lepidium papilliferum* survey inventory. Idaho Army National Guard, Unpublished report. 57 pp.

URS. 2005b. Final Report: Fall 2005 inventory *Lepidium papilliferum* (Crypt Basin). Idaho Army National Guard, Unpublished report. 13 pp.

TRS. 2006. Final Report: Summer 2006 inventory *Lepidium papilliferum* (The States and Christmas Mountain). Idaho Army National Guard, Unpublished report. 74 pp.

Section 2: Rangewide Implications

Chapter 6: Habitat Quality of Idaho Army National Guard Orchard Training Area and Habitat Integrity and Population Monitoring Locations

Many of the monitoring programs make some attempt at assessing the habitat quality of the sites monitored. The Idaho Natural Heritage Program has also assigned habitat quality rankings to each of the Element Occurrences (EOs). In this chapter we describe the habitat on each of the EOs as well as the different areas monitored for slickspot peppergrass (*Lepidium papilliferum*) on the Idaho Army National Guard Orchard Training Area (OTA). We show the relationship between the monitored areas on the OTA with wild fires that have occurred since 1990. The vegetation classification performed by the OTA includes areas of cheatgrass (*Bromus tectorum*) which corresponds best with the Gap Ecological Systems' Introduced Upland Vegetation - Annual Grassland class. Figures 6-1 and 6-2 display the two different classification systems on the OTA.

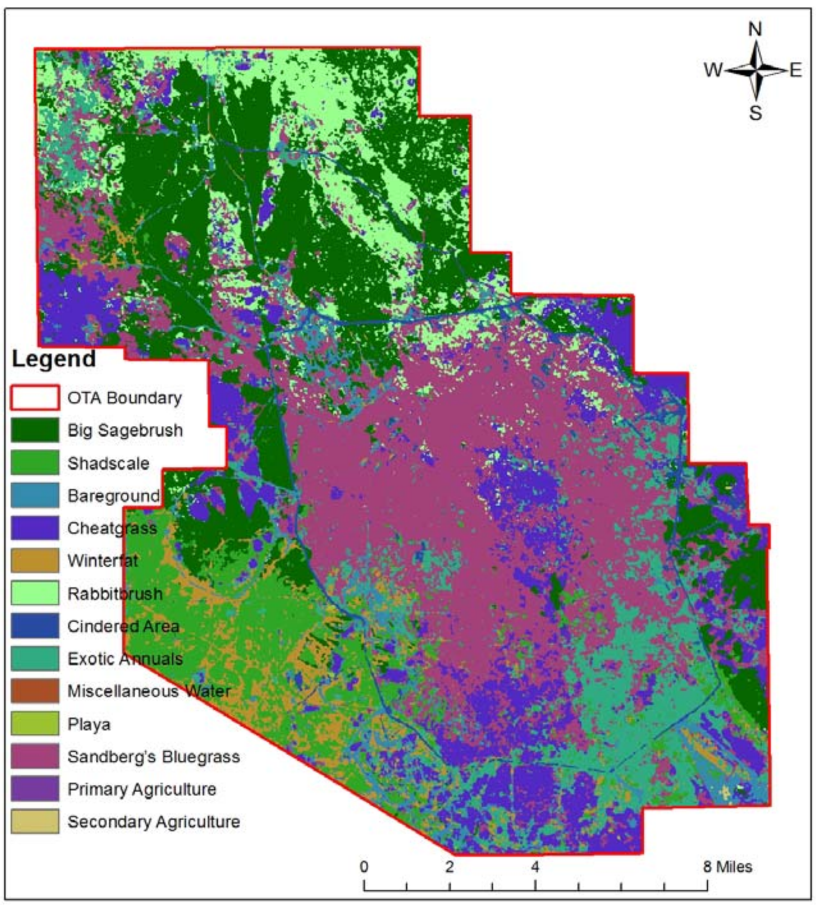

Figure 6-1. Vegetation present on the Orchard Training Area based on Orchard Training Area vegetation GIS layer.

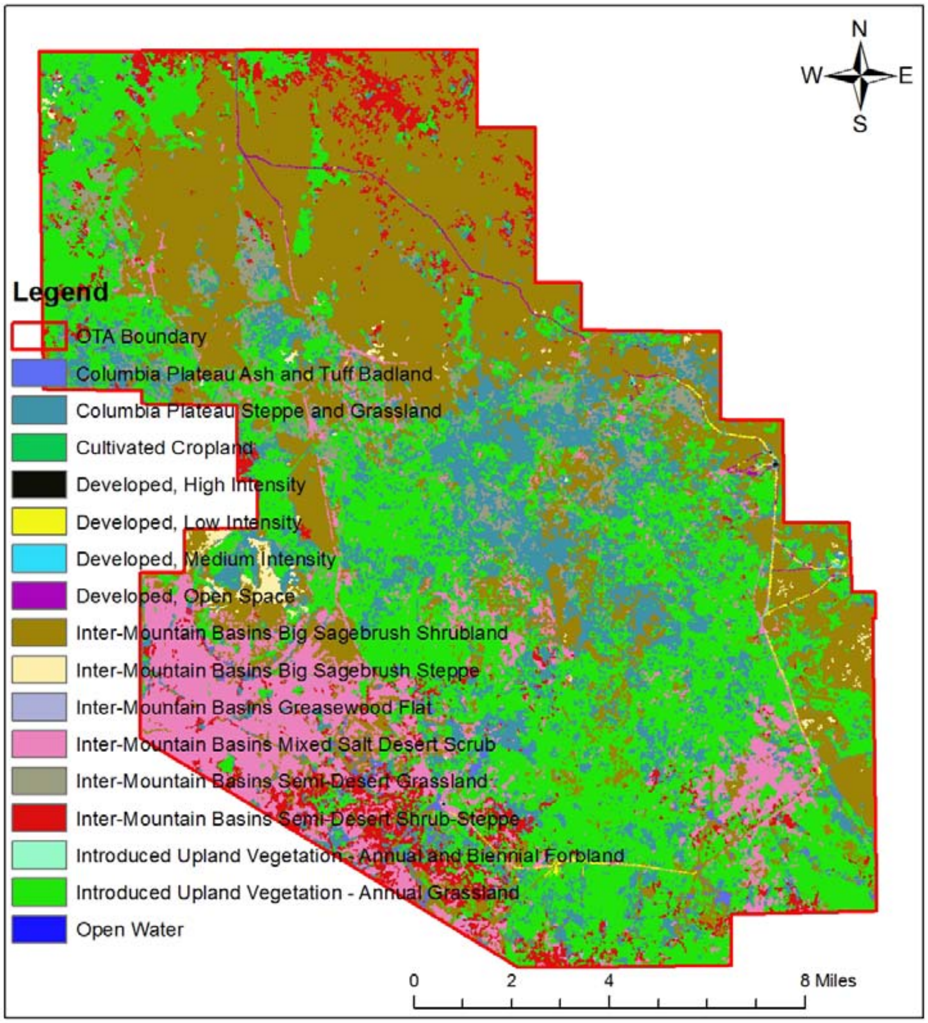

Figure 6-2. Vegetation present on the Orchard Training Area based on GAP Ecological Systems, USGS Mapping Zone 18 GIS layer.

Element Occurrences on the Orchard Training Area

Methods and Data Sources

Two raster-based dataset were used to analyze vegetation across the slickspot peppergrass range. One dataset was created by and available from the OTA. The second dataset was created as GAP Ecological Systems, USGS Mapping Zone 18 and available from Institute for Natural Resources, Oregon State University, Corvallis, Oregon for the USGS GAP Program.

Mapping Zone 18 was completed in November 2007 using multi-season satellite imagery (Landsat ETM+) from 1999-2001 in conjunction with digital elevation model (DEM) derived datasets (e.g. elevation, landform, aspect, etc.) to model natural and semi-natural vegetation. The minimum mapping unit for this dataset is approximately 1 hectare. Landcover classes are drawn from NatureServe's Ecological System concept. For the majority of classes, a decision tree classifier was used to discriminate landcover types, while a minority of classes (e.g. urban classes, burn scars, etc.) were mapped using other techniques (Kagen *et al.* 2008). The metadata for this dataset, including the vegetation class descriptions, are provided in Appendix 2. No ground-truthing and subsequent accuracy assessment was performed on Mapping Zone 18 vegetation classification (A. Davidson, pers. comm.).

To classify the vegetation on areas of the OTA, we used the classification system provided by the OTA. The OTA's vegetation dataset was created using Landsat images from throughout the calendar year during 1999 to 2001. The peak month for each vegetation type was selected to map that particular vegetation class (N. Nydegger, pers. comm.). The metadata for this dataset, as well as the vegetation class descriptions, are provided in Appendix 1. An accuracy assessment was performed using the OTA's Land Condition Trend Analysis data from the 2000 survey. The results of the accuracy assessment are provided in Table 1-1.

Description of Habitat on Slickspot Peppergrass EOs

Three extant Element Occurrences (EOs) for the slickspot peppergrass exist on the OTA (Figure 6-3). The vegetation within each EO differs (Table 6-1), but big sagebrush is the most common vegetation in each EO. The vegetation within all the EOs on the OTA combined (Table 6-2) is mostly big sagebrush and differs from the composition of vegetation throughout the OTA (Table 6-2 and Table 1-1). Big sagebrush comprises 65% of the EOs on the OTA, but contributes only 21% to the overall landcover of the OTA. The most common vegetation throughout the OTA is Sandberg's bluegrass (29%), but very little of the EOs on the OTA (2%) consist of Sandberg's bluegrass. Rabbitbrush (14%) is more common on the EOs than across the OTA (9%). Exotic annuals (10%), shadscale (9%), and winterfat (4%) are more common across the OTA, but they each comprise less than one percent of the area of the EOs on the OTA. The proportions of the other vegetation classes covering the remainder of the EOs do not differ greatly from that on the OTA. The areas of the OTA where EOs occur are more dominated by sagebrush and have a less grasses than the OTA overall.

Element Occurrence Habitat Ranks

Three GIS datalayers were available depicting the original EO ranks, the EO ranks in 2005, and the current EO ranks in 2008. These datalayers from the Idaho Natural Heritage Program depict the EOs ranked according to a qualitative assessment of the habitat quality for slickspot peppergrass (Figure 6-4).

Element Occurrence Rank Specifications

Each EO has been provided a rank, and the ranks are periodically updated. No EOs currently has a rank of A, but these would represent EOs with the largest number of plants and the best habitat and landscape quality. The habitat quality rank diminishes from ranks of A through D. The habitat in EOs with a rank of E is assigned when at least one plant was observed, but no abundance, habitat, or landscape data are available (B. Colket, pers. comm.). A rank of F indicates a survey failed to find any slickspot peppergrass. A rank of H indicates no slickspot peppergrass has been found since 1970, and a rank of X indicates slickspot peppergrass has been extirpated from that EO. Definitions for each rank as provided by Colket *et al.* (2006) are provided below.

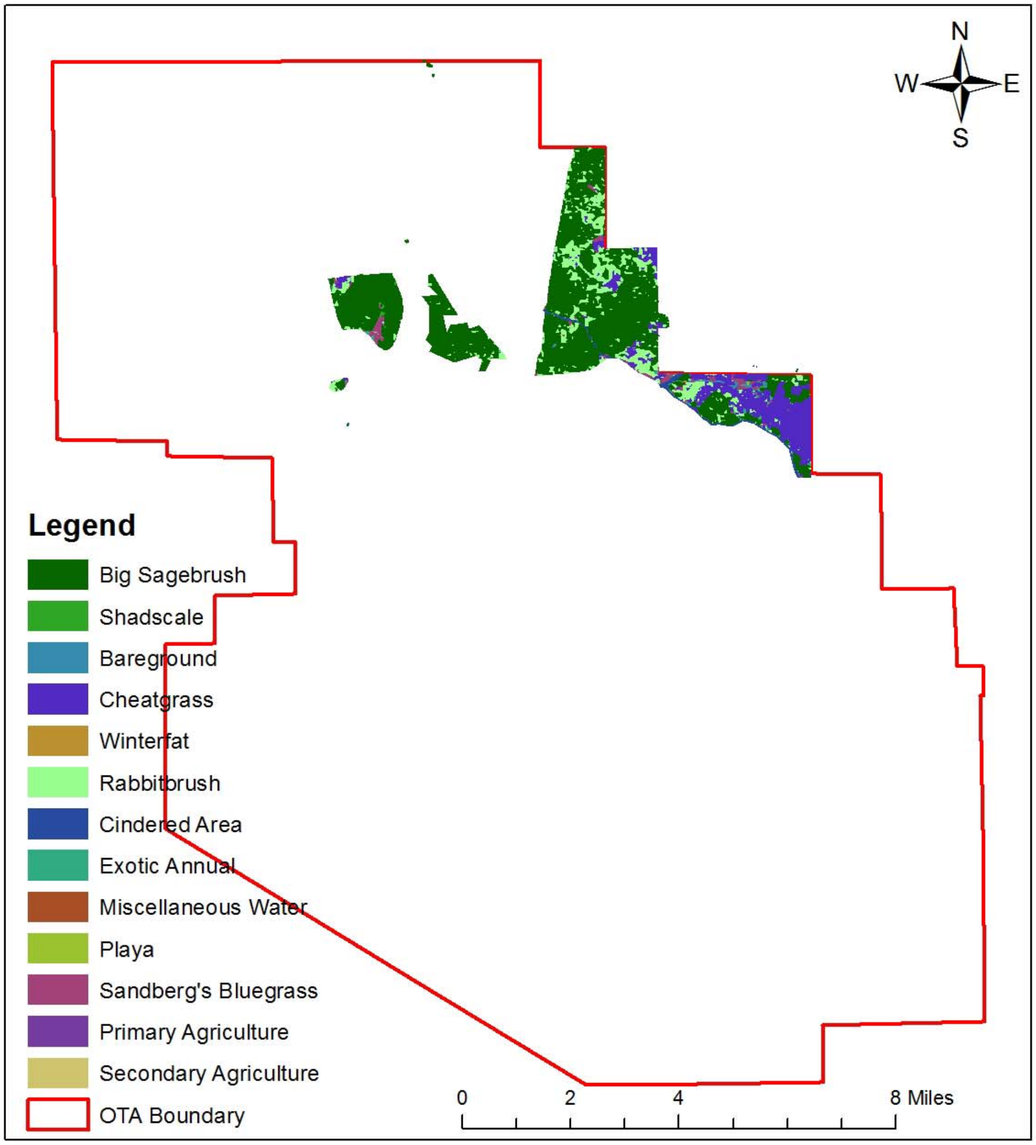

Figure 6-3. Slickspot peppergrass Element Occurrences on the Orchard Training Area with vegetation types shown.

Table 6-1. Vegetation classes within each slickspot peppergrass Element Occurrence on the Orchard Training Area based on Orchard Training Area vegetation GIS layer.

	Element Occurrence			
Class	27	53	67	Entire OTA
Big Sagebrush (*Artemisia tridentata*)	1884.45 (64.96%)	7.82 (47.88%)	889.14 (100.00%)	11,652.13 (20.73%)
Shadscale (*Atriplex confertifolia*)	9.33 (0.32%)	0.00 (0.00%)	0.00 (0.00%)	4,911.69 (8.74%)
Bareground	16.23 (0.56%)	0.09 (0.57%)	0.00 (0.00%)	2,280.63 (4.06%)
Cheatgrass (*Bromus tectorum*)	446.82 (15.40%)	0.97 (5.93%)	0.00 (0.00%)	7,083.88 (12.60%)
Winterfat (*Ceratoides lanata*)	1.10 (0.04%)	0.00 (0.00%)	0.00 (0.00%)	2,486.63 (4.42%)
Rabbitbrush (*Chrysothamnus visidiflores*)	408.79 (14.09%)	6.12 (37.43%)	0.00 (0.00%)	4,865.94 (8.66%)
Cindered Areas (volcanic)	48.08 (1.66%)	0.00 (0.00%)	0.00 (0.00%)	1,019.00 (1.81%)
Exotic Annuals	18.72 (0.65%)	0.33 (2.04%)	0.00 (0.00%)	5,827.19 (10.37%)
Miscellaneous Water	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	1.25 (0.00%)
Playa areas	0.82 (0.03%)	0.00 (0.00%)	0.00 (0.00%)	14.50 (0.03%)
Sandberg's Bluegrass (*Poa sandbergii*)	66.82 (2.3%)	1.00 (6.14%)	0.00 (0.00%)	16,048.88 (28.55%)
Primary Agriculture	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	2.94 (0.01%)
Secondary Agriculture	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	22.25 (0.04%)
	2901.16 (100.00%)	16.34 (100.00%)	889.14 (100.00%)	56,216.88 (100.00%)

A Specifications

SIZE: >1000 detectable genets. CONDITION: Native plant community is intact with trace introduced plant species cover. Slickspots have zero or trace introduced weed cover and/or livestock disturbance. Zero or few minor anthropogenic disturbances are present. EO is unburned. LANDSCAPE CONTEXT: Surrounding landscape within 1 km has not been fragmented by agricultural lands, residential or commercial development, introduced annual grasslands, or drill seeding projects.

Table 6-2. Vegetation classes within all slickspot peppergrass Element Occurrences on the Orchard Training Area combined based on Orchard Training Area vegetation GIS layer.

Class	Hectares	Acres	Percent of area	Entire OTA
Big Sagebrush (*Artemisia tridentata*)	1892.27	4675.81	64.86	20.73%
Cheatgrass (*Bromus tectorum*)	447.79	1106.48	15.35	12.60%
Rabbitbrush (*Chrysothamnus visidiflores*)	414.91	1025.24	14.22	8.66%
Sandberg's Bluegrass (*Poa sandbergii*)	67.83	167.60	2.32	28.55%
Cindered Areas (volcanic)	48.08	118.81	1.65	1.81%
Exotic Annuals	19.05	47.07	0.65	10.37%
Bareground	16.33	40.35	0.56	4.06%
Shadscale (*Atriplex confertifolia*)	9.33	23.05	0.32	8.74%
Winterfat (*Ceratoides lanata*)	1.10	2.72	0.04	4.42%
Playa areas	0.82	2.02	0.03	0.03%
	2917.50	7209.15	100.00	

B Specifications
SIZE: 400-999 detectable genets. CONDITION: Native plant community is intact with low introduced plant species cover. Slickspots have low introduced weed cover and/or livestock disturbance. Zero or few minor anthropogenic disturbances present. EO is predominantly unburned. LANDSCAPE CONTEXT: Surrounding landscape within 1 km is minimally to partially fragmented by agricultural lands, residential or commercial development, introduced annual grasslands, or drill seeding projects.

C Specifications
SIZE: 50-399 detectable genets. CONDITION: Native plant community is partially intact with low to moderate introduced plant species cover. Slickspots have low to moderate introduced weed cover and/or livestock disturbance. Few or several minimally to moderately severe anthropogenic disturbances are evident. EO has partially burned. Portions of EO may have been drill seeded, but slickspots are largely intact. LANDSCAPE CONTEXT: Surrounding landscape within 1 km is partially to predominantly fragmented by agricultural lands, residential or commercial development, introduced annual grasslands, or drill seeding projects.

D Specifications
SIZE: 1-49 detectable genets. CONDITION: Few components of the native plant community remain and introduced plant species cover is high. Slickspots have high introduced weed cover and/or livestock disturbance. Few or several moderately severe anthropogenic disturbances are evident. EO has been predominantly to completely burned. Portions of EO may have been drill seeded, and slickspot soils have been altered by drill seeding. LANDSCAPE CONTEXT: Surrounding landscape within 1 km is moderately to completely fragmented by agricultural lands, residential or commercial development, introduced annual grasslands, or drill seeding projects.

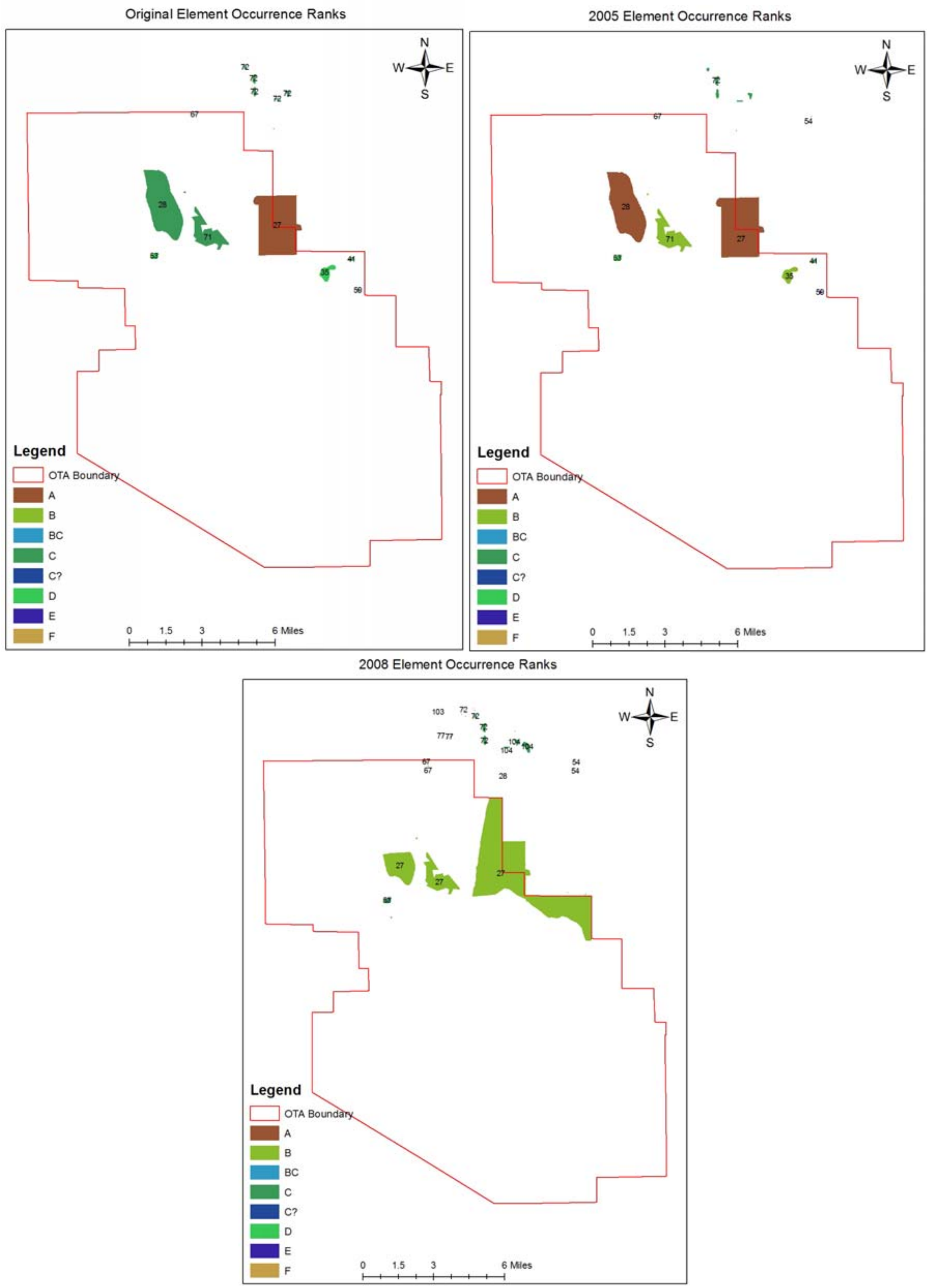

Figure 6-4. Slickspot peppergrass Element Occurrences habitat rankings from A through F (extant EOs only) on the Orchard Training Area.

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E Specifications
Extant: EO has been verified extant, but population size, condition, and landscape context have not been assessed.

F Specifications
Failed to find: EO has been surveyed by experienced individuals who failed to find any slickspot peppergrass individuals, despite searching under conditions appropriate for the element at a location where it was previously recorded. Only one visit is required for this rank designation, but the survey should cover the entire extent of the EO.

H Specifications
Historical: An EO that has not been observed since 1970. These are historical EOs indicating where slickspot peppergrass was reported, often based on older herbarium records. Location records are typically geographically vague and may be simply indicated by the name of a town.

X Specifications
Extirpated: EO has been extirpated. Extirpation is based on: 1) agricultural conversion, commercial or residential development, or other documented habitat destruction where slickspot peppergrass has been previously recorded, or 2) when an EO has consistently has received an F-rank five times within a 12-year time period.

As can be seen in Figure 6-4, EOs have changed numbers, been grouped together, or changed in size and shape. The ranks of EOs have also changed over time. Many EOs exist with ranks of H or X indicating past occurrences, but these EOs generally have vague boundaries from a lack of knowledge of specific locations or size of the previous occurrence. We present only the extant EOs here. The current ranks represent the best knowledge regarding the abundance and habitat quality for each area.

Between 2005 and 2008, many of the EOs in the northern OTA changed shape, and some were combined. EOs 28, 35, 41, 59, and 71 were all combined with EO 27 to form a single EO. All the area between the original EO 27 and EOs 35, 41, and 59 are included in the new expanded EO 27. However, the northern section of EO 28 was eliminated, but the original shape of EO 71 was retained. No area between EOs 28, 71 and the original EO 27 is included in the new EO 27, but the area north of the old EO 27 is added. The expansion of EO 27 reflects the new slickspots surveyed in 2005 and 2006 by URS (2005a) and TRS Range Services (2006). The new EO 27 is given a B rank. The final EO in the northern OTA is EO 67 along the northern boundary. Some new areas were added to this EO and the rank was changed from a BC to a B between 2005 and 2008.

Element Occurrences Rangewide

The most common EO ranks for slickspot peppergrass EOs rangewide are C and D (Table 6-3 and Figure 6-5). The ranks of H and X or X? apply to those EOs where slickspot peppergrass plants have not been observed for over 30 years or the habitat is too degraded to support viable populations. The historic and extirpated EOs are not included in this discussion because the boundaries of such EOs are not known accurately enough to assess the area to be included. A little more than one-half of the extant EO area in the Boise Foothills is ranked as C. Almost three-quarters of the extant EO area in the Snake River Plain is ranked B. The vast majority of the extant EO area in the Owyhee Plateau is ranked B. EO 16 in the Owyhee Plateau is not included in this calculation because it encompasses many of the other EOs and is not really a well-defined EO. No EOs received a rank of A in 2008. EO 27 in the OTA has a total area of 2899 ha (7163 acres) and therefore only accounts for roughly 60% of all the area within EOs assigned a B rank throughout the entire range and 75% of the area with a B rank on the Snake River Plain. Less than one hectare received a B rank in the Boise Foothills, but almost 940 hectares is ranked B in the Owyhee Plateau. Therefore, the majority of the highest quality areas for slickspot peppergrass occur on the Snake River Plain, with most of that occurring within the OTA.

Table 6-3. Element Occurrences Ranks across the entire range of slickspot peppergrass.

Element Occurrence Rank	No. EO's	Hectares	Acres	Percent of Area
Boise Foothills				
B	1	0.84	2.07	1.65
BC	1	1.79	4.41	3.53
C	5	28.34	70.03	56.05
D	6	15.37	37.99	30.40
F	3	4.23	10.46	8.37
	16	50.57	124.96	100.00
Snake River Plain				
B	5	3,875.14	9,575.47	73.77
BC	1	1.42	3.51	0.03
C	19	935.06	2,310.53	17.80
D	12	350.44	865.94	6.67
D?	1	0.78	1.93	0.01
F	4	89.82	221.94	1.71
NR	1	0.20	0.48	0.00
	43	5,252.86	12,979.81	100.00
Owyhee Plateau				
B	7	937.87	2,317.48	87.65
C	11	77.57	191.67	7.25
D	15	51.68	127.71	4.83
E	1	0.39	0.97	0.04
F	8	2.54	6.28	0.24
	42	1,070.05	2,644.10	100.00

Element Occurrences throughout the range of slickspot peppergrass

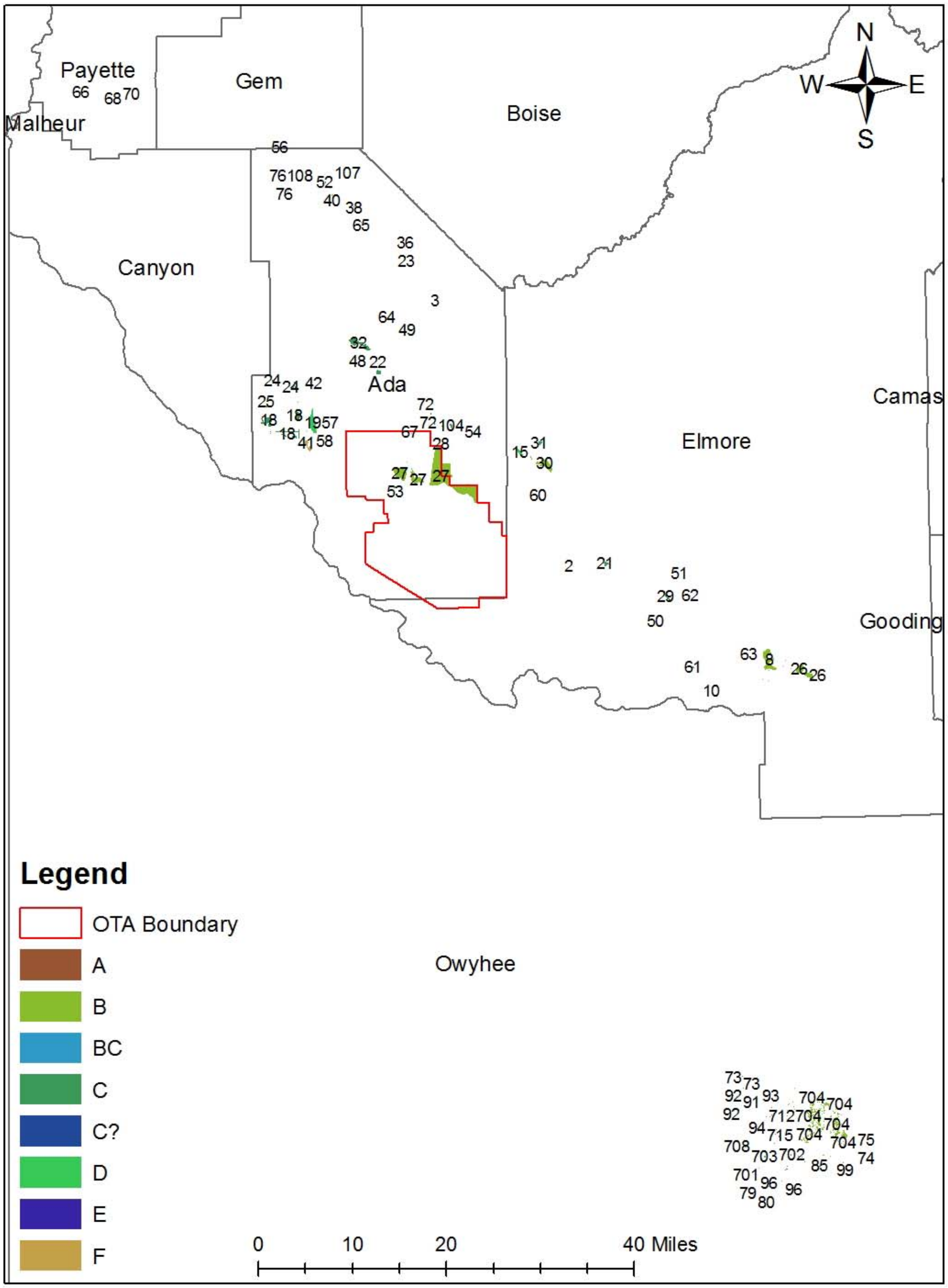

Figure 6-5. Slickspot peppergrass rangewide Element Occurrences habitat rankings from A through F (extant EOs only).

Table 6-4. Rangewide Element Occurrences (EO) providing the area, slickspot peppergrass abundance and dominant habitat.

EO Number	EO Rank	Hectares	Acres	Average Number of Plants per HIP Transect: Rosettes	Reproductive	Total Plants	Dominant Habitat	Percent of Area
2	C	1.00	2.48	145.00	44.20	189.20	Inter-Mountain Basins Big Sagebrush Shrubland	100
3							Developed, Open Space	20.99
8	B	412.37	1018.97	271.30	352.40	623.70	Inter-Mountain Basins Big Sagebrush Shrubland	65.5
10	D	1.59	3.93	0.00	0.00	0.00	Introduced Upland Vegetation - Annual Grassland	90.11
12	F	0.20	0.48	0.00	0.00	0.00	Introduced Upland Vegetation - Annual Grassland	91.77
15	D	62.93	155.49	10.20	116.00	126.20	Recently burned grassland	64.54
18	C	373.31	922.45	239.64	113.73	360.86	Introduced Upland Vegetation - Annual Grassland	79.83
19	D	274.50	678.28	0.00	0.00	0.00	Introduced Upland Vegetation - Annual Grassland	61.27
20	C	1.30	3.21	69.75	133.75	203.50	Introduced Upland Vegetation - Annual Grassland	49.44
21	C	40.54	100.18	0.00	0.00	0.00	Inter-Mountain Basins Big Sagebrush Shrubland	81.2
22	C	51.15	126.40				Introduced Upland Vegetation - Annual Grassland	45.57
23	D	2.34	5.79				Inter-Mountain Basins Big Sagebrush Shrubland	88.05
24	C	36.34	89.79	51.67	31.56	83.22	Inter-Mountain Basins Big Sagebrush Shrubland	77.62
25	C	15.38	38.01	114.75	131.25	246.00	Introduced Upland Vegetation - Annual Grassland	98.25
26	B	286.22	707.24	67.40	79.20	146.60	Inter-Mountain Basins Big Sagebrush Shrubland	86.31
27	B	2899.02	7163.47	429.34	209.55	638.89	Inter-Mountain Basins Big Sagebrush Shrubland	79.34
28	D	0.20	0.48				Inter-Mountain Basins Big Sagebrush Shrubland	100
29	C	42.29	104.50	245.50	117.75	363.25	Inter-Mountain Basins Big Sagebrush Shrubland	51.74
30	B	273.65	676.18	0.40	3.00	3.40	Introduced Upland Vegetation - Annual Grassland	51.56
31	C	28.84	71.25	73.20	117.20	190.40	Introduced Upland Vegetation - Annual Grassland	56.3
32	C	250.53	619.06	0.40	0.40	0.80	Inter-Mountain Basins Big Sagebrush Shrubland	81.12
35				7.00	15.50	22.50		
36	D	2.34	5.79				Inter-Mountain Basins Big Sagebrush Shrubland	29.37
38	D	6.82	16.86	25.50	5.75	31.25	Inter-Mountain Basins Big Sagebrush Shrubland	63.36
39	F	0.78	1.93				Inter-Mountain Basins Big Sagebrush Shrubland	57.3
40	F	3.25	8.04				Introduced Upland Vegetation - Annual Grassland	37.18
41	F	86.62	214.03				Introduced Upland Vegetation - Annual Grassland	96.75
42	F	0.86	2.11	0.00	0.00	0.00	Inter-Mountain Basins Big Sagebrush Shrubland	97.27
43	D	0.38	0.95				Introduced Upland Vegetation - Annual Grassland	100
48	C	0.73	1.79	26.60	36.40	63.00	Inter-Mountain Basins Big Sagebrush Shrubland	100
49	F	1.56	3.86				Inter-Mountain Basins Big Sagebrush Shrubland	54.45
50	C	1.72	4.25	163.20	54.60	217.80	Inter-Mountain Basins Big Sagebrush Shrubland	100
51	BC	1.42	3.51	65.11	87.00	152.11	Inter-Mountain Basins Big Sagebrush Shrubland	69.65
52	C	12.62	31.18	1854.25	638.75	2493.00	Introduced Upland Vegetation - Annual Grassland	71.15
53	C	16.35	40.41	363.50	290.00	653.50	Columbia Plateau Steppe and Grassland	55.71
54	F	0.78	1.93	0.00	0.00	0.00	Introduced Upland Vegetation - Annual Grassland	52.24

Table 6-4 (Continued)

EO Number	EO Rank	Hectares	Acres	Average Number of Plants per HIP Transect Rosettes	Reproductive	Total Plants	Dominant Habitat	Percent of Area
56	D	1.97	4.86	0.00	0.00	0.00	Introduced Upland Vegetation - Annual Grassland	88.11
57	D	0.20	0.48				Introduced Upland Vegetation - Annual Grassland	100
58	D?	0.78	1.93				Introduced Upland Vegetation - Annual Grassland	99.9
59				0.00	0.00	0.00		
60	D	5.89	14.55	0.20	0.20	0.40	Inter-Mountain Basins Big Sagebrush Shrubland	99.95
61	C	6.41	15.83	222.00	79.00	301.00	Inter-Mountain Basins Big Sagebrush Shrubland	96.5
62	C	2.18	5.38	48.25	33.00	81.25	Inter-Mountain Basins Big Sagebrush Shrubland	87.29
63	D	3.18	7.87	83.00	70.75	153.75	Introduced Upland Vegetation - Annual Grassland	97.36
64	C	1.15	2.84				Inter-Mountain Basins Big Sagebrush Shrubland	50.8
65	D	0.20	0.48	8.20	4.60	12.80	Inter-Mountain Basins Big Sagebrush Shrubland	100
66	C	3.85	9.52	3396.00	773.50	4169.50	Introduced Upland Vegetation - Annual Grassland	62.4
67	B	3.89	9.61	250.20	254.20	504.40	Inter-Mountain Basins Big Sagebrush Shrubland	100
68	C	2.80	6.91	51.50	49.25	206.86	Introduced Upland Vegetation - Annual Grassland	84.77
69	D	1.70	4.20	5.75	4.25	10.00	Introduced Upland Vegetation - Annual Grassland	95.64
70	B	0.84	2.07	1241.25	438.25	1679.50	Inter-Mountain Basins Big Sagebrush Shrubland	100
71				152.75	69.13	221.88		
72	C	27.26	67.36	111.70	86.70	198.40	Inter-Mountain Basins Big Sagebrush Shrubland	98.9
73	D	14.23	35.15				Inter-Mountain Basins Big Sagebrush Shrubland	99.87
74	C	1.05	2.59				Inter-Mountain Basins Big Sagebrush Shrubland	98.98
75	F	0.39	0.97				Inter-Mountain Basins Big Sagebrush Shrubland	100
76	C	8.88	21.94	2748.75	1076.25	3825.00	Introduced Upland Vegetation - Annual Grassland	89
77	C	1.72	4.24				Inter-Mountain Basins Big Sagebrush Shrubland	100
78	F	0.39	0.97				Inter-Mountain Basins Big Sagebrush Steppe	99.99
79	F	0.39	0.97				Inter-Mountain Basins Big Sagebrush Steppe	99.92
80	B	1.84	4.54				Inter-Mountain Basins Big Sagebrush Shrubland	100
81	F	0.20	0.48				Inter-Mountain Basins Big Sagebrush Steppe	57.37
83	F	0.20	0.48				Inter-Mountain Basins Big Sagebrush Shrubland	100
84	B	0.87	2.14	111.40	23.20	134.60	Inter-Mountain Basins Big Sagebrush Shrubland	100
85	C	3.84	9.49				Inter-Mountain Basins Big Sagebrush Shrubland	99.3
87	F	0.20	0.48				Inter-Mountain Basins Big Sagebrush Shrubland	99.89
88				70.25	47.40	101.00		
89	D	0.20	0.48				Inter-Mountain Basins Big Sagebrush Shrubland	99.99
90	D	0.43	1.07				Inter-Mountain Basins Big Sagebrush Shrubland	100
91	D	1.38	3.40				Inter-Mountain Basins Big Sagebrush Shrubland	100
92	C	16.29	40.24	0.80	0.60	1.40	Inter-Mountain Basins Big Sagebrush Shrubland	98.67
93	D	2.18	5.38	2.40	4.80	7.20	Inter-Mountain Basins Big Sagebrush Shrubland	99.62

Table 6-4 (Continued)

EO Number	EO Rank	Hectares	Acres	Average Number of Plants per HIP Transect Rosettes	Reproductive	Total Plants	Dominant Habitat	Percent of Area
94	F	0.59	1.45				Inter-Mountain Basins Big Sagebrush Shrubland	99.89
95	C	0.96	2.38	22.80	5.60	28.40	Inter-Mountain Basins Big Sagebrush Shrubland	99.88
96	B	16.98	41.95	73.79	44.50	118.29	Inter-Mountain Basins Big Sagebrush Steppe	84.88
97	B	6.17	15.24	113.40	39.60	153.00	Inter-Mountain Basins Big Sagebrush Shrubland	99.73
98	C	0.67	1.64	44.40	13.80	58.20	Inter-Mountain Basins Big Sagebrush Shrubland	100
99	B	2.13	5.27	50.60	19.00	69.60	Inter-Mountain Basins Big Sagebrush Shrubland	100
100				16.00	18.00	34.00		
101	D	0.20	0.48				Introduced Upland Vegetation - Annual Grassland	100
102	D	0.98	2.41				Inter-Mountain Basins Big Sagebrush Shrubland	95.04
103	D	0.22	0.54				Inter-Mountain Basins Semi-Desert Shrub-Steppe	100
104	C	36.87	91.11	75.75	91.25	167.00	Inter-Mountain Basins Big Sagebrush Shrubland	99.11
105	D	0.20	0.48				Introduced Upland Vegetation - Annual Grassland	99.72
107	C	0.20	0.48				Introduced Upland Vegetation - Annual Grassland	96.31
108	BC	1.79	4.41				Introduced Upland Vegetation - Annual Grassland	98.5
700	C	0.20	0.48				Inter-Mountain Basins Big Sagebrush Steppe	100
701	D	1.91	4.71				Inter-Mountain Basins Big Sagebrush Steppe	100
702	C	27.80	68.70	28.20	19.60	47.80	Inter-Mountain Basins Big Sagebrush Steppe	56.67
703	D	17.49	43.21	6.40	3.80	10.20	Inter-Mountain Basins Big Sagebrush Steppe	64.2
704	B	895.63	2213.09	71.60	22.80	94.40	Inter-Mountain Basins Big Sagebrush Steppe	53.11
705	D	2.08	5.14				Inter-Mountain Basins Big Sagebrush Steppe	100
706	D	1.27	3.13				Inter-Mountain Basins Big Sagebrush Steppe	99.95
708	D	7.85	19.41	0.00	0.00	0.00	Inter-Mountain Basins Big Sagebrush Shrubland	97.89
709	D	0.20	0.48				Inter-Mountain Basins Big Sagebrush Shrubland	99.46
712	B	14.27	35.26	120.00	88.20	208.20	Inter-Mountain Basins Big Sagebrush Steppe	64.77
715	C	17.75	43.87	43.50	35.20	82.25	Inter-Mountain Basins Big Sagebrush Steppe	64.12
716	C	5.15	12.72	100.60	154.00	254.60	Inter-Mountain Basins Big Sagebrush Steppe	64.73
717	D	0.45	1.10	16.00	9.80	25.80	Inter-Mountain Basins Big Sagebrush Steppe	96.2
718				133.50	49.60	193.75		
719	F	0.20	0.48				Inter-Mountain Basins Big Sagebrush Shrubland	100
720	C	0.66	1.63				Inter-Mountain Basins Big Sagebrush Shrubland	99.86
721	D	0.36	0.90				Inter-Mountain Basins Big Sagebrush Steppe	99.98
722	E	0.39	0.97				Inter-Mountain Basins Big Sagebrush Steppe	99.99
723	D	1.48	3.65				Inter-Mountain Basins Big Sagebrush Steppe	99.98
725	C	3.21	7.93				Inter-Mountain Basins Big Sagebrush Steppe	64.63
726	D	0.20	0.48				Inter-Mountain Basins Big Sagebrush Shrubland	100
		6373.29	15748.39					

Habitat Description of the "Rough Census" Areas

The "rough census" areas are comprised of seven vegetation categories (Figure 6-6). The vegetative composition differs considerably among the census area (Table 6-5). For example, Alamo, Study 4 Site, Quarry Butte, and Box Car Rye are all 100% big sagebrush, whereas Range 6, East Alamo, North Fork of the Road, Orchard Corner, TRex Hill, Christmas Mtn., Traditional 1, Traditional 3, and Traditional 4 are all mostly Rabbitbrush. However, when all the vegetation cover types within all the "rough census" areas are combined (Table 6-6), the vegetation is greatly dominated by big sagebrush (86%). The OTA overall is only 21% big sagebrush, so the "rough census" areas differ considerably from the OTA as a whole.

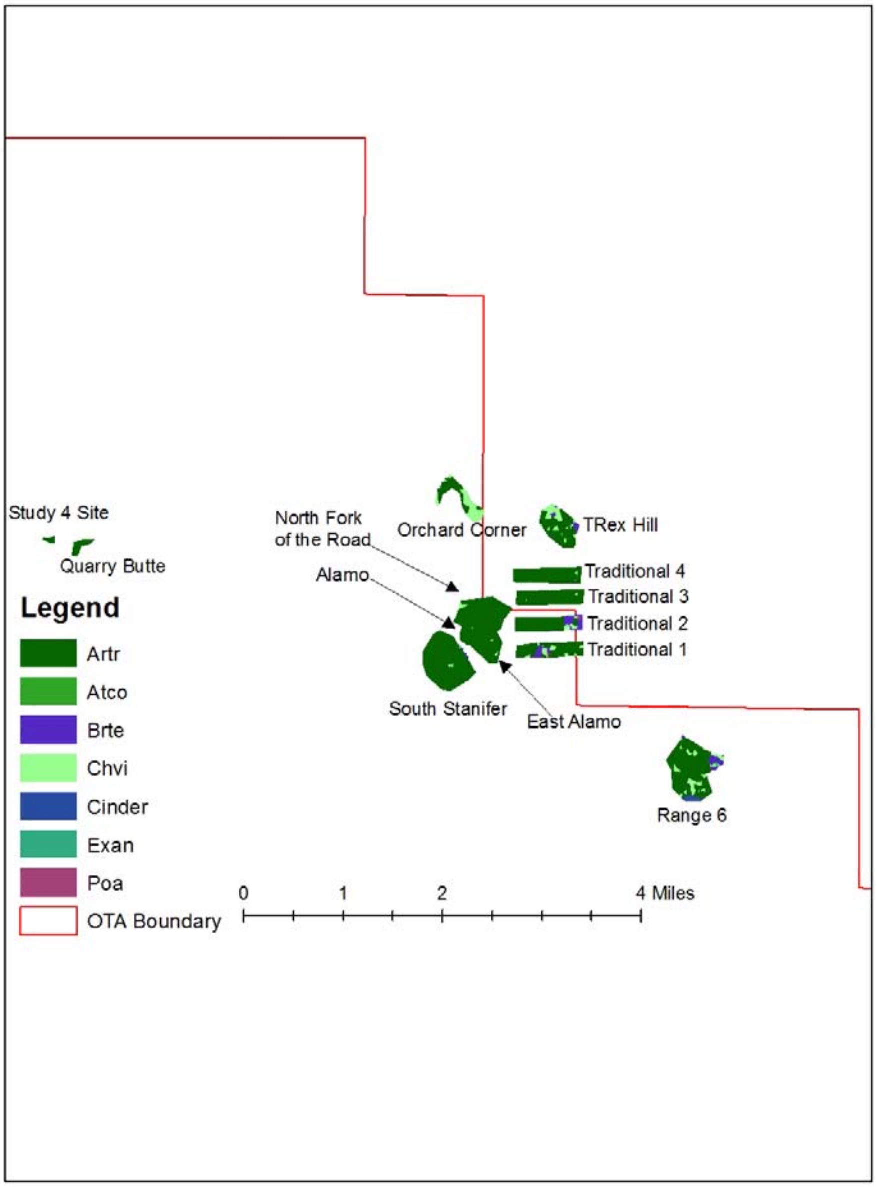

Figure 6-6. Detailed view of labeled "rough census" areas on the Orchard Training Area.

Table 6-5. Vegetation make-up of the "rough census" areas (hectares) based on Orchard Training Area vegetation GIS layer.

Class	Range 6	East Alamo	Alamo	North Fork of the Road	South Stanifer	Orchard Corner	TRex Hill	Study 4 Site	Quarry Butte	Christmas Mtn	BoxCar Rye	Traditional 1	Traditional 2	Traditional 3	Traditional 4
Big Sagebrush (*Artemisia tridentata*)	123.64 (7.69%)	22.45 (33.33%)	4.54 (100%)	37.61 (25.00%)	55.96 (8.33%)	40.64 (25.00%)	30.46 (6.25%)	1.66 (100%)	4.66 (100%)	1.92 (25.00%)	3.50 (100%)	79.21 (20.00%)	52.81 (22.22%)	26.40 (33.33%)	26.40 (25.00%)
Shadscale (*Atriplex confertifolia*)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	111.92 (16.67%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)
Cheatgrass (*Bromus tectorum*)	309.10 (19.23%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	20.32 (12.50%)	91.37 (18.75%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	52.81 (13.33%)	52.81 (22.22%)	0.00 (0.00%)	0.00 (0.00%)
Rabbitbrush (*Chrysothamnus visidiflores*)	1050.95 (58.33%)	44.90 (66.67%)	0.00 (0.00%)	112.82 (75.00%)	111.92 (16.67%)	101.60 (62.50%)	365.46 (75.00%)	0.00 (0.00%)	0.00 (0.00%)	5.77 (75.00%)	0.00 (0.00%)	237.64 (60.00%)	105.62 (44.44%)	52.81 (66.67%)	79.21 (75.00%)
Cindered Areas (volcanic)	61.82 (3.85%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	391.74 (58.33%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)
Exotic Annuals	61.82 (3.85%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)
Sandberg's Bluegrass (*Poa sandbergii*)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	0.00 (0.00%)	26.40 (6.67%)	26.40 (11.11%)	0.00 (0.00%)	0.00 (0.00%)
	1607.33 (100%)	67.34 (100%)	4.54 (100%)	150.43 (100%)	671.55 (100%)	162.56 (100%)	487.29 (100%)	1.66 (100%)	4.66 (100%)	7.69 (100%)	3.50 (100%)	396.07 (100%)	237.64 (100%)	79.21 (100%)	105.62 (100%)

Table 6-6. Vegetation make-up of the combined "rough census" areas based on Orchard Training Area vegetation GIS layer.

CLASS	Hectares	Acres	Percent of Area	Entire OTA
Big Sagebrush (*Artemisia tridentata*)	300.72	743.08	85.80	20.73%
Rabbitbrush (*Chrysothamnus visidiflores*)	32.09	79.30	9.16	8.66%
Cheatgrass (*Bromus tectorum*)	13.02	32.17	3.71	12.60%
Cindered Areas (volcanic)	3.70	9.14	1.06	1.81%
Sandberg's Bluegrass (*Poa sandbergii*)	0.44	1.08	0.12	28.55%
Exotic Annuals	0.37	0.91	0.10	10.37%
Shadscale (*Atriplex confertifolia*)	0.12	0.31	0.04	8.74%
Bareground	0.02	0.05	0.01	4.06%
	350.48	866.04	100.00	

Habitat Description of the Areas Around Special Use Plots

The locational information provided by the OTA for each special use plot consisted of a set of coordinates that defines a single point, not the entire transect. To provide a description of the vegetation near each special use plot, a 100-m buffer was drawn around each point. Using the same vegetation classification system as with the previous descriptions, the combined areas within 100 m of each point can be described (Table 6-7). The area around the special use plots is dominated by big sagebrush (80%). The areas around the special use plots does not differ greatly from the “rough census” areas, which is not surprising since the special use plots all occur within the “rough census” areas. There is slightly more rabbitbrush and slightly less cheatgrass surrounding the special use plots than is found within the “rough census” areas.

Table 6-7. Vegetation make-up of the combined special use plots based on Orchard Training Area vegetation GIS layer.

Class	Hectares	Acres	Percent of Area	Total OTA
Big Sagebrush (*Artemisia tridentata*)	34.04	84.10	80.22	20.73%
Rabbitbrush (*Chrysothamnus visidiflores*)	7.83	19.36	18.46	8.66%
Cheatgrass (*Bromus tectorum*)	0.45	1.11	1.06	12.60%
Cindered Areas (volcanic)	0.11	0.27	0.26	1.81%
	42.43	104.84	100.00	

Habitat Description of the Areas Around URS and TRS Range Services Slickspots

The final monitoring efforts with sampling locations available were the surveys conducted by URS (2005a) and TRS Range Services (2006). To assess the vegetation surrounding the slickspots where slickspot peppergrass was counted, we again created 100-m buffers around the point locations using ArcView. The vegetation classes near the slickspots differ slightly among the five areas surveyed by URS (Table 6-8). The East of Patch, North Quarry, and Red Tie areas are all greater than 90% big sagebrush, whereas the Emerald Wash and Orchard Corner are less than 80% big sagebrush. Please recall that the names used to denote the areas surveyed by URS do not correspond to the names of the “rough census” areas (see Table 6-1). TRS Range Services surveyed slickspots in very nearly the same area as the Orchard Corner of the URS surveys and the Range 6 “rough census” area referring to the area as The States (Table 6-9). The composition of the vegetation cover classes is very similar between the survey areas in the two years, but the TRS survey area consisted of less big sagebrush and more cheatgrass than the URS survey area. The areas around the slickspots in the Christmas Mountain area surveyed by TRS Ranges Services consisted of a slightly higher proportion of big sagebrush and more bare ground than The States area.

Table 6-8. Vegetation make-up of the areas surrounding (within 100 m) of the sampled slickspot locations sampled in the URS studies based on Orchard Training Area vegetation GIS layer.

Class	Hectares	Acres	Percent of Each Area	Percent of Entire URS Study Area
East of Patch				
Big Sagebrush (*Artemisia tridentata*)	119.89	296.25	91.34	22.76
Rabbitbrush (*Chrysothamnus visidiflores*)	9.70	23.96	7.39	1.84
Cindered Areas (volcanic)	1.14	2.83	0.87	0.22
Sandberg's Bluegrass (*Poa sandbergii*)	0.23	0.58	0.18	0.04
Shadscale (*Atriplex confertifolia*)	0.12	0.31	0.10	0.02
Cheatgrass (*Bromus tectorum*)	0.09	0.22	0.07	0.02
Bareground	0.08	0.20	0.06	0.02
	131.26	324.34	100.00	24.92
Emerald Wash				
Big Sagebrush (*Artemisia tridentata*)	64.68	159.81	79.82	12.28
Rabbitbrush (*Chrysothamnus visidiflores*)	16.15	39.90	19.93	3.07
Cheatgrass (*Bromus tectorum*)	0.20	0.50	0.25	0.04
	81.02	200.21	100.00	15.38
North Quarry				
Big Sagebrush (*Artemisia tridentata*)	22.90	56.59	100.00	4.35
	22.90	56.59	100.00	4.35
Orchard Corner				
Big Sagebrush (*Artemisia tridentata*)	52.86	130.63	75.28	10.04
Cindered Areas (volcanic)	6.96	17.19	9.91	1.32
Rabbitbrush (*Chrysothamnus visidiflores*)	4.69	11.58	6.67	0.89
Cheatgrass (*Bromus tectorum*)	4.47	11.04	6.36	0.85
Exotic Annuals	0.53	1.32	0.76	0.10
Shadscale (*Atriplex confertifolia*)	0.31	0.77	0.45	0.06
Sandberg's Bluegrass (*Poa sandbergii*)	0.30	0.74	0.42	0.06
Bareground	0.10	0.25	0.15	0.02
	70.22	173.51	100.00	13.33
Red Tie				
Big Sagebrush (*Artemisia tridentata*)	199.30	492.48	90.02	37.83
Rabbitbrush (*Chrysothamnus visidiflores*)	17.17	42.42	7.75	3.26
Cheatgrass (*Bromus tectorum*)	4.36	10.77	1.97	0.83
Sandberg's Bluegrass (*Poa sandbergii*)	0.41	1.02	0.19	0.08
Cindered Areas (volcanic)	0.09	0.23	0.04	0.02
Shadscale (*Atriplex confertifolia*)	0.06	0.14	0.03	0.01
	221.39	547.06	100.00	42.03

Table 6-9. Vegetation make-up of the areas surrounding (within 100 m) of the sampling slickspot locations sampled in the TRS Range Services study based on Orchard Training Area vegetation GIS layer.

Class	Hectares	Acres	Percent of Each Area	Percent of Entire TRS Study Area
The States				
Big Sagebrush (*Artemisia tridentata*)	54.77	135.33	67.32	61.95
Cheatgrass (*Bromus tectorum*)	12.39	30.62	15.23	14.02
Cindered Areas (volcanic)	6.43	15.89	7.90	7.27
Rabbitbrush (*Chrysothamnus visidiflores*)	4.91	12.12	6.03	5.55
Exotic Annuals	1.91	4.71	2.34	2.16
Shadscale (*Atriplex confertifolia*)	0.63	1.54	0.77	0.71
Sandberg's Bluegrass (*Poa sandbergii*)	0.23	0.56	0.28	0.26
Bareground	0.10	0.25	0.13	0.12
	81.36	201.03	100.00	92.04
Christmas Mountain				
Big Sagebrush (*Artemisia tridentata*)	5.08	12.55	72.11	5.74
Bareground	1.02	2.53	14.52	1.16
Rabbitbrush (*Chrysothamnus visidiflores*)	0.48	1.18	6.77	0.54
Sandberg's Bluegrass (*Poa sandbergii*)	0.18	0.43	2.50	0.20
Shadscale (*Atriplex confertifolia*)	0.14	0.33	1.92	0.15
Cheatgrass (*Bromus tectorum*)	0.07	0.16	0.93	0.07
Cindered Areas (volcanic)	0.05	0.13	0.75	0.06
Exotic Annuals	0.03	0.09	0.49	0.04
	7.04	17.40	100.00	7.96

Habitat Description of the Crypt Basin

Similar to many of the other areas surveyed for slickspot peppergrass, the Crypt Basin is dominated by big sagebrush (Table 6-10). The vegetation composition within Crypt Basin differs from that within the entire EO 27 (See Table 6-1). The Crypt Basin consists of approximately 88% big sagebrush, but the entire EO 27 is only 65% big sagebrush and contains much more cheatgrass than the Crypt Basin.

Table 6-10. Vegetation classes in Crypt Basin area surveyed by URS Corporation (2005b) based on Orchard Training Area vegetation GIS layer.

Class	Hectares	Acres	Percent of Area
Big Sagebrush (*Artemisia tridentata*)	373.34	922.53	87.63
Rabbitbrush (*Chrysothamnus visidiflores*)	48.88	120.78	11.47
Cheatgrass (*Bromus tectorum*)	2.40	5.93	0.56
Sandberg's Bluegrass (*Poa sandbergii*)	1.22	3.02	0.29
Shadscale (*Atriplex confertifolia*)	0.19	0.47	0.04
Bareground	0.03	0.07	0.01
	426.06	1052.80	100.00

Habitat Description of the Areas Around HIP Transects

Similar to the special use plots, the GIS locations for HIP Transects included point locations for each slickspot along the transects. We created 100-m buffer areas around each slickspot and merged these areas for each transect. The vegetation cover types within these areas were assessed.

We separated the HIP transects into groups consisting of those on the OTA and those off the OTA (Tables 6-11 and 6-12) as well as among the Boise Foothills, Snake River Plain, and Owyhee Plateau. We used the OTA GIS vegetation classification to evaluate the HIP transects on the OTA, and then used the GAP Ecological Systems vegetation classification for the entire range, including the transects on the OTA. The most common vegetation class across all HIP transects is Inter-Mountain Basins Big Sagebrush Shrubland. However, this vegetation class is more prevalent near HIP transects on the Snake River Plain and Owyhee Plateau than in the Boise Foothills. The most prevalent vegetation class in the Boise Foothills is Introduced Upland Vegetation – Annual Grassland. Inter-Mountain Basins Big Sagebrush Shrubland is more prevalent around HIP transects on the OTA (91%) than on the Snake River Plain outside the OTA (56%). Introduced Upland Vegetation – Annual Grassland is the second most prevalent vegetation class around HIP transects on the Snake River Plain, but is present in only small quantities around HIP transects on the OTA. When all the vegetation around all HIP transects rangewide is considered, it becomes apparent that the HIP transects on the OTA differ from the entire group in that there is more big sagebrush around HIP transects on the OTA than rangewide.

Table 6-11. Vegetation make-up of the combined HIP transects on the Orchard Training Area based on Orchard Training Area vegetation GIS layer.

Class	Hectares	Acres	Percent of Area
Big Sagebrush (*Artemisia tridentata*)	86.21	213.02	78.72
Cheatgrass (*Bromus tectorum*)	8.01	19.80	7.32
Rabbitbrush (*Chrysothamnus visidiflores*)	7.75	19.14	7.07
Cindered Areas (volcanic)	2.73	6.74	2.49
Sandberg's Bluegrass (*Poa sandbergii*)	2.21	5.47	2.02
Bareground	1.49	3.68	1.36
Exotic Annuals	0.77	1.89	0.70
Shadscale (*Atriplex confertifolia*)	0.26	0.65	0.24
Playa areas	0.09	0.21	0.08
	109.51	270.61	100.00

Table 6-12. Vegetation make-up of the combined HIP transects outside the Orchard Training Area based on GAP Ecological Systems, USGS Mapping Zone 18 GIS layer.

Class	Hectares	Acres	Percent of Area
Boise Foothills			
Introduced Upland Vegetation - Annual Grassland	31.22	77.16	60.22
Inter-Mountain Basins Big Sagebrush Shrubland	18.17	44.90	35.04
Columbia Basin Foothill and Canyon Dry Grassland	0.99	2.44	1.90
Columbia Plateau Steppe and Grassland	0.66	1.63	1.27
Developed, Open Space	0.50	1.23	0.96
Cultivated Cropland	0.31	0.78	0.61
	51.86	128.14	100.00
Entire Snake River Plain			
Inter-Mountain Basins Big Sagebrush Shrubland	218.93	540.97	67.65
Introduced Upland Vegetation - Annual Grassland	51.31	126.79	15.86
Columbia Plateau Steppe and Grassland	17.22	42.54	5.32
Inter-Mountain Basins Semi-Desert Shrub-Steppe	10.62	26.23	3.28
Developed, Open Space	9.61	23.74	2.97
Inter-Mountain Basins Semi-Desert Grassland	4.06	10.04	1.26
Inter-Mountain Basins Mixed Salt Desert Scrub	2.98	7.35	0.92
Cultivated Cropland	2.66	6.57	0.82
Inter-Mountain Basins Big Sagebrush Steppe	2.47	6.11	0.76
Developed, Medium Intensity	1.21	2.99	0.37
Recently burned grassland	1.06	2.61	0.33
Developed, Low Intensity	0.91	2.26	0.28
Pasture/Hay	0.34	0.85	0.11
Columbia Basin Foothill Riparian Woodland and Shrubland	0.24	0.60	0.08
	323.61	799.65	100.00
Snake River Plain Within OTA			
Inter-Mountain Basins Big Sagebrush Shrubland	99.84	246.71	91.11
Columbia Plateau Steppe and Grassland	4.79	11.84	4.37
Introduced Upland Vegetation - Annual Grassland	1.70	4.21	1.55
Inter-Mountain Basins Semi-Desert Shrub-Steppe	1.40	3.47	1.28
Developed, Low Intensity	0.91	2.26	0.83
Developed, Open Space	0.72	1.78	0.66
Developed, Medium Intensity	0.21	0.53	0.20
	109.59	270.79	100.00

Table 6-12 (Continued)

Class	Hectares	Acres	Percent of Area
Snake river Plain Outside OTA			
Inter-Mountain Basins Big Sagebrush Shrubland	119.08	294.26	55.64
Introduced Upland Vegetation - Annual Grassland	49.61	122.58	23.18
Columbia Plateau Steppe and Grassland	12.42	30.70	5.81
Inter-Mountain Basins Semi-Desert Shrub-Steppe	9.21	22.77	4.30
Developed, Open Space	8.89	21.96	4.15
Inter-Mountain Basins Semi-Desert Grassland	4.06	10.04	1.90
Inter-Mountain Basins Mixed Salt Desert Scrub	2.98	7.35	1.39
Cultivated Cropland	2.66	6.57	1.24
Inter-Mountain Basins Big Sagebrush Steppe	2.47	6.11	1.16
Recently burned grassland	1.06	2.61	0.49
Developed, Medium Intensity	1.00	2.46	0.47
Pasture/Hay	0.34	0.85	0.16
Columbia Basin Foothill Riparian Woodland and Shrubland	0.24	0.60	0.11
	214.03	528.86	100.00
Owyhee Plateau			
Inter-Mountain Basins Big Sagebrush Shrubland	82.85	204.71	59.13
Inter-Mountain Basins Big Sagebrush Steppe	54.03	133.50	38.56
Introduced Upland Vegetation - Annual Grassland	1.87	4.61	1.33
Columbia Plateau Silver Sagebrush Seasonally Flooded Shrub-Steppe	0.89	2.19	0.63
Inter-Mountain Basins Semi-Desert Grassland	0.29	0.73	0.21
Great Basin Xeric Mixed Sagebrush Shrubland	0.18	0.44	0.13
	140.10	346.18	100.00

Wild Fires on the Orchard Training Area

The locations of fires in the vicinity of the OTA were acquired from the Bureau of Land Management as a GIS shapefile. Fire locations were available through 2008 (Figure 6-7). Only a single small fire in 1995 burned near the EOs in the northern OTA, just along the western border of the east section of EO 27. Fires have been less of an impact at the locations on the OTA where the majority of the slickspot peppergrass has recently been observed.

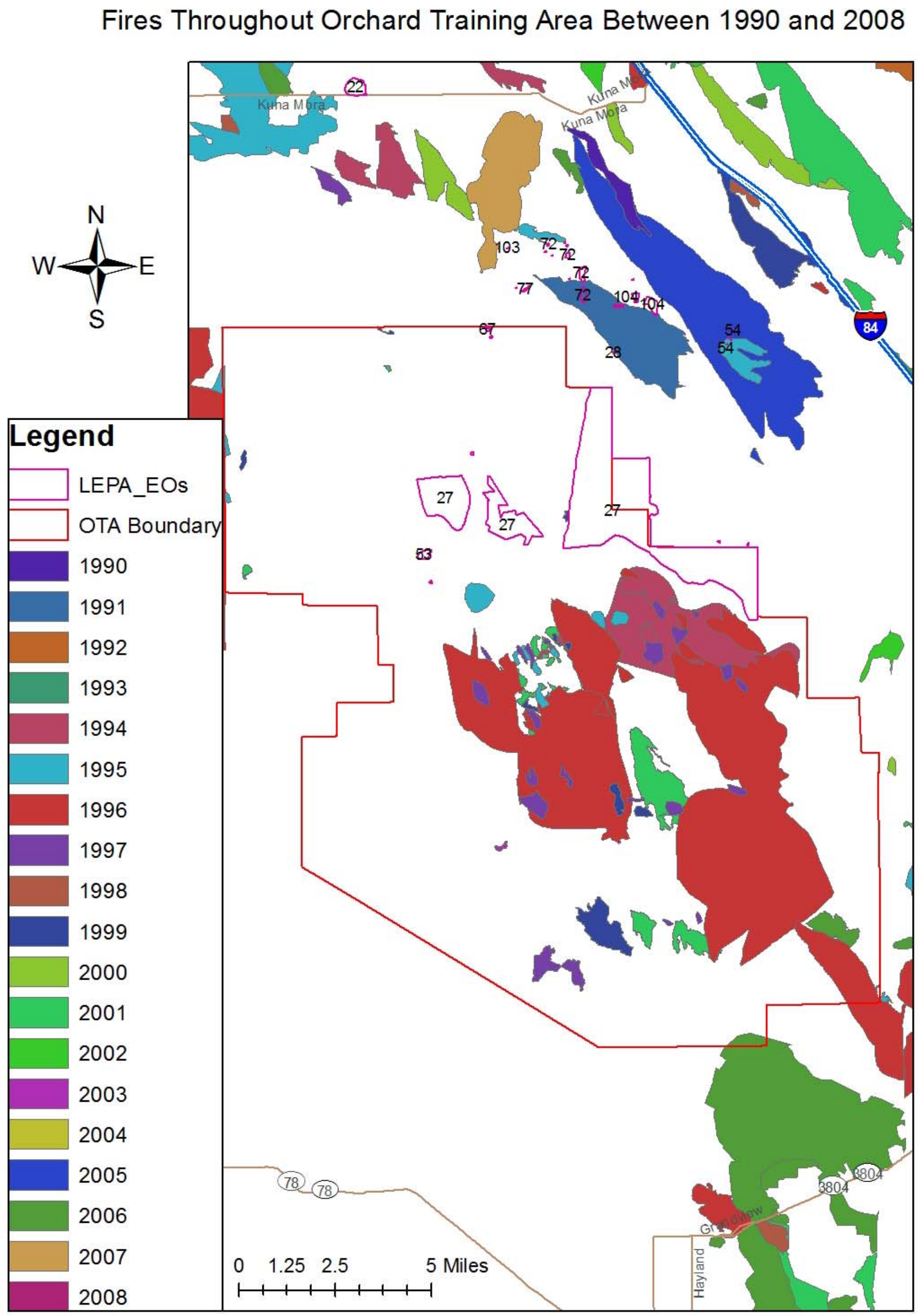

Figure 6-7. Locations of wild fires since 1990 at the Orchard Training Area.

Conclusions

The habitat composition differs among the many areas monitored for slickspot peppergrass as part of a number of programs on the OTA. When the three extant slickspot peppergrass EOs on the OTA are considered together, the habitat consists of approximately 65% big sagebrush with the remainder split fairly evenly between cheatgrass and rabbitbrush.

Almost all of the monitoring efforts on the OTA have been restricted to EO 27. EO 27 has the best EO rank for slickspot peppergrass habitat and population status on the OTA. The "rough census" areas are dominated by big sagebrush with almost 10% rabbitbrush and a small amount of cheatgrass. There is almost no Sandberg's bluegrass on the "rough census" areas, although it constitutes 29% of the entire OTA. Special use plots consist of only four of the cover classes, and have a larger amount of big sagebrush. Rabbitbrush has a higher percent cover area around the special use plot than on the "rough census" areas as a whole. Remember that all the special use plots occur on "rough census" areas.

Additional monitoring efforts focusing on EO 27 were those conducted by URS Corporation and TRS Range Services in 2005 and 2006. These areas were dominated again by big sagebrush with considerable small amounts of rabbitbrush, and very little cheatgrass except in the area designated as "The States" surveyed by TRS in 2006 where cheatgrass represented 15% of the area.

Since EO 27 on the OTA accounts for 60% of all the area of EOs with a B rank rangewide, it suggests that much of the best remaining habitat for slickspot peppergrass exists on the OTA. Remember that EO 16 is excluded from this discussion since it represents an area that merely encompasses all the individual EOs on the Owyhee Plateau. Only a single EO in the Boise Foothills qualified for a B rank and was only 0.84 hectares in size. Five EO's on the Snake River Plain qualified for B ranks, totaling 3875 hectares with EO 27 contributing 75% of that area. The EOs with B ranks on the Snake River Plain constitute 74% of the area of all EOs on the Snake River Plain. Seven EOs on the Owyhee Plateau have a rank of B, but these seven constitute 88% of the area of all the EOs on the Owyhee Plateau. The Snake River Plain has the majority of the area with the highest rank of B with most of that being on the OTA.

Finally the HIP monitoring locations present on the OTA are also dominated by big sagebrush. Rabbitbrush and cheatgrass each comprise approximately 7% of the area around the HIP transects on the OTA. Throughout the range of slickspot peppergrass, the areas surrounding HIP transects are dominated mostly by Inter-Mountain Basins Big Sagebrush Shrubland. Inter-Mountain Basins Big Sagebrush Steppe is common on the Owyhee Plateau, and Introduced Upland Vegetation - Annual Grassland is the most common vegetation class in the Boise Foothills. Inter-Mountain Basins Big Sagebrush Shrubland is more common around HIP transects on the OTA than on the Snake River Plain in general or rangewide.

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Chapter 7: Comparison Between Slickspot Peppergrass at the Idaho Army National Guard Orchard Training Area and Rangewide

Slickspot peppergrass (*Lepidium papilliferum*) counts have been conducted at the Idaho Army National Guard Orchard Training Area (OTA) since 1990. Two monitoring programs are conducted solely on the OTA: the "rough census" area counts and the special use plot counts. These are the longest running monitoring programs for slickspot peppergrass. However, the OTA encompasses only a portion of the range for slickspot peppergrass. Two rangewide monitoring programs have been established. The Habitat Integrity Index (HII) program was conducted by the Idaho Conservation Data Center from 1998 through 2002. In 2004, the Habitat Integrity and Population (HIP) monitoring program replaced the HII program. The HIP program collected abundance counts from 2004 through the present. The methods of each of these four programs are described in detail in Chapter 2.

Since the "rough census" area counts and special use plot counts have been conducted using the same methods for nearly 20 years, these data can be used to assess population trends of slickspot peppergrass on the OTA (See Chapter 3). However, the shorter-running HII and HIP do not yet have sufficient data to determine population trends rangewide. Therefore, we assessed whether the rangewide data appear to mirror changes observed in the OTA data. We use only the HIP data for the rangewide counts for the years 2004 through 2008.

We made four comparisons to evaluate whether similar fluctuations are observed in the different programs. We compared the "rough census" area counts with special use plot counts using data from 17 years when counts were conducted by both programs. We compared the counts from the "rough census" areas and the special use plots with the HIP counts using only those transects found on the OTA. These comparisons evaluate whether the different methods perceive similar fluctuations across the years when the programs were conducted simultaneously. Finally, we compared the HIP data from the OTA to those HIP transects that are located outside the OTA. Since the same program's data are used, we investigated whether slickspot peppergrass counts changed similarly in different years across the entire range.

Methods

Data Collection and Organization

Data for the "rough census" area counts and the special use plot counts were provided by the OTA staff members Jay Weaver and Dana Quinney. The HIP data were provided by Beth Colket of the Idaho Natural Heritage Program. Since all the "rough census" area counts and the special use plot counts prior to 2000 only recorded total abundance counts, we did not include the counts of reproductive or non-reproductive plants in any of our comparisons.

The HIP program in 2004 did not always record absolute plant counts. Some transects reported a range of values (*e.g.*, 200 – 250) or reported a lower threshold number (*e.g.*, >200). When a range of values was reported, we used the midpoint (*e.g.*, 225) of the range for our analyses. When a threshold value was reported, we used that threshold value (*e.g.*, 200). The "rough census" area counts and special use plot counts did not require any adjustments and were used as provided.

Statistical Analyses

All correlation analyses were based on total annual counts (summed across all transects or plots). The nonparametric Spearman rank correlation was calculated since it is less sensitive to outliers than is the standard Pearson correlation. The Spearman correlation is obtained by first ranking the observations, independently for each survey, and then applying the Pearson correlation to the ranks rather than the raw observations.

Results and Discussion

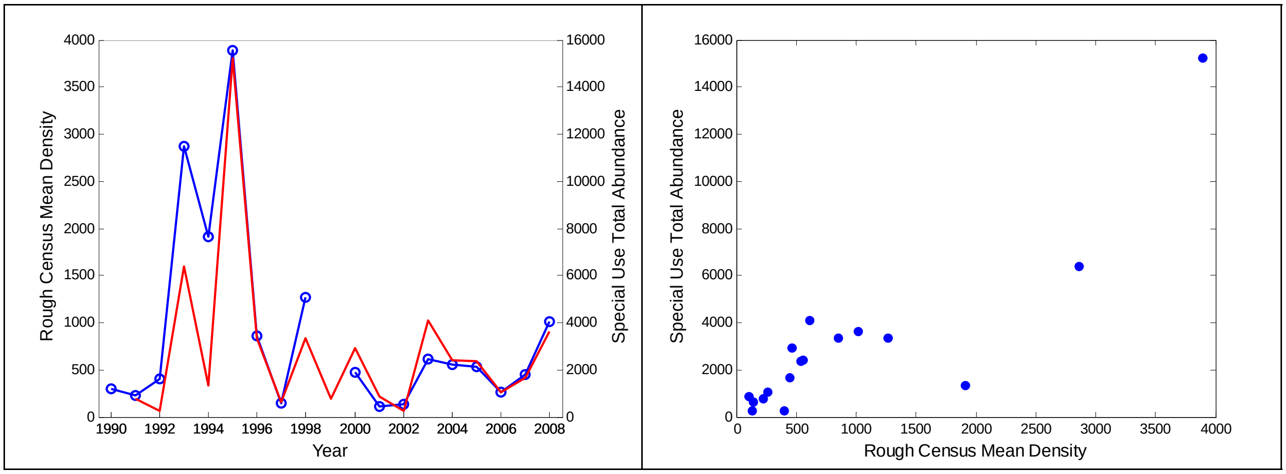
All analyses indicate a good relationship between any of the programs, either on the OTA or rangewide. "Rough census" area counts and special use plots showed a significant correlation (Table 7-1) and appear to fluctuate similarly across the years (Figure 7-1). The magnitude of the changes in the counts for the different programs might differ, but the direction of the changes from year to year corresponded well. When the "rough census" area counts increased or decreased from year to year, the special use plots increased or decreased similarly. From this, we conclude that the different methods used to conduct the "rough census" area counts and special use plot counts document similar changes in slickspot peppergrass abundance.

Table 7-1. Spearman rank correlation (*r*) and associated sample size (*n*).

Survey 1	Survey 2	r	n	Years
Rough Census	Special Use	0.8309	17	1991 – 2008
Rough Census	HIP (within OTA)	0.7000	5	2004 – 2008
Special Use	HIP (within OTA)	0.7000	5	2004 – 2008
HIP (within OTA)	HIP (outside OTA)	0.9000	5	2004 – 2008

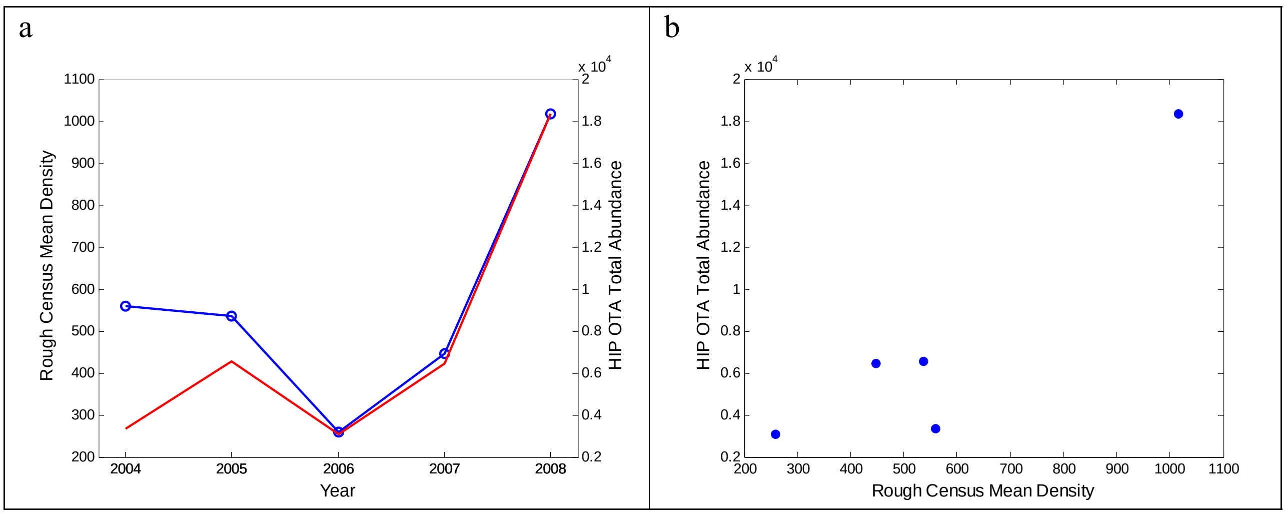
Comparisons between "rough census" area counts and special use plot counts with counts on HIP transects on the OTA showed that both the methods employed solely on the OTA document slickspot peppergrass abundance in a similar manner as the HIP methods (Table 7-1 and Figures 7-2 and 7-3). The totals that result from each method differ by as much as 2 orders of magnitude. It is not likely that any one of the monitoring programs provides a true representation of the numbers of plants present, but each program can act as an index that provides an indication of whether the number of plants in the area monitored is changing and the direction of that change (*i.e.*, positive or negative).

a	b



Blue line and circles refer to "rough census" area counts; red line refers to special use plot counts

Figure 7-1. (a) "Rough census" annual total counts of slickspot peppergrass and special use annual total counts. (b) "Rough census" vs. special use counts.



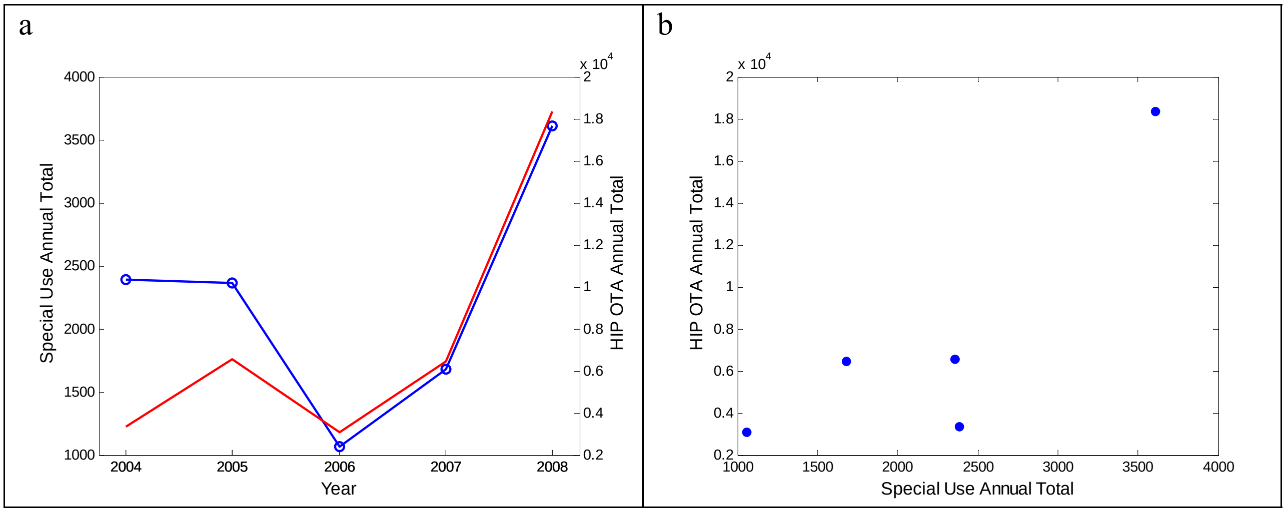
Blue line and circles refer to "rough census" area counts; red line refers to HIP counts

Figure 7-2. (a) "Rough census" annual total counts of slickspot peppergrass and HIP annual total counts on the Orchard Training Area. (b) "Rough census" vs. HIP OTA counts.

The final comparison was between the HIP transect counts on the OTA and outside the OTA. This comparison was to evaluate whether the counts are changing in a similar manner rangewide. This comparison provided the highest correlation coefficient (Table 7-1) of any of the comparisons. As was seen in the other comparisons among programs, the graphical depiction of the counts shows the annual changes track well between on the OTA and off the OTA (Figure 7-4). From this we conclude that the rangewide counts vary from year to year in a similar fashion.

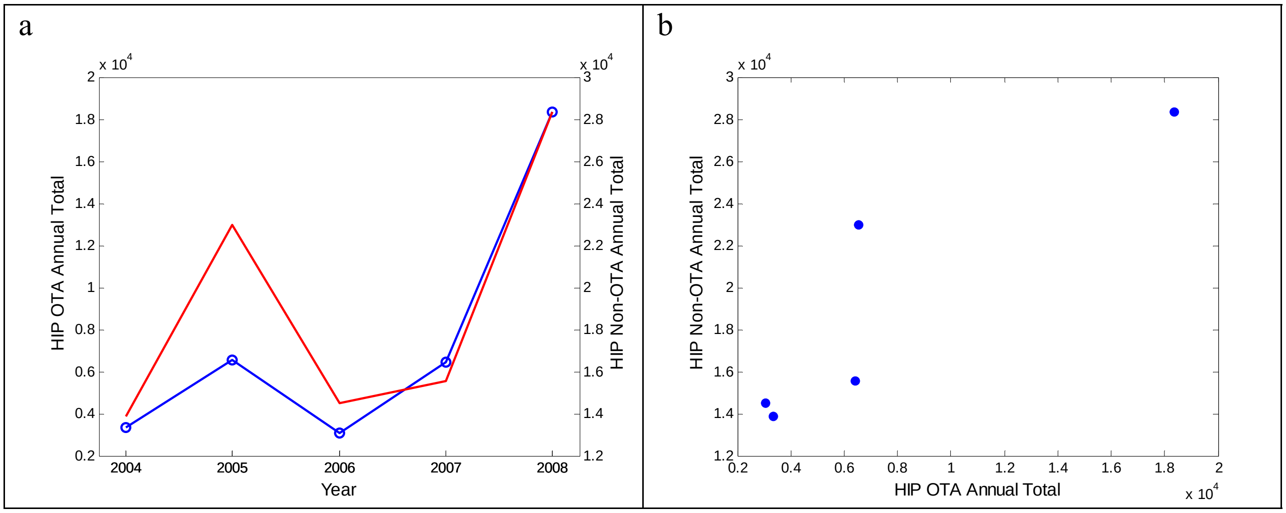
Conclusions

In this chapter we compared three different monitoring programs. Two focus only on slickspot peppergrass abundance on the OTA. The HIP program monitors slickspot peppergrass abundance rangewide. We found that the three programs all track annual changes similarly, so each can act as an index and shows similar abundance fluctuations from year to year. The comparison of the HIP program on the OTA with that off the OTA suggests that the fluctuations observed on the OTA are similar to those seen off the OTA. Although the rangewide monitoring has not been conducted for as long as the monitoring on the OTA, the trend observed on the OTA is likely representative of the trend across the entire range. Because the data from the "rough census" areas area slightly less variable, the trend from the "rough census" areas can be considered slightly more reliable.



Blue line and circles refer to special use plot counts; red line refers to HIP counts

Figure 7-3. (a) Special use annual total counts of slickspot peppergrass and HIP annual total counts on the Orchard Training Area. (b) Special use vs. HIP OTA counts.



Blue line and circles refer to HIP counts within OTA; red line refers to HIP counts outside OTA

Figure 7-4. (a) HIP annual total counts of slickspot peppergrass on the Orchard Training Area and outside the OTA. (b) Counts outside the OTA vs. within the OTA.

Chapter 8: Analyses of Habitat Integrity and Population (HIP) Data

Habitat Integrity and Population (HIP) monitoring for slickspot peppergrass has occurred since 2004. Each HIP transect consists of 10 slickspots. In 2004, the slickspot peppergrass abundance counts were categorical, but starting in 2005, the abundance counts have been total counts of slickspot peppergrass plants observed. The rosettes, reproductive plants and total plants are reported. The slickspot peppergrass counts occur on the 10 slickspots.

In addition to the counts of slickspot peppergrass, numerous other factors are recorded on the slickspot or in the surrounding habitat. For a complete summary of the HIP methods and the factors recorded see Colket (2005). Factors recorded within the slickspots include such things as prints from livestock or wildlife, cover by non-native plants, evidence whether the slickspot was previously burned, etc. The surrounding plant community is described by establishing three 10-m transects near slickspots. The shrub community was described using the line-intercept method, and grass and herbaceous cover was determined using Daubenmire plots (these methods are described in greater detail in Chapter 2).

In this chapter, we attempt to identify those factors collected within or adjacent to slickspots along the HIP transects that can be associated positively or negatively with slickspot peppergrass total abundance. In addition, we look at temperature and precipitation data to determine whether changes in weather during the previous fall or winter or during the spring impacts slickspot peppergrass abundance.

Methods

General Approach

Slickspot peppergrass abundance in the 2004 survey had been recorded in range categories, either bounded (e.g., 200 – 250) or unbounded (e.g., > 300). To allow consistent analysis with data from 2005 – 2008, bounded ranges were represented by the corresponding midpoints and unbounded ranges by the lower limit. Thereafter, the substituted values were treated as continuous data (see Chapter 7 Methods). This approach imputed precision that did not truly exist within the 2004 data, but required no loss of information from the remaining data (as would have been the case, for example, if actual counts from 2005 – 2008 had been converted to categories).

In nearly all analyses described below, slickspot peppergrass abundance was the response variable in negative binomial regression models. Temporal correlations were assumed to be present in the data due to repeated measurements on the same transects over time. To account for the effects of these potential correlations, models were estimated using the Generalized Estimating Equation (GEE) method and assuming a first-order autoregressive correlation structure. Further details on negative binomial regression and GEE are given in Chapter 3 Methods.

Abundance was modeled as a function of one or more explanatory variables including region, year, percent cover of each of several non-native plants, percent cover of livestock hoof prints, and fire history. In most cases, region and year were both considered as potential covariates along with another variable of interest such as plant cover. The intent of this strategy was to account for potential interactions between region and/or year and the other variable of interest, for example, to determine whether the effect of livestock prints on slickspot peppergrass abundance differed among regions. However, it was generally not possible to analyze these full models either because of sparse data or confounding effects between region (or year) and the variable of interest. Therefore, separate models were sometimes estimated for each region or each year or both. The chosen final analysis depended on the configuration of the data and the results of initial analyses. Details are given in each subsection below.

In these negative binomial regression models, HIP transects were treated as the sample units. Transects were regarded as constant in size; while transects varied in length, each consisted of 10 slickspots. Therefore, fixed size appeared to be a reasonable assumption, and abundance was an appropriate response variable. If transects varied in size (i.e., in number of slickspots) or if slickspots varied in size systematically with another covariate such as region, then it would have been appropriate to standardize the response, for example, as density rather than abundance. We did not examine systematic variation in slickspot size.

Region and Year

The relationships between slickspot peppergrass abundance and region (Boise Foothills, Owyhee Plateau, and Snake River Plain) or year (2004 to 2008), considered separately, were examined using negative binomial regression. Year was treated as a categorical rather than a continuous variable, such that the model independently estimated the mean response (abundance) in each year rather than fitting a linear trend to the data. Thus, models for both region and year were analogous to analysis of variance in that they addressed whether mean abundance differed among categories (i.e., among regions or among years). Consistent with that analogy, the fact that sample size (number of transects) varied among regions does not affect the validity of the analysis. The response was not total abundance per region, but rather, mean total abundance *per transect*, with region as the explanatory variable.

Temperature and Precipitation

Weather data were obtained from two to three stations for each of the three regions. For the Boise Foothills, we used data from the weather station at the Boise Airport and at the Parma Agricultural Research Center. For the Snake River Plain, we again used data from the Boise Airport, and also from Glenns Ferry and Grand View.For the Owyhee Plateau, one of the weather stations was represented by PRISM modeled data (PRISM Group, Oregon State University, http://www.prismclimate.org, created 9 December, 2008); for several months in 2005, no data other than those from PRISM were available. The other weather stations used were the Juniper Butte and Murphy Desert Hot Spring stations. The data from each station were averaged within each region providing a single estimate for a region for each month. Variables considered for analysis included minimum monthly temperature, mean monthly temperature, maximum monthly temperature, total montly precipitation, and degree-days. However, because degree-days data were incomplete for the Owyhee Plateau (no data prior to November 2005), that variable was dropped from further consideration. Furthermore, mean monthly temperature was highly correlated with both minimum and maximum temperature ($r \geq 0.99$), so only mean temperature was retained for analysis. We calculated 3-month running averages of mean monthly temperature and total monthly precipitation over the period from October through May of the following spring. These calculations yielded averages for October – December, November – January, …, and March – May of each year, preceding the period when HIP surveys were conducted (generally, June – July).

Negative binomial regression was used to model slickspot peppergrass abundance as a function of each of the 3-month averages of temperature and precipitation, separately for each of the three regions. The data for each regression analysis represented all 5 years of the HIP surveys (2004 – 2008). Potential temporal correlations in the data were modeled using Generalized Estimating Equations (GEEs) assuming a first-order autoregressive correlation structure.

There was an important limitation to further analyses due to the structure of the data. Separate analyses by both region and year (i.e., "within-year") were not possible because the weather variables were represented by a single value for each region and year. That is, weather data were only available for an entire region and not for individual HIP transects; thus, there was no variability other than region-to-region and year-to-year.

Plant Cover Within Slickspots

We examined the relationship between slickspot peppergrass abundance and cover of several selected plant species or groups that had been measured within slickspots on the HIP transects. These species or groups included biological crust, crested wheatgrass (*Agropyron cristatum*), cheatgrass (*Bromus tectorum*), forage kochia (*Bassia prostrata*, previously *Kochia prostrata*), total seeded non-native plants, and total unseeded non-native plants. During HIP surveys, plant cover within each slickspot was classified according to estimated ranges of percent cover (Table 8-1). Subsequently, transect cover values were obtained by converting each class value into the mid-points of the corresponding range, and then averaging these mid-points (usually, 10 for each transect). For each of the plant species or groups, the association between mean cover and slickspot peppergrass abundance was analyzed by region (Boise Foothills, Owyhee Plateau, and Snake River Plain) across years. Analysis consisted of both graphical assessment and negative binomial regression modeling. The Generalized Estimating Equation (GEE) method, available within SAS Proc Genmod, was used to account for potential temporal correlation within transects; a first-order autoregressive correlation structure was assumed for all GEE analyses. To assess whether the effect of cover differed among years, we examined models that included the interaction between cover and year, separately by region.

Fire

Number of fires

Based on both HIP survey data and a Bureau of Land Management fire database, a fire history for each transect was established referenced to the year 2008 (the most recent year of HIP surveys) (Beth Colket, pers. comm.). For each transect, the following data were recorded: the number of times the transect had been burned; and, for each of these occasions, the number of years since the fire.

Table 8-1. Vegetation cover classes and corresponding ranges in estimated percent cover.

Class	Range (%)
0	0
1	<1
2	1 – 4.9
3	5 – 9.9
4	10 – 24.9
5	25 – 49.9
6	50 – 74.9
7	75 – 94.9
8	95 – 100

A weighted number of fires was calculated for each transect based on the rationale that more recent fires would likely have a greater impact on slickspot peppergrass abundance than would older fires. The histories of transects that had experienced only one fire were examined to determine the age of fires (based on the BLM database) at which they became undetectable during HIP surveys. Fires greater than 39 years old could not be detected by observers monitoring HIP transects, so fires occurring 40 or more years in the past were assigned a weight equal to 0. Fires that had occurred within the year preceding the 2008 survey were assigned a weight equal to 1. Fires of intermediate age were assigned weights that decreased linearly from 1 to 0 (decreasing by 0.02564/year), depending on the age. First, the age of the fire was subtracted from 40. Then, the annual weighting factor was applied to that difference. For example, a fire occurring 25 years before 2008 or in 1983 would be assigned a weight of 0.3846 ($15 \times 0.02564 = 0.3846$). Finally, on transects where two or more fires had occurred, the weights were summed to obtain the weighted number of fires. For example, the weighted number of fires in 2008 for a transect that burned in 1994 and 1996 would be 1.3846 ($[26 \times 0.02564] + [28 \times 0.02564] = 1.3846$).

For each of the preceding years, 2004 – 2007, ages were recalculated by simple adjustment of the ages in 2008. "New" fires (when the adjusted age reached 0 or became negative) were removed from the record. Weights were recalculated based on the adjusted ages, and the weighted number of fires was similarly recalculated. The result of these data processing steps was a weighted number of fires for each year of the HIP survey, 2004 – 2008.

Analysis consisted primarily of negative binomial regression in which the response variable was abundance of slickspot peppergrass and the explanatory variables included region (Boise Foothills, Owyhee Plateau, and Snake River Plain) and either unadjusted number of fires (for 2008 only) or weighted number of fires. Interaction between region and number of fires was examined to determine whether the potential effect of fires differed among regions. If the interaction was not significant, then it was removed and the model with simple additive effects of region and fire was examined.

Short-term effects of fire

A separate analysis addressed the question of whether fires might have a short-term positive effect, leading to a temporary increase in slickspot peppergrass abundance. This analysis relied on the newly created fire history described above (*Number of fires*), in particular the ages of fires in each year of the survey. Transects that had been burned within the previous year were classified with *Recent burn*, transects that had burned two or more years previously were classified with *Old burn*, and otherwise transects were classified as *Unburned*. Negative binomial regression was used to model slickspot peppergrass abundance as a function of the burn class.

In analyses of both short-term effects and effects of number of fires, significance of categorical variables, such as region or burn class, was assessed from a Type 3 analysis (available in SAS Proc Genmod). Type 3 analysis provides a more easily interpreted summary of an overall effect than do individual parameter estimates of each category (e.g., each region).

Livestock and Ungulate Wildlife Disturbance

HIP surveys include several measurements of livestock disturbance to slickspots. Measurements used in the analysis described below were percent cover of penetrating footprints, percent cover of all livestock footprints (both penetrating and non-penetrating), and percent cover of livestock feces. Penetrating prints were defined as those prints greater than 1 inch in depth (refered to as Method 1), rather than attempting to determine whether the print broke through into the clay layer of the slickspot. Prints from ungulate wildlife used as indicators of wildlife activity were also assessed during the surveys. Subsequently, total percent cover of ungulate tracks was calculated as the sum of percent cover of deer, elk, and pronghorn antelope tracks.

Analysis addressed the potential association between slickspot peppergrass abundance and livestock or wildlife disturbance, separately within each of the three regions. As in other analyses of the HIP survey data, each of those potential associations was modeled using negative binomial regression in which slickspot peppergrass abundance was the response variable and the explanatory variable was percent cover of footprints or feces. Regressions were conducted separately for each region.

Two approaches were taken in the regression analyses. The first approach was designed to address the potential cumulative impact of disturbance. For each of the explanatory variables, percent cover values were averaged over the 5 years of the survey (2004 – 2008), while slickspot peppergrass abundance in 2008 only was used as the response. Total cover (*i.e.*, the sum of cover values over the survey) might be considered a more appropriate measure of cumulative disturbance. Note, however, that when the number of observations (years) is constant, the mean and the total differ only by a multiplicative constant (say, 5, if data were available in all 5 years). In that case, regressions on the sum, or alternatively on the mean, are equivalent. On the other hand, if one or more observations are missing, then the mean is more representative of cumulative impact. The mean effectively treats missing values as if they also equaled the mean, whereas the total under-represents the entire 5-year period. For the regression response, it was assumed that abundance in 2008 would best reflect potential cumulative impacts over the entire survey period.

The second approach simply examined each year separately. Slickspot peppergrass abundance for a particular year was regressed against the percent cover of footprints or feces for that same year. Thus, analysis of each disturbance effect entailed 15 separate regressions, one for each of the three regions and each of the five years within those regions.

An additional analysis focused on a comparison of livestock and wildlife disturbance levels, more particularly, comparison of percent cover of livestock and wildlife (*i.e.*, ungulate) footprints within slickspots. Direct comparison was conducted using paired *t*-tests in which observations on the same transect were paired together. Separate tests were conducted for each year of the survey. To further the comparison between livestock and wildlife disturbance, we also examined the association between slickspot peppergrass abundance and percent cover of wildlife footprints, using negative binomial regression models parallel to the regressions for livestock disturbance described above.

Vegetation Adjacent to HIP Transects

HIP surveys included sampling of vegetation in the areas immediately surrounding the primary transects through slickspots. Measurements along these secondary transects consisted of percent cover estimates of shrubs, herbaceous plants (grasses and forbs), and ground cover. For this analysis, several larger plant groups were created by summing cover of individual species. These groups (and their component species) included: native bunchgrasses [Indian ricegrass (*Achnatherum hymenoides*), Thurber needlegrass (*Achnatherum thurberianum*), purple threeawn (*Aristida purpurea*), bottlebrush squirreltail (*Elymus elymoides*), needle-and-thread grass (*Hesperostipa comata*), Great Basin wildrye (*Leymus cinereus*), western wheatgrass (*Pascopyrum smithii*), Sandberg bluegrass (*Poa secunda*), and bluebunch wheatgrass (*Pseudoroegneria spicata*)], non-native seeded plants [crested wheatgrass (*Agropyron cristatum*), forage kochia (*Bassia prostrata*), blue flax (*Linum perenne*), alfalfa (*Medicago sativa*), annual rye (*Secale cereale*), and intermediate wheatgrass (*Thinopyrum intermedium*)], non-native unseeded plants [soft brome (*Bromus hordeaceus*), whitetop (*Cardaria draba*), garden cornflower (*Centaurea cyanus*), bur buttercup (*Ceratocephala testiculata*), goosefoot (*Chenopodium* spp.), rush skeletonweed (*Chondrilla juncea*), herb sophia (*Descurainia sophia*), spring draba (*Draba verna*), redstem stork's bill (*Erodium cicutarium*), halogeton (*Halogeton glomeratus*), jagged chickweed (*Holosteum umbellatum*), Mexican-fireweed (*Bassia scoparia*), smotherweed (*Bassia* spp.), prickly lettuce (*Lactuca serriola*), clasping leaf pepperweed (*Lepidium perfoliatum*), bulbous bluegrass (*Poa bulbosa*), prickly Russian thistle (*Salsola tragus*), tall tumblemustard (*Sisymbrium altissimum*), medusahead (*Taeniatherum caput-medusae*), dandelion (*Taraxacum officinale*), yellow salsify (*Tragopogon dubius*), and fescue (*Vulpia* spp.)], and rabbitbrush [green rabbitbrush (*Chrysothamnus viscidiflorus*) and rubber rabbitbrush (*Ericameria nauseosa*)]. In addition to these combined groups, the analysis dataset included big sagebrush (*Artemisia tridentata*), cheatgrass (*Bromus tectorum*) and biological crust.

Each of these species or groups was treated as the explanatory variable in negative binomial regression models for slickspot peppergrass abundance. The association between cover and abundance was analyzed by region across years. The Generalized Estimating Equation (GEE) method, available within SAS Proc Genmod, was used to account for potential temporal correlation within transects; a first-order autoregressive correlation structure was assumed for all GEE analyses. To assess whether the effect of cover differed among years, we examined models that included the interaction between cover and year, separately by region.

Results

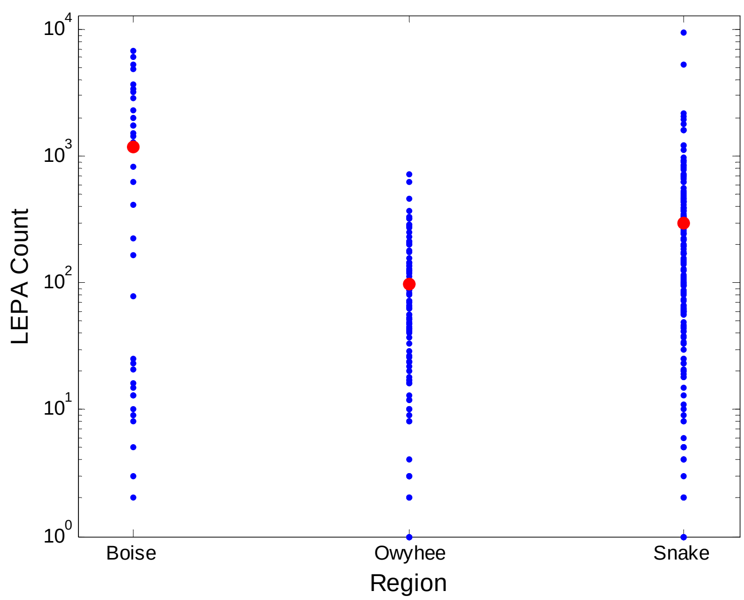
Region and Year

Negative binomial regression showed that the overall effect of region on slickspot peppergrass abundance was signficant ($p = 0.0202$, Table 8-2). Based on the signs of the estimated coefficients ("Estimate" column, Table 8-2), mean abundance across all years was greater in the Boise Foothills than in the Snake River Plain (the reference category), whereas abundance was lower on the Owyhee Plateau than on the Snake River Plain. The *Estimate* for Boise and Owyhee in Table 8-2 represents the difference (on a natural log scale) between mean abundance in each of these regions and the Snake River Plain. These patterns are confirmed by a plot of abundance for each region (Figure 8-1).

Table 8-2. Negative binomial regression results for effect of region on slickspot peppergrass abundance. Both overall Type 3 results and individual parameter statistics are shown (Snake River Plain is the reference category).

Parameter	*df*	Estimate	Std Error	*Z*	X^2	*p*-value
Intercept	1	5.7518	0.2774	20.74		<0.0001
Region - Boise	1	1.3287	0.4814	2.76		0.0058
Region - Owyhee	1	-1.1623	0.3324	-3.50		0.0005
Region (Type 3)	2				7.81	0.0202

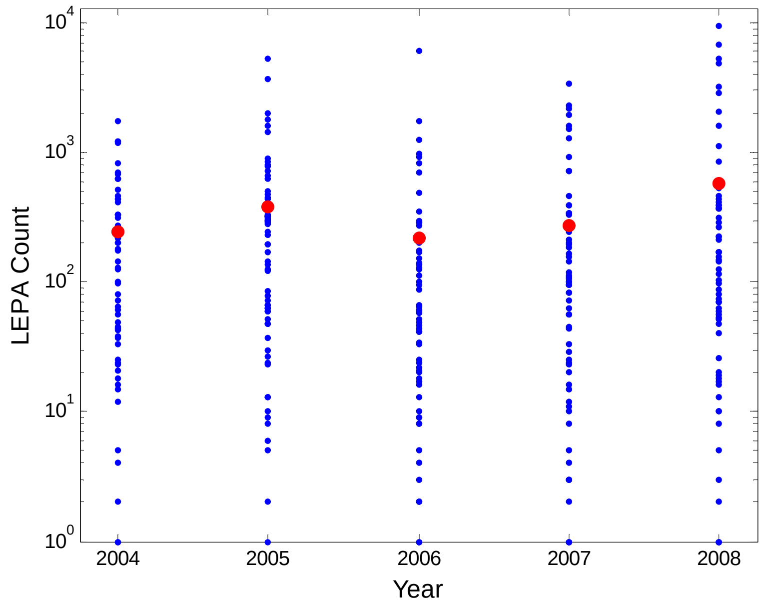
df is degrees of freedom; *Z* is the standard normal statistic; X^2 is the chi-squared statistic.



Blue dots represent individual observations; red circles represent mean abundance.

Figure 8-1. Slickspot peppergrass abundance for each of the 3 regions in the HIP survey, across all years.

Similarly, the overall effect of year was significant ($p = 0.0427$, Table 8-3), though year-to-year variation in mean abundance (Figure 8-2) was somewhat lower than the variation among regions. Mean abundance was greatest in 2008 and lowest in 2006. The *Estimate* for 2005 through 2008 in Table 8-3 represents the difference (on a natural log scale) between mean abundance in each of these years and 2004.



Blue dots represent individual observations; red circles represent mean abundance.

Figure 8-2. Slickspot peppergrass abundance for each year of the HIP survey, across all regions.

Table 8-3. Negative binomial regression results for effect of year on slickspot peppergrass abundance. Both overall Type 3 results and individual parameter statistics are shown (2004 is the reference category).

Parameter	*df*	Estimate	Std Error	*Z*	X^2	*p*-value
Intercept	1	5.4653	0.2838	19.26		<0.0001
2005	1	0.4593	0.2302	2.00		0.0460
2006	1	-0.0739	0.2929	-0.25		0.8009
2007	1	0.1494	0.3287	0.45		0.6493
2008	1	0.9021	0.3510	2.57		0.0102
Year (Type 3)	4				9.87	0.0427

df is degrees of freedom; *Z* is the standard normal statistic; X^2 is the chi-squared statistic.

Temperature and Precipitation

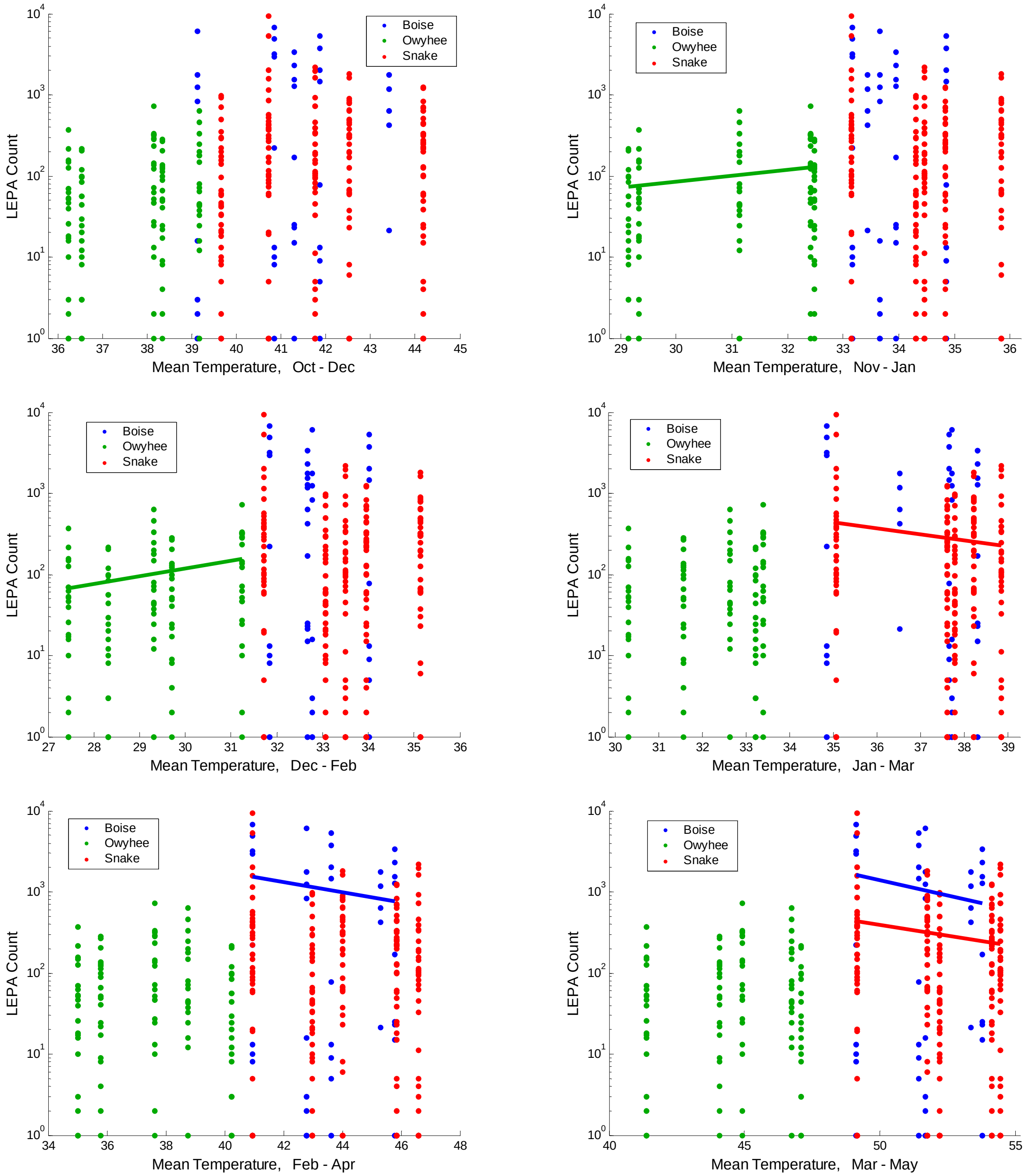
Graphs of slickspot peppergrass abundance versus temperature for each of the 3-month running averages (Figure 8-3) show that temperatures were lower on the Owyhee Plateau than either in the Boise Foothills or on the Snake River Plain in all five years of the HIP surveys. While these graphs show that abundance generally was lower on the Owyhee Plateau than in the other two regions, from the raw data alone (dots in Figure 8-3) it is difficult to discern patterns in abundance within each region as a function of tempererature. Negative binomial regression results indicate that in most cases, abundance was not significantly related to temperature at

Table 8-4. Negative binomial regression results for effect of temperature on slickspot peppergrass abundance. Mean monthly temperature was averaged over 3-month periods.

Period	Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Oct-Dec	Boise	Intercept	10.7988	5.3976	2.00	0.0454
		Slope	-0.0902	0.1305	-0.69	0.4893
	Owyhee	Intercept	-0.4073	3.7450	-0.11	0.9134
		Slope	0.1316	0.0992	1.33	0.1847
	Snake	Intercept	5.8718	4.0352	1.46	0.1456
		Slope	-0.0031	0.0963	-0.03	0.9747
Nov-Jan	Boise	Intercept	7.1392	9.4372	0.76	0.4494
		Slope	-0.0017	0.2791	-0.01	0.9951
	Owyhee	Intercept	-0.7273	2.0267	-0.36	0.7197
		Slope	0.1721	0.0658	2.61	0.0089
	Snake	Intercept	11.1357	5.1347	2.17	0.0301
		Slope	-0.1574	0.1492	-1.06	0.2913
Dec-Feb	Boise	Intercept	8.2089	8.4712	0.97	0.3325
		Slope	-0.0346	0.2586	-0.13	0.8935
	Owyhee	Intercept	-1.6857	2.2464	-0.75	0.4530
		Slope	0.2153	0.0774	2.78	0.0054
	Snake	Intercept	9.5388	3.8022	2.51	0.0121
		Slope	-0.1145	0.1139	-1.00	0.3150
Jan-Mar	Boise	Intercept	13.1385	4.8105	2.73	0.0063
		Slope	-0.1666	0.1310	-1.27	0.2033
	Owyhee	Intercept	1.8216	2.0308	0.90	0.3697
		Slope	0.0862	0.0633	1.36	0.1736
	Snake	Intercept	12.1230	2.7221	4.45	<0.0001
		Slope	-0.1726	0.0732	-2.36	0.0183
Feb-Apr	Boise	Intercept	13.3016	3.0516	4.36	<0.0001
		Slope	-0.1454	0.0702	-2.07	0.0384
	Owyhee	Intercept	5.1975	1.3583	3.83	0.0001
		Slope	-0.0161	0.0361	-0.45	0.6548
	Snake	Intercept	9.7059	2.0445	4.75	<0.0001
		Slope	-0.0907	0.0464	-1.95	0.0506
Mar-May	Boise	Intercept	15.9623	3.8956	4.10	<0.0001
		Slope	-0.1744	0.0757	-2.31	0.0212
	Owyhee	Intercept	5.8065	1.6606	3.50	0.0005
		Slope	-0.0270	0.0370	-0.73	0.4662
	Snake	Intercept	12.2243	2.4224	5.05	<0.0001
		Slope	-0.1250	0.0464	-2.69	0.0071

Z is the standard normal statistic.

$\alpha = 0.05$ (Table 8-4). Significant regressions are shown in Figure 8-3 by lines representing predicted abundance. We could not draw any firm conclusion, though the results show that during late fall and winter (November – January and December – February running averages), the only significant relationships were positive (increasing abundance with increasing temperature) and occurred for the Owyhee Plateau, while later in the spring significant relationships were negative (greater abundance with decreased temperatures) but only in the Boise Foothills and Snake River Plain.



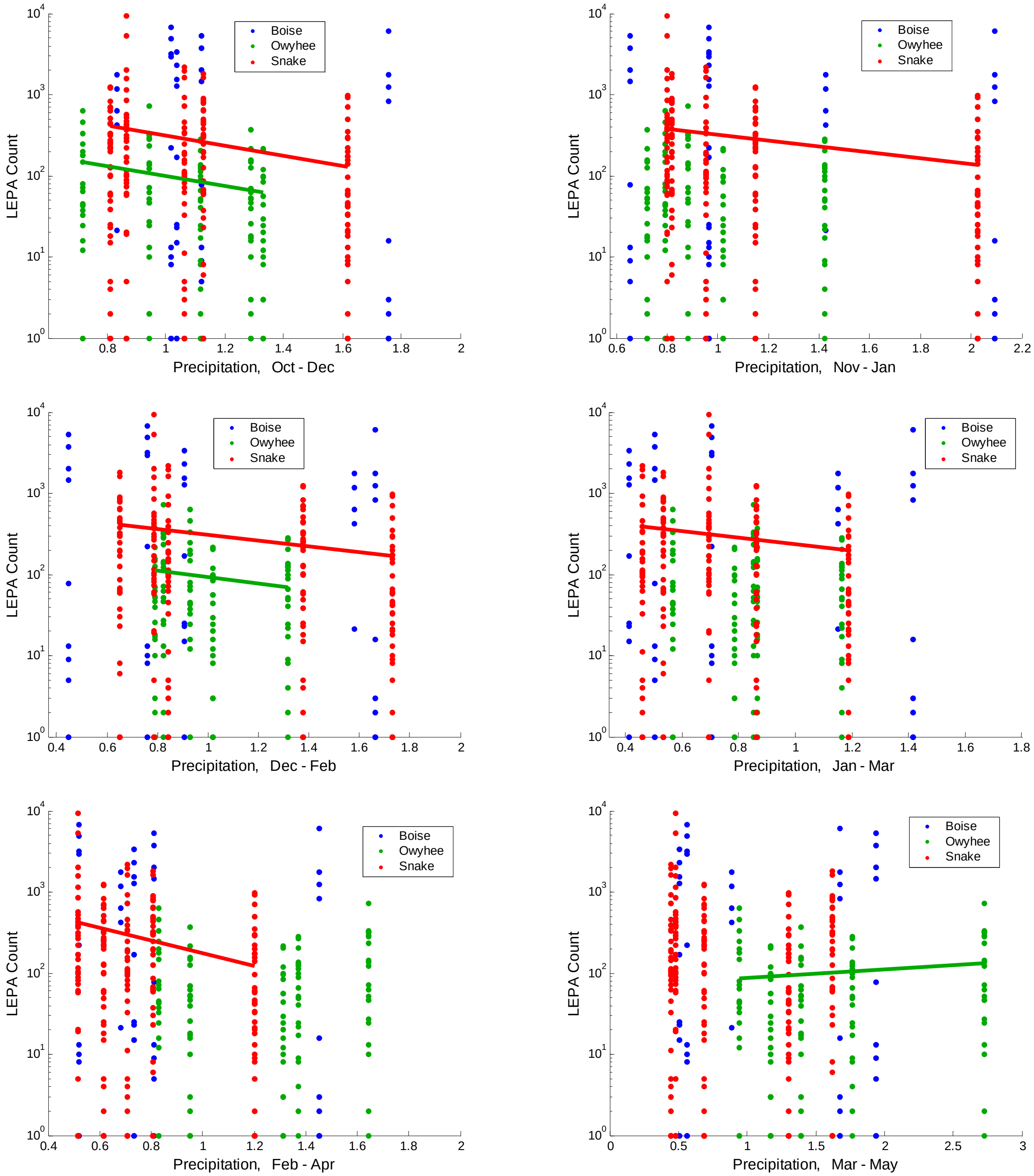
Each dot represents an observation from a transect in one of the five survey years. Lines show predicted abundance based on negative binomial regression models significant at α = 0.05 (Table 8-4).

Figure 8-3. Slickspot peppergrass abundance as a function of mean monthly temperature averaged over 3-month periods, by region.

Table 8-5. Negative binomial regression results for effect of precipitation on slickspot peppergrass abundance. Total monthly precipitation was averaged over 3-month periods.

Period	Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Oct-Dec	Boise	Intercept	7.0438	0.6840	10.30	<0.0001
		Slope	0.0342	0.5318	0.06	0.9487
	Owyhee	Intercept	5.9966	0.5892	10.18	<0.0001
		Slope	-1.3920	0.5320	-2.62	0.0089
	Snake	Intercept	7.1938	0.4709	15.28	<0.0001
		Slope	-1.4371	0.4065	-3.53	0.0004
Nov-Jan	Boise	Intercept	7.2844	0.4660	15.63	<0.0001
		Slope	-0.1815	0.2858	-0.64	0.5253
	Owyhee	Intercept	5.1593	0.3622	14.24	<0.0001
		Slope	-0.6449	0.3374	-1.91	0.0560
	Snake	Intercept	6.5989	0.3205	20.59	<0.0001
		Slope	-0.8299	0.2238	-3.71	0.0002
Dec-Feb	Boise	Intercept	7.4002	0.4560	16.23	<0.0001
		Slope	-0.3360	0.3163	-1.06	0.2882
	Owyhee	Intercept	5.4433	0.4200	12.96	<0.0001
		Slope	-0.9152	0.3977	-2.30	0.0214
	Snake	Intercept	6.5700	0.3303	19.89	<0.0001
		Slope	-0.8262	0.2477	-3.33	0.0009
Jan-Mar	Boise	Intercept	7.1835	0.4432	16.21	<0.0001
		Slope	-0.1306	0.3759	-0.35	0.7283
	Owyhee	Intercept	4.8131	0.4011	12.00	<0.0001
		Slope	-0.2885	0.4367	-0.66	0.5088
	Snake	Intercept	6.4081	0.4059	15.79	<0.0001
		Slope	-0.9368	0.4653	-2.01	0.0441
Feb-Apr	Boise	Intercept	7.2799	0.5384	13.52	<0.0001
		Slope	-0.2650	0.5314	-0.50	0.6180
	Owyhee	Intercept	4.2438	0.3495	12.14	<0.0001
		Slope	0.3195	0.2683	1.19	0.2337
	Snake	Intercept	6.9824	0.3790	18.42	<0.0001
		Slope	-1.8151	0.4431	-4.10	<0.0001
Mar-May	Boise	Intercept	6.9165	0.4791	14.44	<0.0001
		Slope	0.1733	0.3198	0.54	0.5879
	Owyhee	Intercept	4.2362	0.2552	16.60	<0.0001
		Slope	0.2426	0.1229	1.97	0.0485
	Snake	Intercept	5.9460	0.3313	17.95	<0.0001
		Slope	-0.2616	0.3044	-0.86	0.3901

Z is the standard normal statistic.



Each dot represents an observation from a transect in one of the five survey years. Lines show predicted abundance based on negative binomial regression models significant at α = 0.05 (Table 8-5).

Figure 8-4. Slickspot peppergrass abundance as a function of total monthly precipitation averaged over 3-month periods, by region.

Regional differences in precipitation (Figure 8-4) are less conspicuous than the differences in temperature (Figure 8-3). However, it appears that in the fall (October – December) precipitation was generally lower on the Owyhee Plateau than in the other two regions, and furthermore, that this pattern shifted through the winter so that by spring (February – April and

March – May), precipitation was generally higher on the Owyhee Plateau. As with the temperature data, the raw precipitation data do not show clear relationships with slickspot peppergrass abundance when considered separately within each region. However, nearly half of the regression models were significant (Table 8-5) and, of these, most were negative (indicating decreasing abundance with increasing precipitation). These cases occurred throughout the fall, winter, and early spring. The only significant, positive regression was for the Owyhee Plateau in spring (March – May). No significant cases occurred for the Boise Foothills.

Plant Cover Within Slickspots

In general, cover of the six plant species and groups was confounded with region. That is, cover showed strong associations with region (Figure 8-5) such that the effects on slickspot peppergrass abundance were not independent and, thus, not truly separable in this analysis. Based on graphical assessment, the associations between cover and region were strongest for crested wheatgrass, for which observations from the Owyhee Plateau fall primarily along the X-axis (X-axis is % plant cover) while observations for the Boise Foothills and the Snake River Plain fall along the Y-axis (Y-axis is slickspot peppergrass abundance) (Figure 8-5). In other words, crested wheatgrass occurs across a wide range of percent cover on the Owyhee Plateau, but slickspot peppergrass is either absent or only present in relatively low numbers. In the other two regions, crested wheatgrass is either absent or rare, while slickspot peppergrass is relatively abundant especially on the Boise Plateau. Similar associations occur for the other plants, though such patterning is weakest for biological crust (Figure 8-5).

In contrast, associations between plant cover and year are not readily apparent (Figure 8-6). While the near mutual exclusivity of these plants (excepting biological crust) and slickspot peppergrass is a dominant pattern in Figure 8-6 as well as Figure 8-5, it is not clear that cover varies systematically by year as it does by region.

This graphical assessment provides the rationale for separate anlyses by region, though not by year: the confounding between region and plant cover precludes straightforward modeling in which effects of both region and cover would be considered simultaneously. Thus, the analysis here was directed at assessing the associations between plant cover and slickspot peppergrass abundance within each region.

On the other hand, because year was not confounded with cover, both effects were considered together in models. Negative binomial regression models that tested interactions between plant cover and year generally showed that the interactions were not significant (18 models: 6 species/groups × 3 regions). The exceptions included forage kochia for which all interaction models failed to converge due to the extreme configuration of the data (discussed in greater detail below). Otherwise, three models for the Boise Foothills region (those for biological crust, crested wheatgrass, and total unseed non-natives) indicated significant interactions. Thus, there was very limited evidence that the effect of plant cover on slickspot peppergrass abundance varied among years. Therefore, for the sake of consistent and interpretable analysis, the interaction term was dropped from all models.

Furthermore, with the absence of interaction effects, year was dropped completely from all models. Certainly, year could have been retained for assessment of additive effects with plant cover. However, doing so would have added little to the understanding of plant cover effects. There is undoubtedly an association between year and abundance (Table 8-3, Figure 8-2), but the evidence (based on the examination of interactions) indicates that that effect is generally constant irrespective of plant cover.

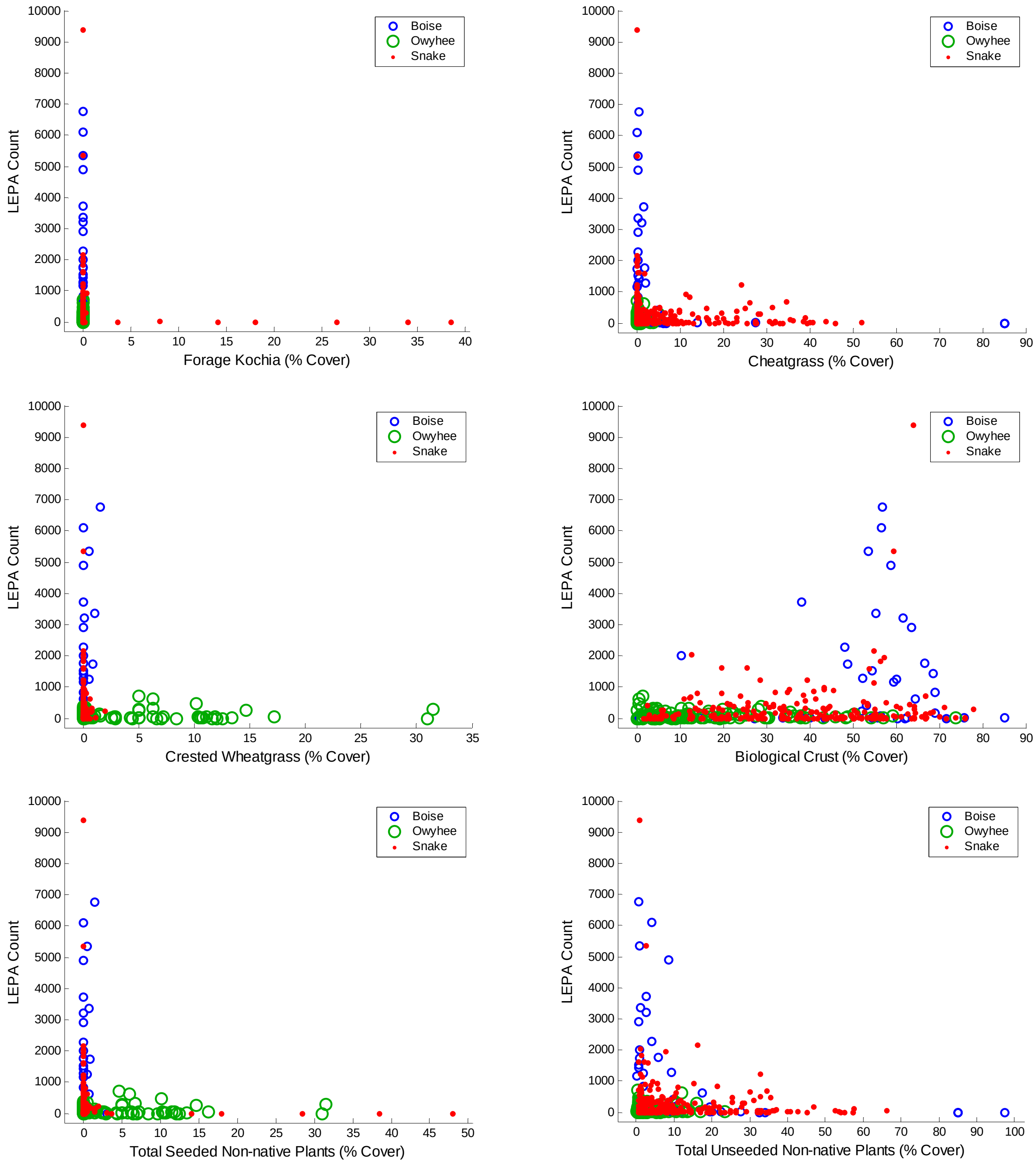


Figure 8-5. Slickspot peppergrass abundance as a function of plant cover within slickspots, by region.

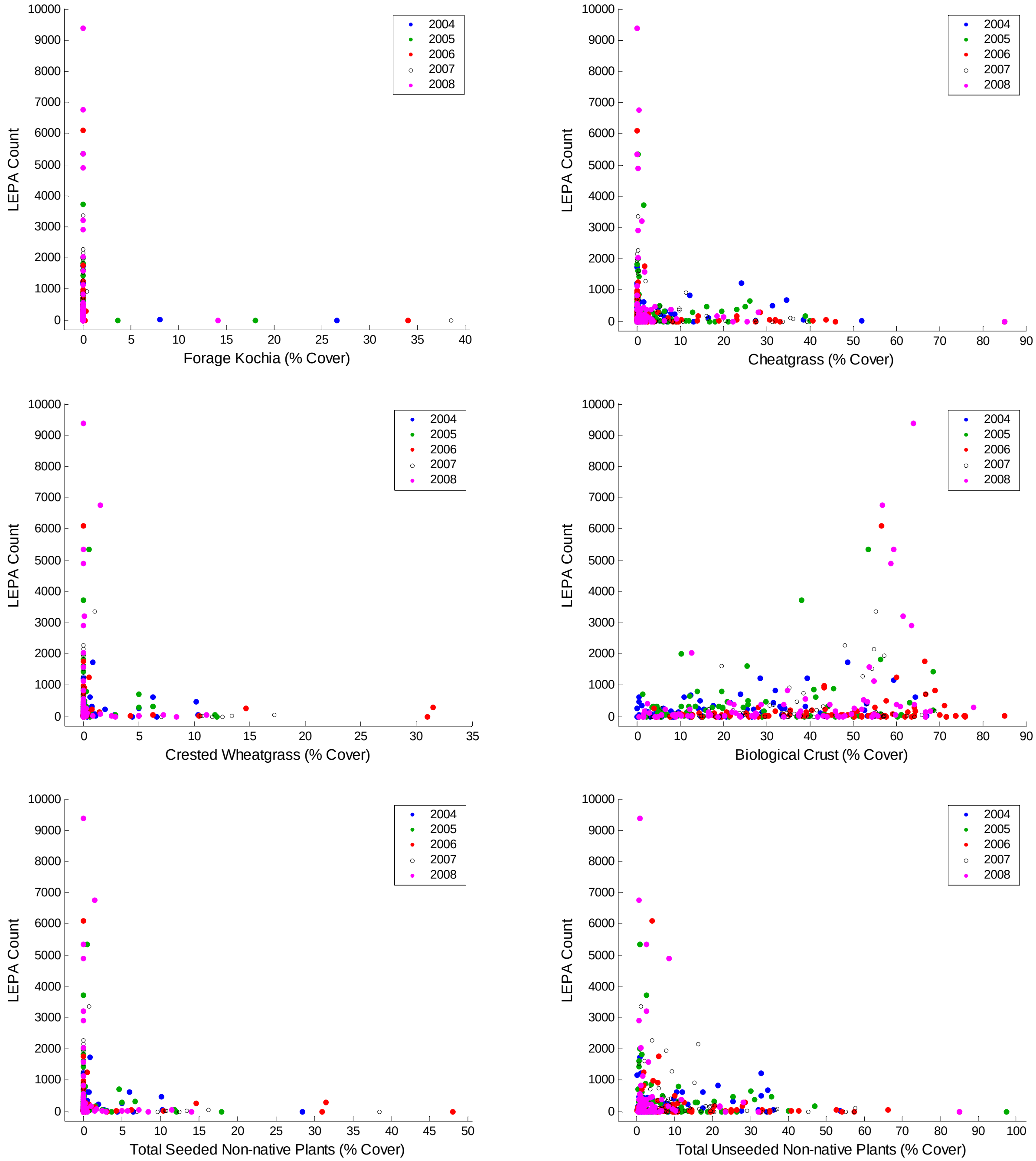


Figure 8-6. Slickspot peppergrass abundance as a function of plant cover within slickspots, by year.

In the remaining analyses, slickspot peppergrass was modeled as a function of plant cover alone, separately for each region. Results from these regression models are shown in Tables 8-6 to 8-11 and Figure 8-7. Fitted regression lines are plotted for models where cover was signficant at the 10% level. In several of these cases, the result was determined largely by apparent mutual exclusivity of the plant species/group in question and slickspot peppergrass. That is, if the plant was present, slickspot peppergrass tended to be absent and vice versa. This relationship is clearest for forage kochia on the Snake River Plain (Figure 8-7), but is also the case for total seeded non-native plants on the Snake River Plain as well as cheatgrass and total unseeded non-native plants both in the Boise Foothills. It might be tempting to conclude that statistical signficance in each of these cases is an artifact of unusual data configuration. It seems plausible, however, that the underlying relationships are real, even though highly non-linear.

Otherwise, the results indicate that slickspot peppergrass abundance decreases with increasing cover of cheatgrass and total unseeded non-natives, both on the Snake River Plain. Cover appears to have opposite effects on abundance depending on region, for both biological crust and total seeded non-natives (Tables 8-9 and 8-10, Figure 8-7).

In summary, interpretation of the relationship between slickspot peppergrass abundance and cover of the six selected species/groups is complicated by the confounded effects between region and cover. When analysis is restricted to within-region effects of cover, the available evidence generally indicates negative association, namely, declining slickspot peppergrass abundance as plant cover increases.

Table 8-6. Negative binomial regression results for effect of forage kochia cover within slickspots on slickspot peppergrass abundance, by region.

Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Boise Foothills	Intercept	7.0819	0.3239	21.86	<0.0001
	Slope	NA[1]			
Owyhee Plateau	Intercept	4.5923	0.1986	23.12	<0.0001
	Slope	NA[1]			
Snake River Plain	Intercept	5.7752	0.2115	27.31	<0.0001
	Slope	-0.6656	0.2645	-2.52	0.0118

df is degrees of freedom; *Z* is the standard normal statistic.

[1]Slope not estimable for this region.

Table 8-7. Negative binomial regression results for effect of cheatgrass cover within slickspots on slickspot peppergrass abundance, by region.

Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Boise Foothills	Intercept	7.3272	0.2923	25.07	<0.0001
	Slope	-0.1757	0.0393	-4.47	<0.0001
Owyhee Plateau	Intercept	4.5065	0.2176	20.71	<0.0001
	Slope	0.1917	0.2032	0.94	0.3453
Snake River Plain	Intercept	5.9088	0.2182	27.08	<0.0001
	Slope	-0.0329	0.0154	-2.13	0.0329

df is degrees of freedom; *Z* is the standard normal statistic.

Table 8-8. Negative binomial regression results for effect of crested wheatgrass cover within slickspots on slickspot peppergrass abundance, by region.

Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Boise Foothills	Intercept	6.7827	0.3722	18.22	<0.0001
	Slope	1.2383	0.9686	1.28	0.2011
Owyhee Plateau	Intercept	4.6295	0.2178	21.26	<0.0001
	Slope	-0.0117	0.0217	-0.54	0.5886
Snake River Plain	Intercept	5.7548	0.2168	26.55	<0.0001
	Slope	-0.3284	0.9804	-0.33	0.7377

df is degrees of freedom; *Z* is the standard normal statistic.

Table 8-9. Negative binomial regression results for effect of biological crust cover within slickspots on slickspot peppergrass abundance, by region.

Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Boise Foothills	Intercept	5.9060	0.5655	10.44	<0.0001
	Slope	0.0226	0.0100	2.27	0.0234
Owyhee Plateau	Intercept	4.7353	0.2061	22.98	<0.0001
	Slope	-0.0127	0.0060	-2.11	0.0348
Snake River Plain	Intercept	5.3455	0.3459	15.45	<0.0001
	Slope	0.0099	0.0080	1.25	0.2126

df is degrees of freedom; *Z* is the standard normal statistic.

Table 8-10. Negative binomial regression results for effect of total seeded non-native plant cover within slickspots on slickspot peppergrass abundance, by region.

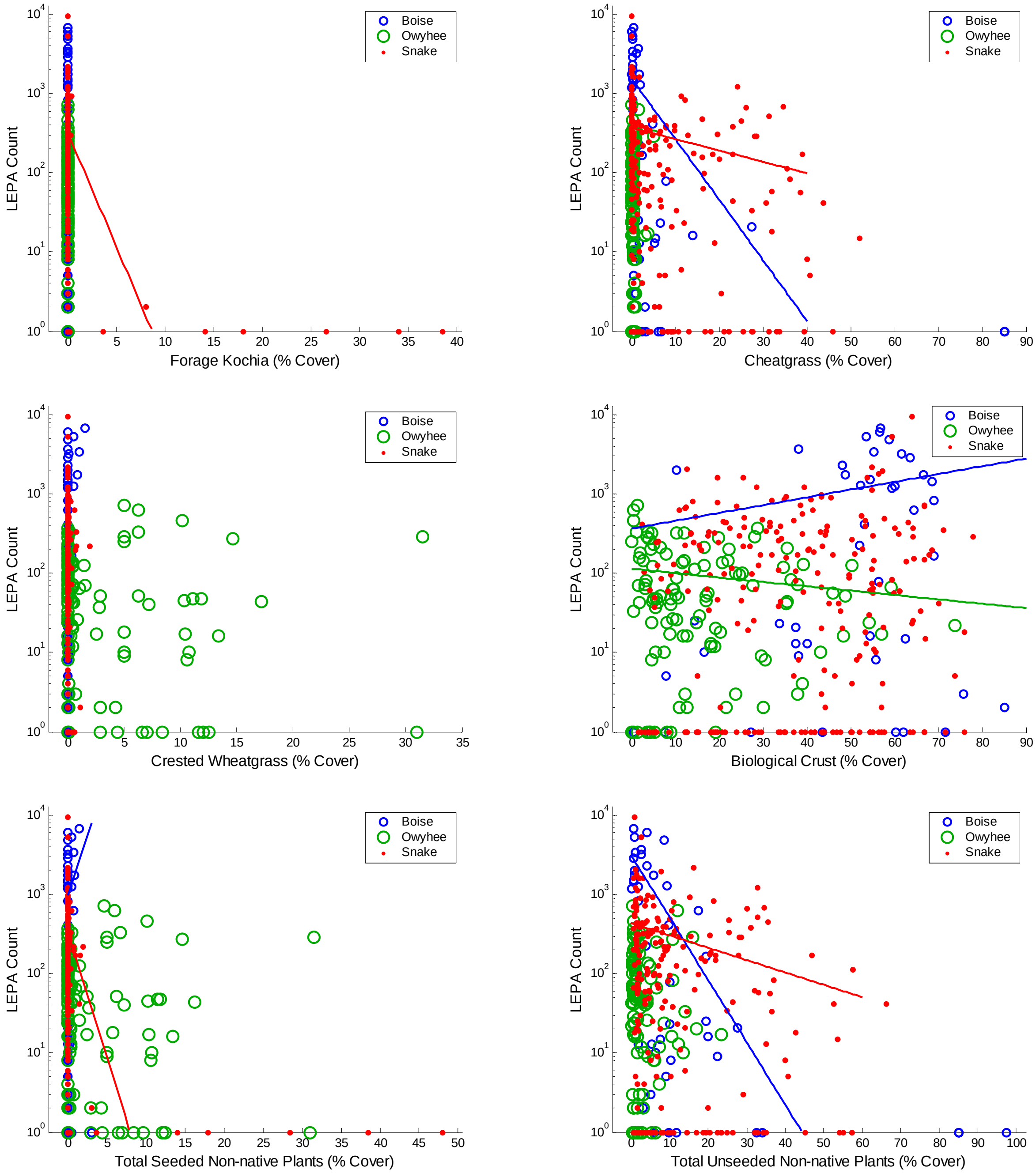
Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Boise Foothills	Intercept	6.8801	0.3449	19.95	<0.0001
	Slope	0.6995	0.3702	1.89	0.0589
Owyhee Plateau	Intercept	4.6317	0.2184	21.21	<0.0001
	Slope	-0.0124	0.0216	-0.57	0.5672
Snake River Plain	Intercept	5.8002	0.2081	27.88	<0.0001
	Slope	-0.7270	0.3762	-1.93	0.0533

df is degrees of freedom; *Z* is the standard normal statistic.

Table 8-11. Negative binomial regression results for effect of total unseeded non-native plant cover within slickspots on slickspot peppergrass abundance, by region.

Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Boise Foothills	Intercept	8.0515	0.3451	23.33	<0.0001
	Slope	-0.1813	0.0270	-6.71	<0.0001
Owyhee Plateau	Intercept	4.5670	0.2168	21.06	<0.0001
	Slope	0.0087	0.0291	0.30	0.7656
Snake River Plain	Intercept	6.0787	0.2295	26.49	<0.0001
	Slope	-0.0359	0.0115	-3.13	0.0017

df is degrees of freedom; *Z* is the standard normal statistic.



Lines show predicted values of abundance based on negative binomial regression models significant at the 10% level (Tables 8-6 to 8-11).

Figure 8-7. Slickspot peppergrass abundance on a logarithmic scale as a function of plant cover within slickspots, by region.

Fire

Number of fires

The number of fires that have occurred on the HIP transects (Table 8-12) does not differ by region (ANOVA F = 0.507, *p-value* = 0.6042). Similarly, the weighted number of fires occurring on the HIP transects (Table 8-13) also does not differ among regions (ANOVA F = 0.753, *p-value* = 0.4754).

Table 8-12. Number of fires occurring on HIP transects presented by Region

Region	n	Mean	Std. Error
Boise Foothills	10	1.10	0.35
Owyhee Plateau	22	0.77	0.16
Snake River Plain	48	0.92	0.13

Table 8-13. Weight number of fires occurring on HIP transects presented by Region

Region	n	Mean	Std. Error
Boise Foothills	10	0.47	0.11
Owyhee Plateau	22	0.48	0.10
Snake River Plain	48	0.34	0.06

Negative binomial regression models including region and weighted number of fires were examined for each year of the HIP survey, 2004 through 2008. Interactions between region and number of fires were not significant at $\alpha = 0.05$, for any of the five years (Table 8-14). That is, there was little evidence that an effect of number of past fires differed among regions, though in 2006 the interaction was strong enough to suggest some effect ($p = 0.0634$). Given the limited evidence, the interaction term was dropped in favor of simpler models based on additive effects of region and number of fires.

The effect of weighted number of fires was significant in all years except 2004 (Table 8-15). Furthermore, for 2005 to 2008, the estimated slope coefficient was negative (*Wtd Number Fires* in Table 8-15) indicating that slickspot peppergrass abundance decreased with increasing weighted number of fires (Figure 8-8). Since the interaction term was dropped from the analysis, the lines in Figure 8-9 are parallel. The slope for each line appears in Table 8-15 as the *Estimate* for the *Wtd Number Fires*. Region was significant at $\alpha = 0.05$ in all years (Table 8-15, Type 3 summary). For each year of the survey, individual parameter estimates for region indicate that the Boise Foothills had somewhat higher (though not necessarily significant) slickspot peppergrass abundance than the Snake River Plain (the reference category). The vertical separation between the lines in Figure 8-8 for Boise and Owyhee compared with the line for the Snake River Plain is given as the *Estimate* for these regions in Table 8-15. This is evident from the positive coefficient of the *Region-Boise* parameter (Table 8-15). In contrast, abundance on the Owyhee Plateau was lower than on the Snake River Plain (see Figure 8-8), based on the negative coefficients of the *Region-Owyhee* parameter. Because the effects of region and number of fires are additive in the model, predicted abundance of slickspot peppergrass shows the same relationship with number of fires in all three regions. That is, fitted regression lines have the same slope, and are parallel on a logarithmic scale (Figure 8-8).

Table 8-14. Negative binomial regression results for interaction between region and weighted number of fires, by year.

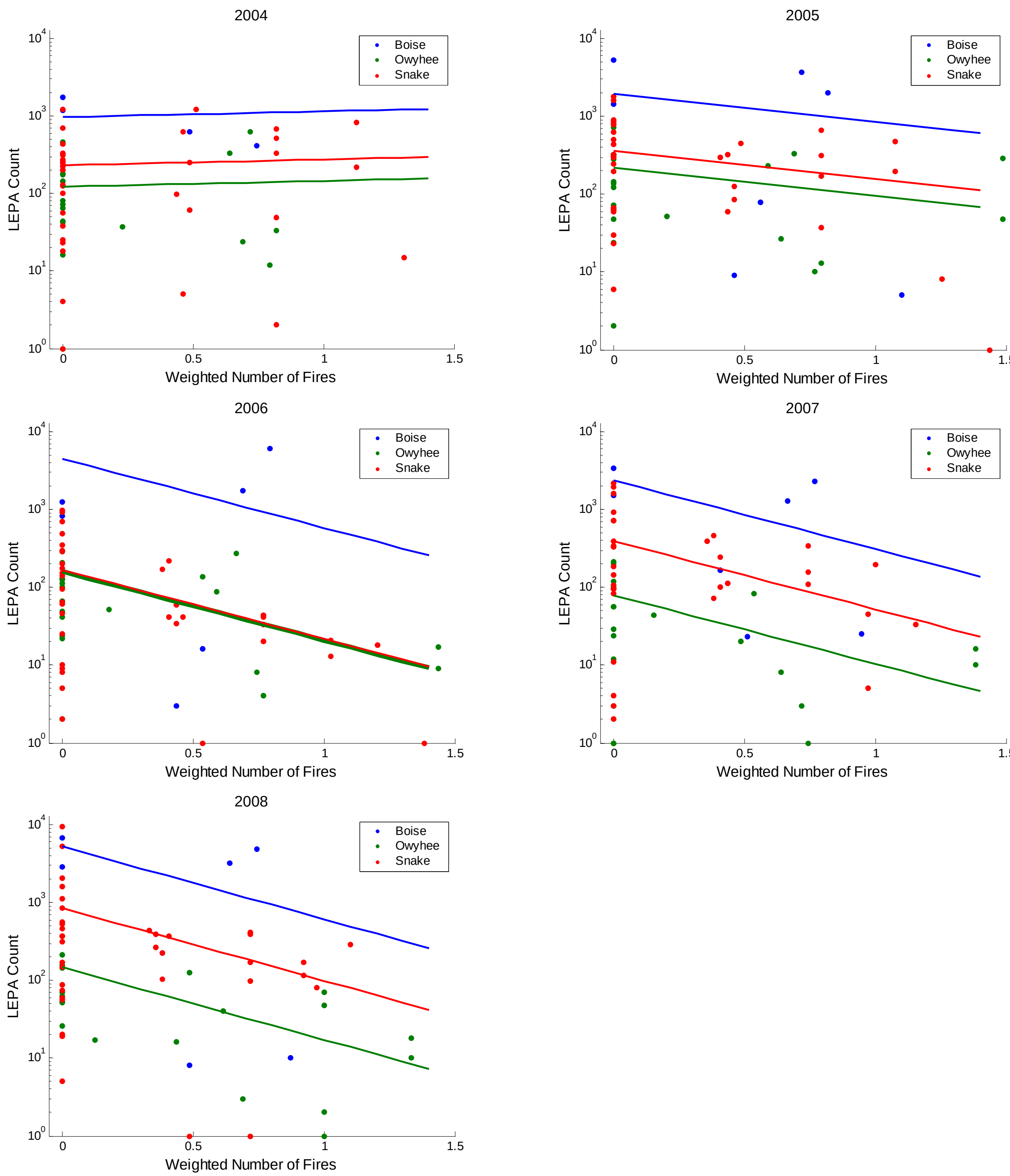
Year	X^2	*p*-value
2004	0.60	0.7396
2005	1.14	0.5662
2006	5.52	0.0634
2007	1.01	0.6023
2008	1.05	0.5919

X^2 is the chi-squared statistic for the Type 3 analysis of the overall effect.

Table 8-15. Negative binomial regression results for additive models including both region and weighted number of fires, by year. For region, both overall Type 3 results and individual parameter statistics are shown (Snake River Plain is the reference category).

Year	Parameter	*df*	Estimate	Std Error	X^2	*p*-value
2004	Intercept	1	5.4430	0.2740	394.55	<0.0001
	Wtd Number Fires	1	0.1735	0.4350	0.16	0.6900
	Region-Boise Foothills	1	1.4296	0.7864	3.31	0.0691
	Region-Owyhee Plateau	1	-0.6346	0.3954	2.58	0.1085
	Region (Type 3)	2			8.71	0.0128
2005	Intercept	1	5.8922	0.2846	428.70	<0.0001
	Wtd Number Fires	1	-0.8310	0.4238	3.84	0.0499
	Region-Boise Foothills	1	1.6911	0.6311	7.18	0.0074
	Region-Owyhee Plateau	1	-0.5004	0.4566	1.20	0.2731
	Region (Type 3)	2			13.73	0.0010
2006	Intercept	1	5.1211	0.2802	334.11	<0.0001
	Wtd Number Fires	1	-2.0400	0.5310	14.76	0.0001
	Region-Boise Foothills	1	3.2857	0.6824	23.18	<0.0001
	Region-Owyhee Plateau	1	-0.0444	0.4739	0.01	0.9254
	Region (Type 3)	2			30.23	<0.0001
2007	Intercept	1	5.9819	0.3107	370.72	<0.0001
	Wtd Number Fires	1	-2.0301	0.4855	17.48	<0.0001
	Region-Boise Foothills	1	1.7876	0.6801	6.91	0.0086
	Region-Owyhee Plateau	1	-1.6104	0.4834	11.10	0.0009
	Region (Type 3)	2			21.67	<0.0001
2008	Intercept	1	6.7385	0.3025	496.29	<0.0001
	Wtd Number Fires	1	-2.1430	0.4860	19.45	<0.0001
	Region-Boise Foothills	1	1.8222	0.6681	7.44	0.0064
	Region-Owyhee Plateau	1	-1.7486	0.4922	12.62	0.0004
	Region (Type 3)	2			24.90	<0.0001

df is degrees of freedom; X^2 is the chi-squared statistic.



Dots represent observed data; lines represent predictions from the negative binomial regression model.

Figure 8-8. Slickspot peppergrass abundance (on a log-scale) as a function of weighted number of fires and region, by year.

Using 2008 data only, slickspot peppergrass abundance was also modeled as a function of actual number of fires (unweighted, i.e., not adjusted for age of fires). Up to 4 fires had been recorded for HIP transects. However, because there were only 3 transects with 3 or more fires, categories were created representing 0, 1, or 2 or more (2^+) fires. Results of negative binomial regression

(Table 8-16) were consistent with those from the analysis of weighted number of fires described above. In particular, the overall effect of the categorical fire variable was significant (*p* = 0.0059) based on the Type 3 analysis. The magnitude and sign of estimated coefficients for categories 1 and 2^+ indicate that increasing numbers of fires were associated with progressively lower abundance of slickspot peppergrass (Figure 8-9). However, more detailed analysis of the least square means based on the regression model reveals that while the difference in abundance between 0 and 1 fires was relatively large and statistically significant (*p* = 0.0159), the difference between 1 and 2+ fires was comparatively small and not significant (*p* = 0.2379) (Table 8-17). Thus, these results for 2008 suggest that the effect could be ascribed to presence or absence of fire: transects on which fires have occurred have lower slickspot abundance than transects where fire has not occurred, though the effect of actual number fires (whether 1 or more) is relatively small. Note that these results are not necessarily contradictory to results from the analysis of weighted number of fires. In particular, the categorization of actual number of fires ignores the age of fires, failing to distinguish, for instance, between 1-year-old and 10-year-old fires.

Table 8-16. Results of negative binomial regression treating actual number of fires as a categorical variable (either 0, 1, or 2+ fires). Both overall Type 3 results and individual parameter statistics are shown (0 fires is the reference category).

Parameter	*df*	Estimate	Std Error	X^2	*p*-value
FireClass 1	1	-1.2645	0.5243	5.82	0.0159
FireClass 2+	1	-1.9921	0.6338	9.88	0.0017
FireClass (Type 3)	2			10.26	0.0059

df is degrees of freedom; Estimate is the difference in abundance on a log-scale; X^2 is the chi-squared statistic.

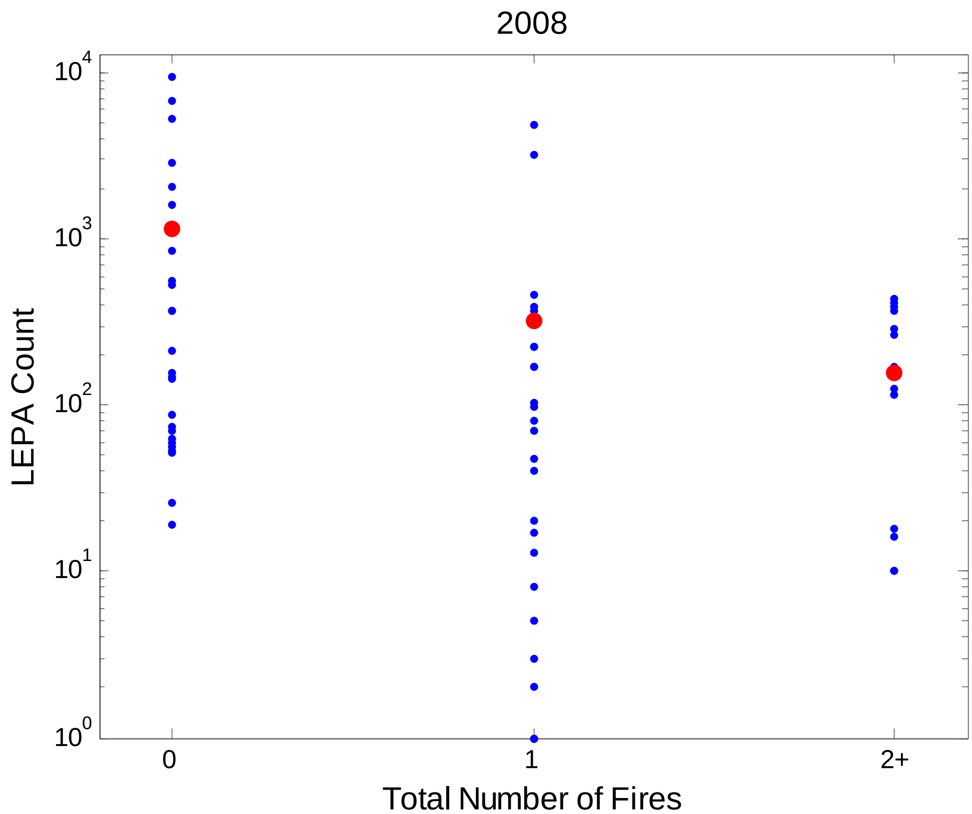
Table 8-17. Differences of least squares means from negative binomial regression treating actual number of fires as a categorical variable.

Difference	*df*	Estimate	Std Error	X^2	*p*-value
1 – 0	1	-1.2645	0.5243	5.82	0.0159
$2^+ - 0$	1	-1.9921	0.6338	9.88	0.0017
$2^+ - 1$	1	-0.7276	0.6164	1.39	0.2379

df is degrees of freedom; Estimate is the difference in abundance on a log-scale; X^2 is the chi-squared statistic.

Short-term effects of fire

The short-term effects of fire were examined by comparing transects classified as having burned recently (within the preceding year) with either those classified as having burned 2 or more years previously or those that were unburned. The sample size for recently burned transects was very small; in the five years of the HIP survey, only 8 of 400 transects (80 transects surveyed each year) received this classification. Thus, it was not possible to conduct separate analyses for each year or region. Doing so would have reduced sizes of cells (i.e., numbers of observations in certain combinations of year and fire class) even further. For instance, there were no recently burned transects in 2004 and only one such transect in each of 2005 and 2006.



Blue dots represent observed data; red circles represent mean values.

Figure 8-9. Slickspot peppergrass abundance (on a log-scale) as a function of total number of fires (not weighted), for 2008 only.

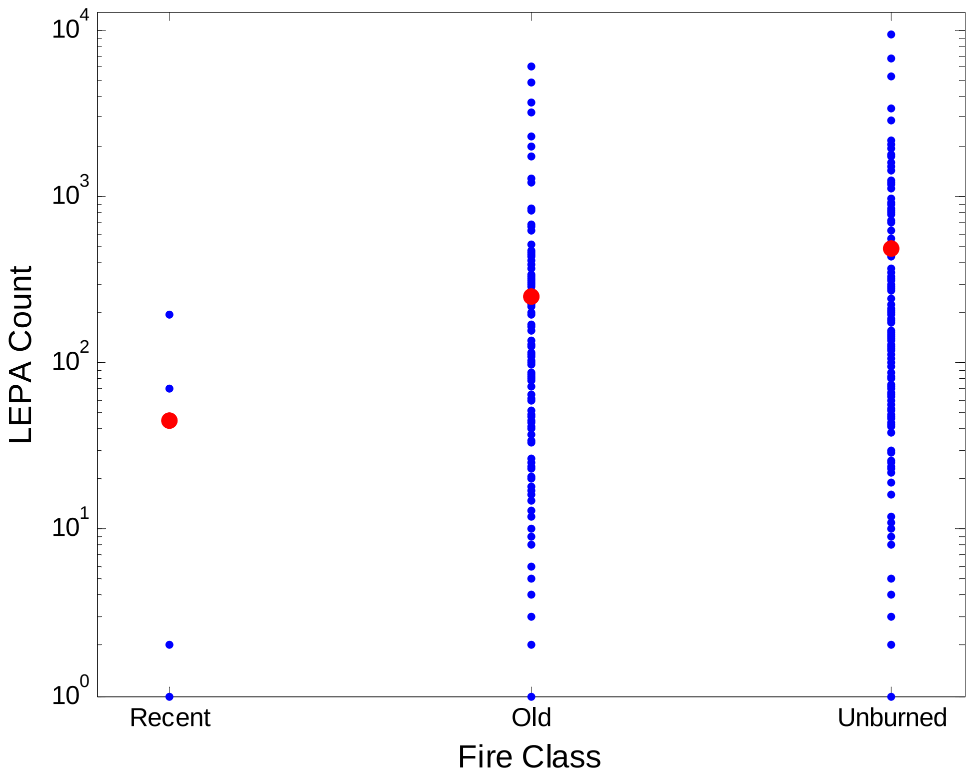
A negative binomial regression model was estimated for slickspot peppergrass abundance as a function of fire class alone. Because measurements were made on the same HIP transects five times during the study, potential temporal correlation within transects was handled using Generalized Estimating Equations (GEEs) assuming first-order autocorrelated errors. Estimated coefficients were negative for transects classified as having burned recently as well as transects with older burns (Table 8-18), indicating that slickspot peppergrass abundance was lower in these transects than in transects classified as unburned. Indeed, the order in the magnitude of the coefficients indicates that recently burned transects had the lowest abundance, transects with old burns had intermediate abundance, and unburned transects had the highest abundance (Figure 8-10). However, the overall effect of fire class was not significant ($p = 0.0657$) (Table 8-18).

In summary, results suggest that there may be an effect of fire class. However, there is no indication of a short-term positive effect of fire on abundance. To the contrary, the very limited evidence suggests a negative short-term effect. Finally, the putative effect is not significant at the 5% level, though this could easily be a consequence of very small sample size and consequent large standard errors.

Table 8-18. Results of negative binomial regression of abundance as a function of fire class, using GEEs to account for temporal correlation. Both overall Type 3 results and individual parameter statistics are shown ('Unburned' is the reference category).

Parameter	*df*	Estimate	Std Error	X^2	*p*-value
Recent burn	1	-1.4467	0.6996	-2.07	0.0386
Old burn	1	-0.7112	0.3838	-1.85	0.0639
Fire Class (Type 3)	2			5.45	0.0657

df is degrees of freedom; X^2 is the chi-squared statistic.



Blue dots represent observed data (some observations with the same or similar values may not be distinguishable); red circles represent mean values.

Figure 8-10. Slickspot peppergrass abundance (on a log-scale) as a function of fire class.

Livestock and Ungulate Wildlife Disturbance

By definition, penetrating livestock footprint cover is a subset of total footprint cover. As would be expected, correlation between these 2 variables was high ($r = 0.89$). Otherwise, pairwise correlation between each of these variables and feces cover was relatively low ($r \leq 0.50$). Penetrating footprint cover and total footprint cover were largely redundant. However, because an overall analysis objective was to explore potential relationships with slickspot peppergrass and, furthermore, because these variables were not considered together in any statistical model, both were retained for analysis.

Mean cover of all three livestock disturbance variables (penetrating footprints, total footprints, and feces) was highest on the Owyhee Plateau, lowest in the Boise Foothills, and intermediate on the Snake River Plain (Table 8-19). The differences in mean cover among regions were all highly significant ($p < 0.0001$) based on one-way analysis of variance tests (Table 8-19). In contrast, mean cover of wildlife footprints was generally very low, and there were no differences among regions ($p = 0.9186$, Table 8-19). For livestock, Table 8-19 provides evidence that the effects of region and each of these measures of disturbance are confounded. The actual mean percent cover values for each region in each year are shown in Table 8-20. The pronounced association between region and disturbance would not allow disturbance on slickspot peppergrass abundance to be clearly separated across regions. (A similar pattern was observed in the relationship between plant cover and region.) The abundance analyses described below were all conducted separately for each region, though at the cost of making inference about the effect of region, or the effect of disturbance across all regions. Instead, inferences are restricted to the effect of disturbance within the individual regions.

Table 8-19. Analysis of variance results for differences among regions in each of the 4 livestock and wildlife activity measurements.

	Region (Mean % Cover)				
Variable	Boise	Owyhee	Snake	*F*-statistic	*p*-value
Livestock Penetrating Footprints	0.496	3.370	1.052	19.99	<0.0001
Livestock Total Footprints	1.343	5.292	1.707	17.10	<0.0001
Livestock Feces	0.292	0.932	0.314	13.54	<0.0001
Wildlife Footprints	0.075	0.084	0.065	0.08	0.9186

Table 8-20. Mean livestock print and feces percent cover values for the different regions in each year.

Region	Year	Mean (Total Livestock Prints)	Mean (Penetrating Livestock Prints)	Mean (Feces)
Boise Foothills	2004	0.0000	0.0000	0.1500
Boise Foothills	2005	0.7950	0.7700	0.2500
Boise Foothills	2006	0.3650	0.2150	0.1750
Boise Foothills	2007	2.3100	0.4700	0.3000
Boise Foothills	2008	2.0800	0.6500	0.4300
Owyhee Plateau	2004	4.5773	2.1432	1.5036
Owyhee Plateau	2005	5.8795	4.7136	0.5023
Owyhee Plateau	2006	5.0386	3.2909	0.9364
Owyhee Plateau	2007	7.3955	4.5318	0.9818
Owyhee Plateau	2008	3.5682	2.1727	0.7364
Snake River Plain	2004	0.8057	0.7318	0.3614
Snake River Plain	2005	1.6181	1.5011	0.1894
Snake River Plain	2006	2.1052	1.1677	0.2031
Snake River Plain	2007	2.1271	1.1146	0.3917
Snake River Plain	2008	1.7935	0.7022	0.4417

In our analyses of cumulative effects, results of negative binomial regression models consistently show that slickspot peppergrass abundance in 2008 is not significantly associated with mean cover of livestock footprints or feces within regions (Tables 8-21 to 8-23), nor with mean cover of wildlife footprints (Table 8-24). That is, there is little evidence that slickspot peppergrass abundance in the last year of the survey depends on livestock or ungulate wildlife disturbance accumulated over the entire 5-year survey period. Most of the estimated slope coefficients in Tables 8-21 to 8-24 are negative suggesting decreasing slickspot peppergrass abundance with increasing disturbance, though the associated large standard errors and, thus, large *p*-values mean that any conclusion of effect is tenuous at best. Graphs of slickspot peppergrass abundance versus each of the disturbance variables, color-coded by region (Figure 8-11), are consistent with these results. While there are differences in disturbance cover values among regions and differences in abundance among regions, abundance and disturbance *within* regions appear to be either unrelated or only weakly associated with each other. No relationship between livestock or ungulate wildlife disturbance was statistically significant.

Table 8-21. Negative binomial regression results for cumulative effect of percent cover of livestock penetrating footprints (mean over 2004 – 2008) on slickspot peppergrass abundance in 2008, by region.

Region	Parameter	Estimate	Std Error	X^2	*p*-value
Boise Foothills	Intercept	7.5857	0.9650	61.79	<0.0001
	Slope	-0.1925	1.2485	0.02	0.8775
Owyhee Plateau	Intercept	4.7469	0.7232	43.08	<0.0001
	Slope	-0.1640	0.1964	0.70	0.4039
Snake River Plain	Intercept	6.5412	0.6356	105.91	<0.0001
	Slope	-0.2027	0.5247	0.15	0.6993

df is degrees of freedom; X^2 is the chi-squared statistic.

Table 8-22. Negative binomial regression results cumulative effect of percent cover of livestock total footprints (mean over 2004 – 2008) on slickspot peppergrass abundance in 2008, by region.

Region	Parameter	Estimate	Std Error	X^2	*p*-value
Boise Foothills	Intercept	7.4574	0.8790	71.98	<0.0001
	Slope	0.0279	0.3529	0.01	0.9371
Owyhee Plateau	Intercept	5.2476	0.7588	47.82	<0.0001
	Slope	-0.2120	0.1333	2.53	0.1116
Snake River Plain	Intercept	6.0992	0.5166	139.40	<0.0001
	Slope	0.1298	0.2399	0.29	0.5884

df is degrees of freedom; X^2 is the chi-squared statistic.

Table 8-23. Negative binomial regression results for cumulative effect of percent cover of livestock feces (mean over 2004 – 2008) on slickspot peppergrass abundance in 2008, by region.

Region	Parameter	Estimate	Std Error	X^2	*p*-value
Boise Foothills	Intercept	8.0509	0.9495	71.90	<0.0001
	Slope	-2.7878	2.1495	1.68	0.1946
Owyhee Plateau	Intercept	4.6550	0.4628	101.16	<0.0001
	Slope	-0.5271	0.3898	1.83	0.1763
Snake River Plain	Intercept	6.7197	0.4960	183.56	<0.0001
	Slope	-1.3918	1.2264	1.29	0.2564

df is degrees of freedom; X^2 is the chi-squared statistic.

Table 8-24. Negative binomial regression results for cumulative effect of percent cover of wildlife footprints (mean over 2004 – 2008) on slickspot peppergrass abundance in 2008, by region.

Region	Parameter	Estimate	Std Error	X^2	*p*-value
Boise Foothills	Intercept	7.2341	0.9307	60.42	<0.0001
	Slope	2.9339	7.6470	0.15	0.7012
Owyhee Plateau	Intercept	3.6991	0.4711	61.65	<0.0001
	Slope	5.4383	4.4549	1.49	0.2222
Snake River Plain	Intercept	6.3682	0.3300	372.43	<0.0001
	Slope	-0.6043	1.4933	0.16	0.6857

df is degrees of freedom; X^2 is the chi-squared statistic.

Regression modeling also examined within-region *and* within-year dependence of slickspot peppergrass abundance on livestock or ungulate wildlife disturbance. While slope estimates from these models are generally negative, in most cases, these slopes are not significantly different from 0 at $\alpha = 0.05$ (Tables 8-25 to 8-28). Models that have a significant disturbance effect are denoted by bold highlighting of the *p*-value in Tables 8-25 to 8-28; in each of these cases, the slope estimate indicates a negative effect on slickspot peppergrass abundance. Each of these cases was examined graphically (Figure 8-12) to assess the relationship between abundance and disturbance more closely. In three of the six cases, a single outlier (shown in red in Figure 8-12) was identified visually; removal of these single observations resulted in non-significant regressions in each case. These three cases are denoted by bold, italicized highlighting of the *p*-value in Tables 8-25 to 8-28. Graphs of the remaining three relationships (Figure 8-12) show data that are consistent with the conclusion of negative associations and all occur in the Owyhee Plateau during 2007. Thus, there is very limited evidence that slickspot peppergrass abundance declines with increases in cover of livestock footprints and feces, when these relationships are examined within each region and each year of the HIP survey. Furthermore, there is essentially no evidence that slickspot peppergrass abundance has any relationship with cover of wildlife footprints. The one signfiicant regression (Table 8-28) was due to a single extreme outlier with strong influence on the regression slope and, thus, it does not provide convincing evidence of a relationship.

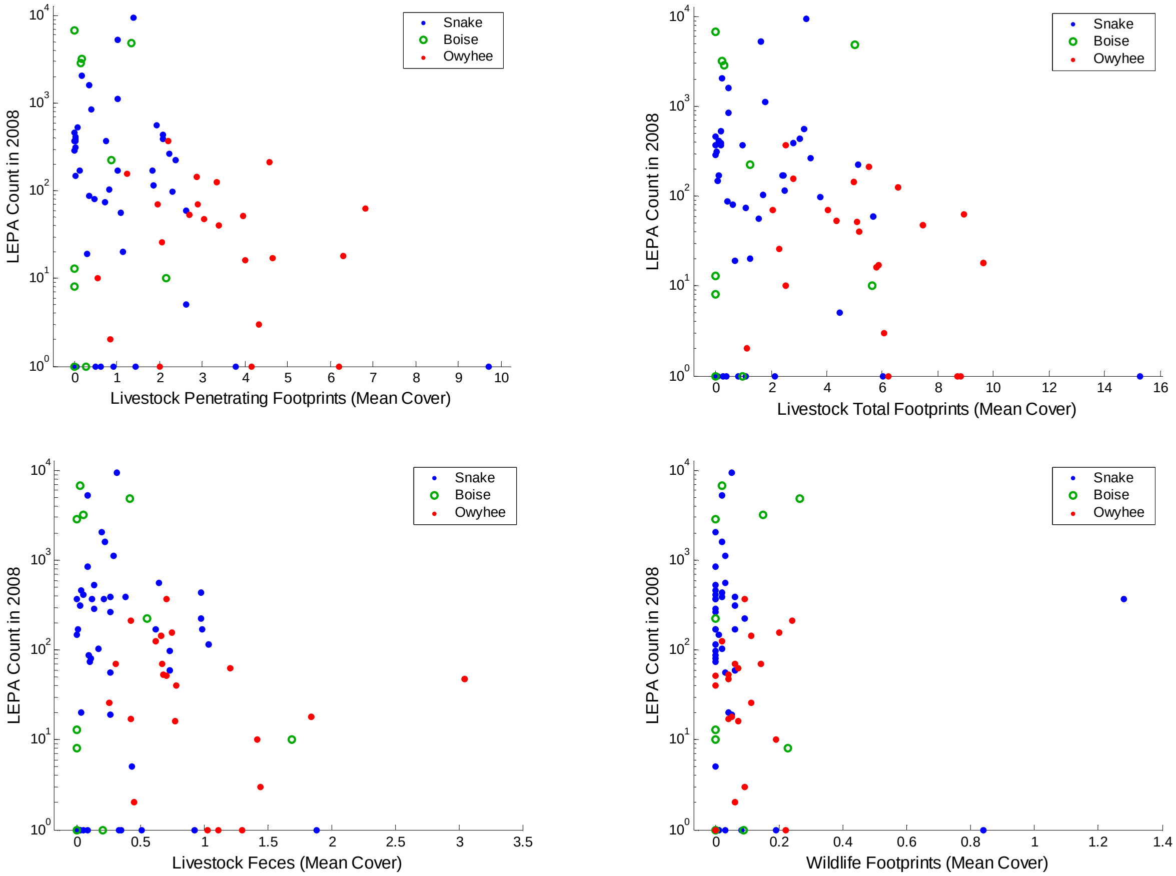


Figure 8-11. Slickspot peppergrass abundance in 2008 as a function of cumulative livestock and wildlife disturbance, by region. Livestock and wildlife activity represented by percent cover of footprints or feces within slickspots, averaged over the period 2004 – 2008.

Table 8-25. Negative binomial regression results for effect of percent cover of livestock penetrating footprints on slickspot peppergrass abundance, by region and year.

Region	Year	Parameter	Estimate	Std Error	X^2	*p*-value
Boise Foothills	2004	Intercept	6.6808	0.4771	196.10	<0.0001
		Slope	NA[1]			
	2005	Intercept	7.2501	0.8567	71.62	<0.0001
		Slope	-0.1700	0.5695	0.09	0.7653
	2006	Intercept	6.1679	0.9400	43.05	<0.0001
		Slope	1.8222	2.0638	0.78	0.3773
	2007	Intercept	7.0948	0.9269	58.59	<0.0001
		Slope	-0.8332	1.3738	0.37	0.5442
	2008	Intercept	7.9616	0.8216	93.91	<0.0001
		Slope	-1.3186	0.6691	3.88	***0.0488***
Owyhee Plateau	2004	Intercept	5.1315	0.3748	187.44	<0.0001
		Slope	-0.1366	0.1267	1.16	0.2808
	2005	Intercept	5.1288	0.4523	128.56	<0.0001
		Slope	-0.0086	0.0784	0.01	0.9128
	2006	Intercept	4.2481	0.3790	125.62	<0.0001
		Slope	0.0363	0.0825	0.19	0.6599
	2007	Intercept	4.2719	0.3339	163.70	<0.0001
		Slope	-0.1179	0.0450	6.86	**0.0088**
	2008	Intercept	4.2521	0.3420	154.60	<0.0001
		Slope	-0.0144	0.0789	0.03	0.8549
Snake River Plain	2004	Intercept	5.5734	0.2908	367.26	<0.0001
		Slope	-0.2482	0.1592	2.43	0.1191
	2005	Intercept	5.4770	0.3771	210.93	<0.0001
		Slope	0.1141	0.1657	0.47	0.4909
	2006	Intercept	4.9368	0.3775	171.06	<0.0001
		Slope	-0.1266	0.2136	0.35	0.5534
	2007	Intercept	5.8225	0.3944	217.98	<0.0001
		Slope	-0.3598	0.1965	3.35	0.0670
	2008	Intercept	6.5214	0.3633	322.22	<0.0001
		Slope	-0.4025	0.2442	2.72	0.0992

df is degrees of freedom; X^2 is the chi-squared statistic. Bold *p*-values indicate relationships significant at the 5% level; bold italicized *p*-values indicate that significance is determined by a single influential outlier.

[1]Slope not estimable for this region and year.

Table 8-26. Negative binomial regression results for effect of percent cover of livestock total footprints on slickspot peppergrass abundance, by region and year.

Region	Year	Parameter	Estimate	Std Error	X^2	*p*-value
Boise Foothills	2004	Intercept	6.6808	0.4771	196.10	<0.0001
		Slope	NA[1]			
	2005	Intercept	7.2348	0.8505	72.36	<0.0001
		Slope	-0.1389	0.5350	0.07	0.7951
	2006	Intercept	6.2155	0.9625	41.70	<0.0001
		Slope	1.0897	1.3143	0.69	0.4070
	2007	Intercept	6.6139	0.7536	77.02	<0.0001
		Slope	0.0519	0.1504	0.12	0.7298
	2008	Intercept	8.1064	0.9377	74.74	<0.0001
		Slope	-0.4447	0.2967	2.25	0.1339
Owyhee Plateau	2004	Intercept	5.2161	0.3765	191.98	<0.0001
		Slope	-0.0881	0.0606	2.11	0.1462
	2005	Intercept	5.0883	0.4574	123.78	<0.0001
		Slope	0.0001	0.0639	0.00	0.9991
	2006	Intercept	4.2828	0.3981	115.72	<0.0001
		Slope	0.0176	0.0590	0.09	0.7654
	2007	Intercept	4.5090	0.3651	152.54	<0.0001
		Slope	-0.1189	0.0363	10.73	**0.0011**
	2008	Intercept	4.3059	0.3315	168.76	<0.0001
		Slope	-0.0278	0.0430	0.42	0.5180
Snake River Plain	2004	Intercept	5.5642	0.2913	364.76	<0.0001
		Slope	-0.2020	0.1442	1.96	0.1613
	2005	Intercept	5.4728	0.3734	214.84	<0.0001
		Slope	0.1073	0.1502	0.51	0.4751
	2006	Intercept	4.8921	0.3628	181.87	<0.0001
		Slope	-0.0460	0.1073	0.18	0.6683
	2007	Intercept	5.6408	0.4162	183.68	<0.0001
		Slope	-0.0536	0.1165	0.21	0.6450
	2008	Intercept	6.3673	0.4608	190.93	<0.0001
		Slope	-0.0309	0.1790	0.03	0.8630

df is degrees of freedom; X^2 is the chi-squared statistic. Bold *p*-values indicate relationships significant at the 5% level; bold italicized *p*-values indicate that significance is determined by a single influential outlier.

[1]Slope not estimable for this region and year.

Table 8-27. Negative binomial regression results for effect of percent cover of livestock feces on slickspot peppergrass abundance, by region and year. .

Region	Year	Parameter	Estimate	Std Error	X^2	*p*-value
Boise Foothills	2004	Intercept	6.6902	0.5727	136.46	<0.0001
		Slope	-0.0637	2.1127	0.00	0.9760
	2005	Intercept	7.4508	0.9349	63.52	<0.0001
		Slope	-1.7320	2.3599	0.54	0.4630
	2006	Intercept	7.4696	0.9343	63.92	<0.0001
		Slope	-7.0870	4.0905	3.00	0.0832
	2007	Intercept	7.0723	0.7613	86.29	<0.0001
		Slope	-1.6032	1.3153	1.49	0.2229
	2008	Intercept	8.2052	0.9503	74.55	<0.0001
		Slope	-2.6418	1.5118	3.05	0.0805
Owyhee Plateau	2004	Intercept	4.9234	0.4981	97.71	<0.0001
		Slope	-0.0321	0.2809	0.01	0.9090
	2005	Intercept	4.4726	0.4625	93.51	<0.0001
		Slope	1.0797	0.7734	1.95	0.1627
	2006	Intercept	4.1517	0.3225	165.72	<0.0001
		Slope	0.1953	0.2039	0.92	0.3380
	2007	Intercept	4.8908	0.3368	210.83	<0.0001
		Slope	-1.5174	0.2843	28.48	**<0.0001**
	2008	Intercept	4.4953	0.3724	145.73	<0.0001
		Slope	-0.4583	0.3229	2.01	0.1559
Snake River Plain	2004	Intercept	5.4896	0.3308	275.44	<0.0001
		Slope	-0.1027	0.5254	0.04	0.8450
	2005	Intercept	5.5285	0.3358	271.12	<0.0001
		Slope	0.6331	0.9500	0.44	0.5052
	2006	Intercept	4.9853	0.3471	206.32	<0.0001
		Slope	-1.0952	0.9989	1.20	0.2729
	2007	Intercept	5.6001	0.4133	183.60	<0.0001
		Slope	-0.1697	0.6184	0.08	0.7837
	2008	Intercept	6.6130	0.3534	350.15	<0.0001
		Slope	-1.0104	0.4029	6.29	***0.0122***

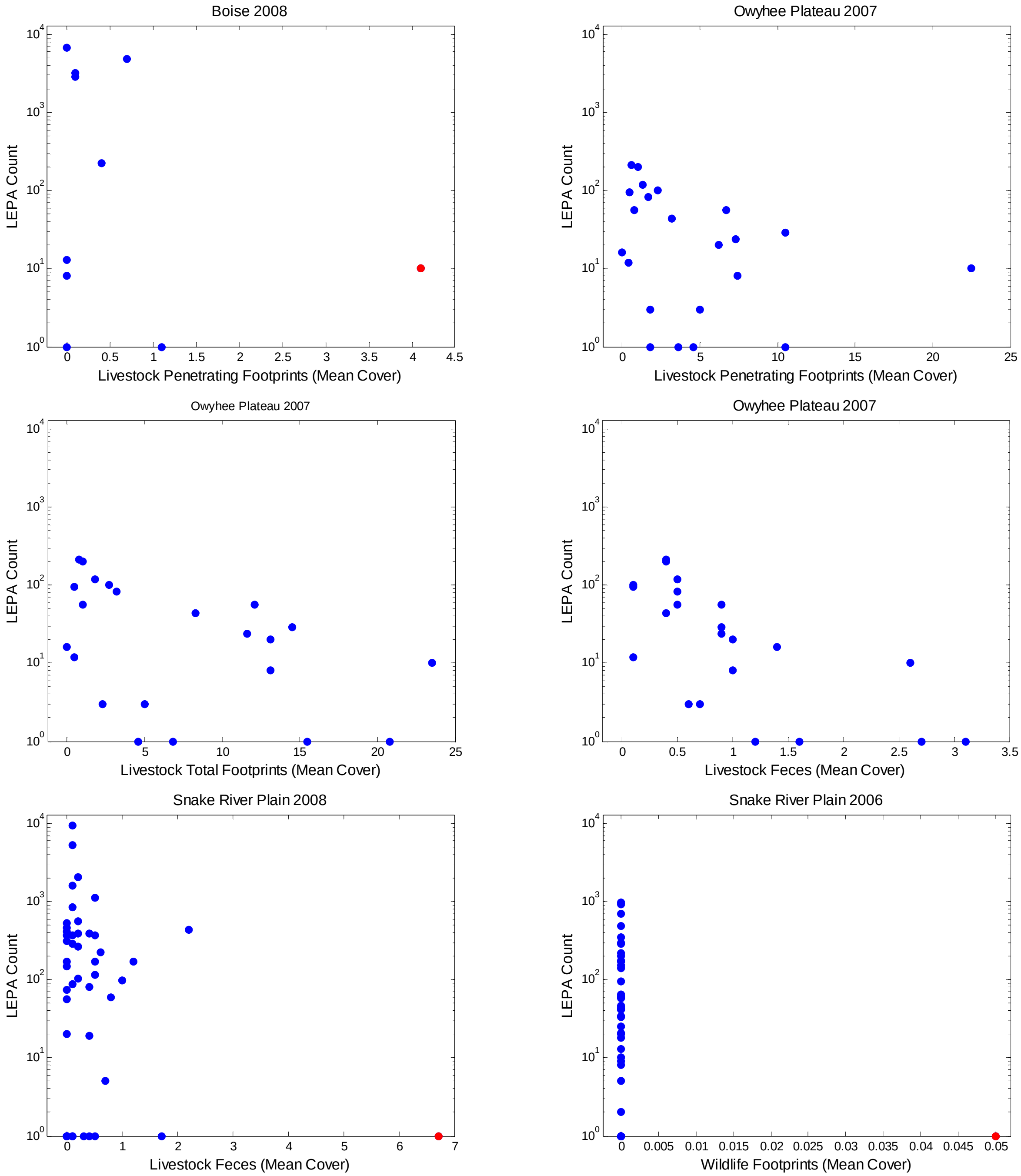
df is degrees of freedom; X^2 is the chi-squared statistic. Bold *p*-values indicate relationships significant at the 5% level; bold italicized *p*-values indicate that significance is determined by a single influential outlier

Table 8-28. Negative binomial regression results for effect of percent cover of wildlife footprints on slickspot peppergrass abundance, by region and year.

Region	Year	Parameter	Estimate	Std Error	X^2	*p*-value
Boise Foothills	2004	Intercept	6.6808	0.4771	196.10	<0.0001
		Slope	NA[1]			
	2005	Intercept	6.8915	0.8761	61.87	<0.0001
		Slope	13.3099	31.9914	0.17	0.6774
	2006	Intercept	6.9045	0.8640	63.86	<0.0001
		Slope	NA[1]			
	2007	Intercept	6.8985	0.7745	79.34	<0.0001
		Slope	-0.9580	2.1785	0.19	0.6601
	2008	Intercept	7.1801	0.8027	80.01	<0.0001
		Slope	1.5890	2.8297	0.32	0.5744
Owyhee Plateau	2004	Intercept	4.8939	0.2695	329.77	<0.0001
		Slope	-10.2379	25.3204	0.16	0.6860
	2005	Intercept	5.0120	0.3177	248.85	<0.0001
		Slope	0.5499	1.4046	0.15	0.6955
	2006	Intercept	4.3746	0.2652	272.05	<0.0001
		Slope	NA[1]			
	2007	Intercept	3.4706	0.4491	59.71	<0.0001
		Slope	2.4924	2.2412	1.24	0.2661
	2008	Intercept	3.4957	0.3986	76.91	<0.0001
		Slope	4.2566	2.1864	3.79	0.0516
Snake River Plain	2004	Intercept	5.4538	0.2710	405.12	<0.0001
		Slope	NA[1]			
	2005	Intercept	5.6749	0.3390	280.24	<0.0001
		Slope	-0.1114	3.3233	0.00	0.9733
	2006	Intercept	4.8232	0.2824	291.75	<0.0001
		Slope	-96.4639	43.9058	4.83	***0.0280***
	2007	Intercept	5.6485	0.3421	272.67	<0.0001
		Slope	-2.6459	1.5690	2.84	0.0917
	2008	Intercept	6.3489	0.3201	393.41	<0.0001
		Slope	-0.1018	0.3088	0.11	0.7417

df is degrees of freedom; X^2 is the chi-squared statistic. Bold *p*-values indicate relationships significant at the 5% level; bold italicized *p*-values indicate that significance is determined by a single influential outlier.

[1]Slope not estimable for this region and year.



Red circles indicate influential outlying observations; removal of these observations results in non-significant or non-estimable relationships. Only results for region and year combinations significant at the 5% level (Tables 8-25 to 8-28)

Figure 8-12. Slickspot peppergrass abundance as a function of livestock and wildlife activity.

Comparison of cover of livestock and ungulate wildlife footprints

Paired *t*-tests to compare cover of livestock total footprints and cover of ungulate wildlife footprints show that the mean difference in cover was highly significant ($p < 0.0001$) in every year of the study irrespective of region (Table 8-29). That is, cover of livestock footprints was much higher than cover of wildlife footprints across all transects. That result is not surprising given that cover of wildlife footprints generally was extremely low (Table 8-19). Furthermore, to re-iterate the results of the regression modeling, while there was very limited evidence of livestock disturbance effects on slickspot peppergrass abundance, there was no evidence that cover of wildlife footprints had any relationship with slickspot peppergrass abundance.

Table 8-29. Results of paired *t*-tests comparing the mean difference in cover of livestock total footprints and wildlife footprints.

Year	Mean Difference (Livestock-Wildlife)	Std Error	*df*	*t*-statistic	*p*-value
2004	1.9169	0.4246	70	4.51	<0.0001
2005	2.6297	0.4276	78	6.15	<0.0001
2006	2.6938	0.4559	79	5.91	<0.0001
2007	3.4775	0.6398	79	5.44	<0.0001
2008	2.1705	0.5145	77	4.22	<0.0001

Vegetation Adjacent to HIP Transects

Results of negative binomial regression for the association between slickspot peppergrass abundance and cover of each of the plant species or groups are shown in Tables 8-30 to 8-36 and Figure 8-13. Most regression models were not significant at $\alpha = 0.05$. Significant relationships are indicated in Figure 8-13 by the plotted lines which represent model predictions. The following is a brief summary of these significant results. Abundance was positively associated with biological crust for the Boise Foothills and Snake River Plain, and with sagebrush for the Snake River Plain. Abundance decreased with increasing cover of native bunchgrass for the Snake River Plain, with increasing cover of cheatgrass in all three regions, and with increasing total cover of non-native unseeded plants for the Owyhee Plateau and Snake River Plain. There were no significant relationships with either rabbitbrush or non-native seeded plants. In part, this result may have been due to the predominance of zeros (75% – 80% of all observations) for these two variables.

Regression tests of interactions between year and plant cover either were not significant ($p \geq 0.11$) for the Owyhee Plateau and Snake River Plain, or could not be evaluated (due to convergence failure of GEE, most likely because data were too sparse) for the Boise Foothills. Thus, we concluded that there was no evidence that the association between plant cover and slickspot peppergrass abundance differed from year to year, when considered separately within each region. In other words, the within-year effect of cover was not different than the effect over all years. Based on the evidence of no unique within-year effects, we did not conduct additional analyses by both region and year.

Table 8-30. Negative binomial regression results for effect of biological crust cover in plant community outside of slickspots on slickspot peppergrass abundance, by region.

Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Boise Foothills	Intercept	6.2031	0.4253	14.58	<0.0001
	Slope	0.0338	0.0156	2.17	0.0297
Owyhee Plateau	Intercept	4.7020	0.2520	18.66	<0.0001
	Slope	-0.0045	0.0061	-0.74	0.4595
Snake River Plain	Intercept	5.1924	0.2699	19.24	<0.0001
	Slope	0.0172	0.0079	2.17	0.0296

df is degrees of freedom; *Z* is the standard normal statistic.

Table 8-31. Negative binomial regression results for effect of cheatgrass cover in plant community outside of slickspots on slickspot peppergrass abundance, by region.

Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Boise Foothills	Intercept	7.4481	0.3842	19.39	<0.0001
	Slope	-0.0711	0.0199	-3.57	0.0004
Owyhee Plateau	Intercept	4.6184	0.2013	22.95	<0.0001
	Slope	-0.0786	0.0360	-2.19	0.0287
Snake River Plain	Intercept	5.9479	0.2182	27.26	<0.0001
	Slope	-0.0279	0.0114	-2.46	0.0139

df is degrees of freedom; *Z* is the standard normal statistic.

Table 8-32. Negative binomial regression results for effect of total cover of native bunchgrasses in plant community outside of slickspots on slickspot peppergrass abundance, by region.

Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Boise Foothills	Intercept	7.0133	0.4487	15.63	<0.0001
	Slope	0.0239	0.0985	0.24	0.8082
Owyhee Plateau	Intercept	4.7332	0.2461	19.23	<0.0001
	Slope	-0.0158	0.0155	-1.02	0.3081
Snake River Plain	Intercept	6.0889	0.2520	24.16	<0.0001
	Slope	-0.0811	0.0352	-2.31	0.0212

df is degrees of freedom; *Z* is the standard normal statistic.

Table 8-33. Negative binomial regression results for effect of total cover of non-native seeded plants in plant community outside of slickspots on slickspot peppergrass abundance, by region.

Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Boise Foothills	Intercept	7.0283	0.3389	20.74	<0.0001
	Slope	0.0952	0.2267	0.42	0.6747
Owyhee Plateau	Intercept	4.6780	0.2385	19.61	<0.0001
	Slope	-0.0165	0.0255	-0.65	0.5164
Snake River Plain	Intercept	5.7545	0.2158	26.67	<0.0001
	Slope	-0.2458	0.5614	-0.44	0.6616

df is degrees of freedom; *Z* is the standard normal statistic.

Table 8-34. Negative binomial regression results for effect of total cover of non-native unseeded plants in plant community outside of slickspots on slickspot peppergrass abundance, by region.

Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Boise Foothills	Intercept	7.3770	0.5373	13.73	<0.0001
	Slope	-0.0239	0.0324	-0.74	0.4605
Owyhee Plateau	Intercept	4.7185	0.1995	23.65	<0.0001
	Slope	-0.1783	0.0561	-3.18	0.0015
Snake River Plain	Intercept	6.1225	0.2695	22.72	<0.0001
	Slope	-0.0791	0.0337	-2.35	0.0189

df is degrees of freedom; *Z* is the standard normal statistic.

Table 8-35. Negative binomial regression results for effect of total cover of rabbitbrush in plant community outside of slickspots on slickspot peppergrass abundance, by region.

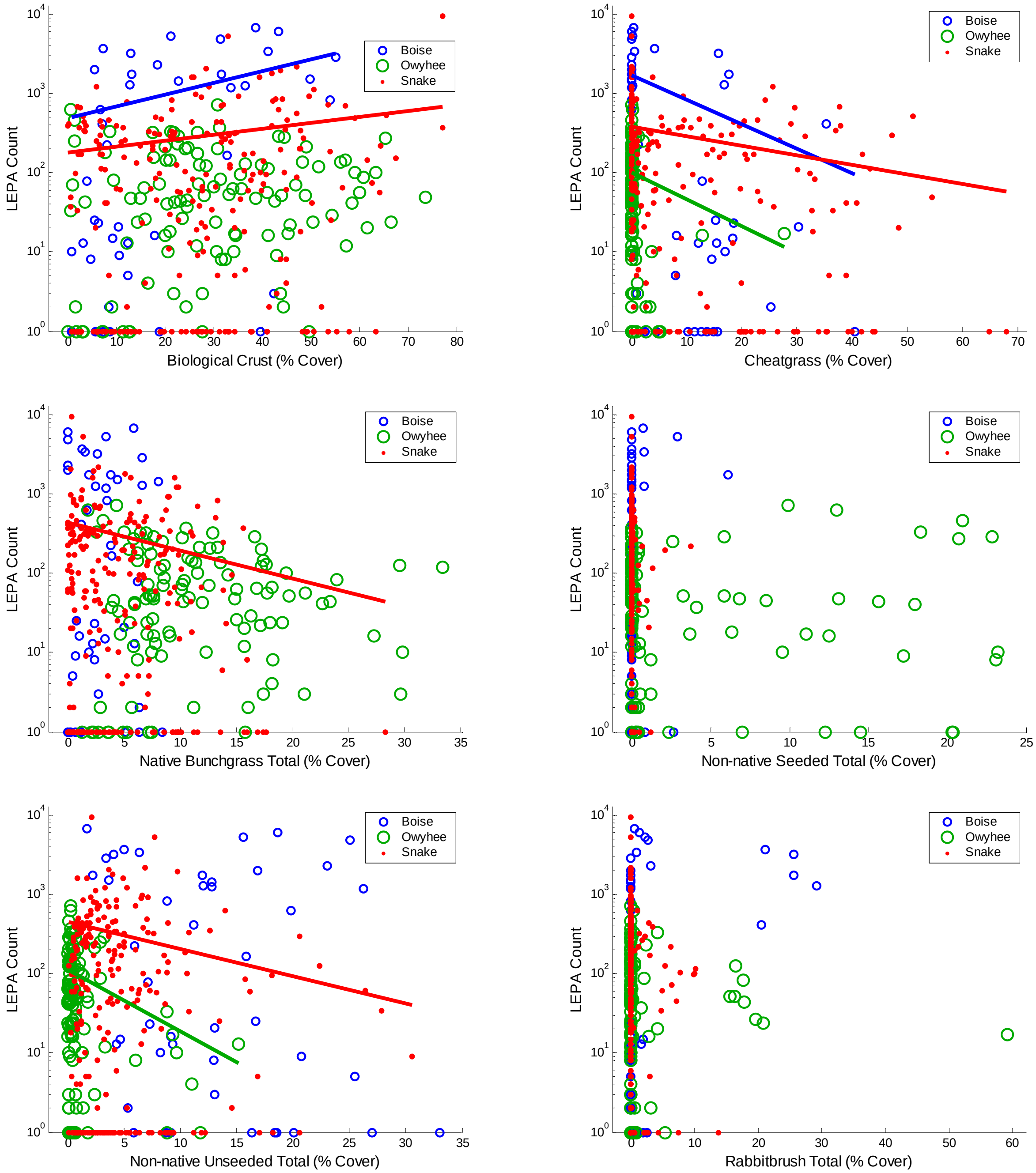
Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Boise Foothills	Intercept	6.9290	0.3865	17.93	<0.0001
	Slope	0.0398	0.0476	0.84	0.4029
Owyhee Plateau	Intercept	4.6313	0.1962	23.61	<0.0001
	Slope	-0.0266	0.0175	-1.52	0.1273
Snake River Plain	Intercept	5.7965	0.2105	27.53	<0.0001
	Slope	-0.1657	0.0893	-1.85	0.0636

df is degrees of freedom; *Z* is the standard normal statistic.

Table 8-36. Negative binomial regression results for effect of sagebrush cover in plant community outside of slickspots on slickspot peppergrass abundance, by region.

Region	Parameter	Estimate	Std Error	*Z*	*p*-value
Boise Foothills	Intercept	7.0722	0.3795	18.64	<0.0001
	Slope	0.0010	0.0237	0.04	0.9679
Owyhee Plateau	Intercept	4.7552	0.2265	20.99	<0.0001
	Slope	-0.0120	0.0108	-1.11	0.2673
Snake River Plain	Intercept	5.1794	0.2666	19.43	<0.0001
	Slope	0.0282	0.0115	2.45	0.0143

df is degrees of freedom; *Z* is the standard normal statistic.



Lines show predicted abundance based on negative binomial regression models significant at α = 0.05 (Tables 8-30 to 8-36).

Figure 8-13. Slickspot peppergrass abundance as a function of plant cover within vegetation transects, by region.

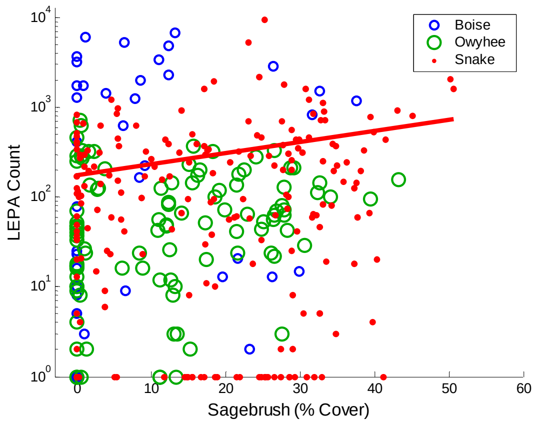


Figure 8-13. Continued.

Discussion

Region and Year

We have analyzed many environmental and habitat features that could influence slickspot peppergrass abundance. It is difficult to identify specific features that could control slickspot peppergrass abundance based on HIP data because only five years of data are presently available. Regional differences are apparent with the Boise Foothills having the highest abundance, followed by the Snake River Plain and the Owyhee Plateau. Also, the abundance differs among the years of HIP, with 2005 and 2008 being statistically greater than 2004. The subsequent discussion attempts to identify which, if any, of the factors we considered accounted for these differences among region or year.

Effects of Weather

The relationship between slickspot peppergrass abundance and temperature differs by region, but the patterns of temperature and precipitation also differed by region. A positive relationship exists between the prior fall and winter temperatures and abundance for the Owyhee Plateau, but a negative relationship exists between spring temperatures and slickspot peppergrass abundance for the Boise Foothills and Snake River Plain. Temperatures tended to be somewhat cooler on the Owyhee Plateau than in the Boise Foothills and the Snake River Plain, so it might be possible that the differences in the temperatures among regions produces some of the overall differences observed, such as lower overall abundance on the Owyhee Plateau because temperatures are often below the optimum. The reverse might be true in the other regions during the spring.

Others (Menke and Kaye 2006a,b) have observed an increase in slickspot peppergrass abundance with an increase in spring precipitation for the period between 1998 to 2004. Similar to Unnasch's (2008) analysis of HIP data from 2004 to 2007, we did not find a strong positive relationship between spring precipitation and slickspot peppergrass abundance from 2004 to 2008. No three-month period analyzed had any significant relationship between abundance and precipitation in the Boise Foothills. The relationship was negative during the fall and winter for the Owyhee Plateau, but was positive for the spring period from March – May. The relationship in the Snake River Plain was negative for all the periods, except March – May, when there was no significant relationship. These results differ from our previous (Chapter 3) analysis using the longer running (1990 to 2008) data set from the Orchard Training Area (OTA) on the Snake River Plain. In that analysis, we found significant positive relationships between slickspot peppergrass abundance and precipitation in the late winter and spring. Unless other factors, unrelated to spring precipitation have changed through time, the results from the longer-running data set should be a better indicator of the relationship between precipitation and abundance. The limited data (few years of weather observations), highly variable slickspot peppergrass abundance data, regional differences, and potential temporal correlations together made including temperature and precipitation in the same analysis too unreliable. We prefer the longer-running data from the OTA to investigate interactions between temperature and precipitation. The results of the analyses from Chapter 4 indicate that both temperature and precipitation can be important to predict the abundance of slickspot peppergrass, but the nature of the importance changes from fall through winter and into spring.

Factors Measured within Slickspots

We did not find consistent trends for plant cover within slickspots in relation to slickspot peppergrass abundance. Forage kochia occurs principally on Snake River Plain slickspots, and appears absent from the Boise Foothills and Owyhee Plateau. Whereas crested wheatgrass is present on slickspots on the Owyhee Plateau, and while present in the other regions, it occurs in much lower amounts. Forage kochia and crested wheatgrass are both seeded to provide forage for livestock. Cheatgrass is most prevalent on slickspots on the Snake River Plain, but is also present at lower levels on slickspots in the other regions. Our statistical analyses focus on how these plants effect slickspot peppergrass abundance, but visual inspection of the plots in Figure 8-5 reveals some regional patterns that indicate differences in land management practices or the general condition of the land from either anthropogenic or natural causes.

Boise Foothills had an overall greater percent cover of biological crust, and a positive relationship existed between slickspot peppergrass and biological crust; no relationship was evident in the Snake River Plain where the percent cover was intermediate; and Owyhee Plateau had the lowest percent cover of biological crust and a negative relationship with slickspot peppergrass abundance. Additionally, Boise Foothills has the highest abundance of slickspot peppergrass; the Snake River Plain is intermediate; and Owyhee Plateau has the overall lowest abundance. It appears that the factors in the different regions that influence the abundance of slickspot differ. A greater percent cover of biological crust could indicate less physical disturbance at that location. This could explain the positive relationship in Boise Foothills, assuming slickspot peppergrass benefits from reduced disturbance. However, this does not explain a negative relationship in Owhyee Plateau.

A negative relationship exists between cheatgrass and slickspot peppergrass abundance in the Boise Foothills and Snake River Plain, but no relationship was evident on the Owyhee Plateau. Cheatgrass was present in lower amounts on the Owyhee Plateau, so there might not be sufficient cheatgrass on the slickspots to impact slickspot peppergrass abundance on the Owyhee Plateau. Since cheatgrass would be included in the Total Unseeded Non-native Plant category, the results seen for cheatgrass could be the underlying cause of the pattern seen for Total Unseeded Non-native Plants.

No relationship existed between crested wheatgrass and slickspot peppergrass abundance in any of the regions. We do not have an explanation for the divergent results for Total Seeded Non-native Plants in the Boise Foothills and Snake River.

The number of fires did not differ among regions. Fire had a negative impact on slickspot peppergrass abundance, but since there were no differences among regions, we cannot attribute the differences among the regions to the number of fires or the time since an area burned. The negative relationship between fire and abundance of slickspot peppergrass became stronger (*i.e.*, more negative) through time. Nothing was obvious in the data to provide an explanation for this change in the trend. We did not find a short-term benefit of fire when we compared those areas that had burned within the 12 months prior to when slickspot peppergrass was counted on that HIP transect. However, there were few instances where a HIP transect has burned since 2004, so our small sample could have prevented an effect from being apparent.

The amount of livestock prints was greatest on the Owyhee Plateau, but was low (mean of <6% cover) in all regions. There was no difference among regions for ungulate wildlife prints, and the percent cover was always much less (mean of <0.1% cover) than that of livestock. We found no cumulative effect of livestock print or feces percent cover or wildlife print percent cover on 2008 slickspot peppergrass abundance. There is only a single year (2007) where a consistent negative relationship existed between slickspot peppergrass and each of the measures of livestock presence, and it occurred only on the Owyhee Plateau. The mean total livestock prints were highest on the Owyhee Plateau in 2007, but mean penetrating prints and mean feces cover were intermediate. The high level of mean total prints suggests there might have been a higher level of livestock activity, at least along some HIP transects on the Owyhee Plateau, which could have lead to the negative relationship observed for that year.

Plant Community around Slickspots

Most of the analyses looking at the plant community surrounding the slickspots and the abundance of slickspot peppergrass did not show significant relationships. These analyses differ from the analyses discussed earlier in that the vegetation was measured outside the slickspot as opposed on within the slickspots as in the earlier discussion. Here we would not expect a direct impact on slickspot peppergrass, but these community measures could help to describe good slickspot peppergrass habitat.

Biological crust was positively associated with slickspot peppergrass abundance in the Boise Foothills and Snake River Plain. The slope of the regression line biological crust on the Owyhee Plateau was slightly negative, but not significantly so. In the earlier discussion, biological crust was significantly and negatively associated with slickspot peppergrass abundance on the Owyhee Plateau. So, for an unknown reason, the relationship between slickspot peppergrass and biological crust differs on the Owyhee Plateau than elsewhere in the range of slickspot peppergrass.

Cheatgrass was negatively associated with slickspot peppergrass abundance in all regions. Since cheatgrass within slickspots was not significantly related to abundance on the Owyhee Plateau, it might not have invaded the slickspots themselves to a great extent, but its presence across the landscape is indicative of degraded habitat.

Native bunchgrass was negatively associated with slickspot peppergrass abundance on the Snake River Plain, only. Non-native unseeded species were also negatively related to abundance on the Snake River Plain and Owyhee Plateau, but not in the Boise Foothills. From this it would seem that an abundance of grass or other herbaceous cover might also be indicative of suboptimal habitat.

Rabbitbrush did not have any significant relationships with slickspot peppergrass abundance, and sagebrush was positively related to abundance on the Snake River Plain, only. In Chapter 6, we found that the habitat surrounding the HIP transects differed among regions. The Boise Foothill HIP transects were predominantly surrounded by Introduced Upland Vegetation – Annual Grassland, and the Snake River Plain and Owyhee Plateau HIP transects were predominantly surrounded by Inter-Mountain Basin Big Sagebrush Shrubland. So it is not surprising that sagebrush is not associated with slickspot peppergrass in the Boise Foothills, but the fact that sagebrush is associated with slickspot peppergrass on the Snake River Plain but not on the Owyhee Plateau again points to some inherent differences among the three regions.

Finally, we must be cautious in interpreting the results of all of the HIP analyses. Only five years of data are currently available. As more years become available, some of the time-dependent issues might become easier to discern. More importantly, the HIP transects were subjectively located across the landscape. Therefore, our inferences regarding the relationships between slickspot peppergrass and the environmental and particularly landscape features are strictly applicable only to the HIP transects themselves. Attempts to infer how slickspot peppergrass is likely to react to the same factors away from the HIP transects should be done only with a knowledge of how similar the areas around the HIP transects are to other areas where slickspot peppergrass occurs.

Conclusions

Very few of the factors we analyzed for relationships with slickspot peppergrass abundance demonstrated a consistent pattern across the Boise Foothills, Snake River Plain and Owyhee Plateau. The annual abundance counts for slickspot peppergrass are highly variable making it difficult for regression analyses to identify significant relationships. Numerous differences were identified among the regions, complicating analyses across the entire range.

The abundance of slickspot peppergrass differs among regions and across years. Slickspot peppergrass abundance was lower within those slickspot that had previously burned. Only the amount of cheatgrass in the plant community surrounding HIP transects showed a consistent relationship with slickspot peppergrass abundance across all regions, and it was negative. No factor showed a consistently positive impact on slickspot peppergrass. From this, we conclude that managing slickspot peppergrass across the three regions might require region-specific approaches. As more years of HIP data become available, these analyses can be refined.

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Chapter 9: Critiques of Previous Data Analyses

Menke and Kaye 2006a

This report analyzed the HII data. Attempts were made to acquire animal unit month (AUM) data from BLM for grazing intensity, but these data were incomplete or insufficient for assessing grazing intensity. Three questions were addressed in the analyses:
1) Are trends in slickspot peppergrass abundance correlated with weather, alterations in slickspot condition or disturbance?
2) What factors degrade slickspots?
3) What factors degrade the habitat surrounding slickspots?

HII transects were grouped into either burned or unburned, and grazed or ungrazed. Those transects that burned during years when HII data were collected (1998 – 2001) were excluded from the analyses. Few slickspots showed any indications of OHV tracks. Since many of the habitat variables were not recorded as continuous data, a threshold was developed for each variable, and converted to a dichotomous variable indicating impacted or not impacted or present or absent. PRISM data were used for climate analyses.

For the slickspot condition analyses, only the condition in 2001 was considered since the impacts through time would have been cumulative with little likelihood of natural recovery in the brief 4-year period of the study. Almost all the ungrazed transects have previously burned, and only half of the grazed transects had burned, the analysis of grazing was restricted to those that had previously burned. Too few transects were available from unburned areas to analyze. Also, the four transects that burned during the study were eliminated.

The number of slickspots impacted by burning or grazing was analyzed by comparing the numbers of above threshold slickspots in 1998 and 2001. Habitat and plant community variables were also assigned threshold values, and the numbers of above threshold slickspots compared in 1998 and 2001.

Statistical Analyses

HII data were analyzed for the period 1998 – 2001. Menke and Kaye conducted 2 distinct sets of analyses. The first set concerned the relationship between slickspot peppergrass abundance and each of several factors including weather, changes in slickspot condition, and disturbance. The second set of analyses concerned factors that "degrade" slickspots and the habitat surrounding slickspots. This second set did not make any use of slickspot peppergrass abundance data, but instead examined the relationships among other variables measured on the HII transects. Our critique only addresses the first set of analyses that are concerned with slickspot peppergrass.

Weather-related variables were obtained from the PRISM model. These variables included monthly precipitation and monthly minimum and maximum temperatures. For analysis, monthly data were combined over both 2- and 3-month periods. Abundance was averaged across transects within each of the 4 years of the survey, and then regressed on each of the derived weather variables. Results indicated that precipitation in the spring (March – May) immediately preceding the survey period was significantly and strongly (high R^2) associated with abundance, though neither precipitation in other seasons nor minimum and maximum temperature in any season had significant relationship with abundance.

To assess the effects of slickspot condition and disturbance, Menke and Kaye calculated proportional change in abundance over the study period (the difference in abundances in 2001 and 1998, divided by the abundance in 1998). Grazing and burning on HII transects were each treated as categorical variables such that each transect was classified as either grazed or ungrazed and either burned or unburned. A Kruskal-Wallis test was used to test whether the grazed and burned conditions had any effect on proportional change in abundance. Results of this test indicated no association between abundance and either burning or grazing. Several other measures of slickspot condition and disturbance were continuous rather than categorical. These included organic matter accumulation, perimeter compromise, cumulative livestock sign, weedy species density, and perennial forb and grass establishment). The relationship between each of these variables and proportional change in slickspot peppergrass abundance was assessed using Spearman rank correlation. Results indicated that none of these correlations was significant.

Numerous analyses were conducted among slickspot condition and plant community variables. Many analyses considered the differences among burned and unburned, grazed and ungrazed, or with and without OHV use, but these variables were not related directly to slickspot peppergrass abundance. Therefore, it is not possible from this report to evaluate how any of the condition or community variables impact or relate to slickspot peppergrass abundance.

Critique

(1) It is not clear how Menke and Kaye obtained slickspot peppergrass abundance values from the categorical data recorded for the HII surveys. We might assume that midpoints of category ranges were chosen and then averaged, but there is no mention of the categorical nature of the data.

(2) Standard linear regression was used to assess the relationship between mean annual abundance and each of several weather variables. Averaging across transects within each year has a couple of important consequences. First, it tends to generate values that are more normally distributed so that log-transformation of individual observations is no longer necessary. Second, it eliminates the issue of temporal correlations within individual transects. This is good in that simpler analysis (such as linear regression) is justified, but less desirable in that temporal patterns within individual transects will be obscured. More specific to Menke and Kaye's analysis, regression sample size is very small ($n = 4$) and one observation (for 1998) appears to be highly influential. Because this observation is an outlier with respect to both abundance and precipitation, it largely determines the regression relationship by itself. Thus, the conclusion that abundance increases with spring precipitation is not well-supported by these data.

(3) Proportional change in abundance was calculated to assess potential effects of slickspot condition and disturbance. Analysis using this derived measure of abundance was intended to address the effects of some variables that were assumed not to change during the study (grazing and burning), and the cumulative effects of other variables (e.g.,

organic matter accumulation). Given the limitations of the data and accepting these assumptions, proportional change in abundance was an appropriate response variable. Furthermore, this approach eliminated the issue of temporal correlation within transects, so that a repeated measures approach was not necessary. That is, with a single value representing each transect for the entire study period, year-to-year similarity in values within transects was no longer an issue.

(4) A Kruskal-Wallis test was used to assess the relationship between proportional change in abundance and both grazing and burning. Spearman rank correlations were used to assess relationships between proportional change in abundance and each of several continuous measures of slickspot condition and disturbance. Based on the information provided, all of these tests appear to have been used appropriately.

(5) An important factor that influences the outcome of the analyses that include slickspot peppergrass abundance is the period of the analyses. When the data from the OTA are considered, both the data from the "rough census" areas (Figure 3-1) and special use plots (Figure 3-4) indicate 1998 was higher than average, but years subsequent to 1998 had comparable slickspot peppergrass numbers. For the HII data considered by Menke and Kaye in this report, the mean abundance in 1998 is more than twice that of any other year. Therefore, the fact that the HII transects were first monitored during a higher than average abundance year greatly influenced the interpretation of the relatively short (4-year) dataset. Consideration of subsequent years shows that any decrease in abundance is not as dramatic as suggested by this analysis. Furthermore, no formal test of trend accompanied the analysis.

Summary

Given the questions that were asked and the ways that the data were managed, the statistical procedures were chosen and used appropriately. However, the conclusion that slickspot peppergrass abundance depended on spring precipitation was not well-supported by the results. Similarly, a statement that slickspot peppergrass abundance was decreasing over time was not accompanied by any direct statistical test of trend, and appears to have been influenced by an initial year of particularly high abundance.

Menke and Kaye 2006b

This report analyzed the HII and HIP data. No additional data except for climate data were included in the analyses. The same three questions were addressed in this report as were addressed in Menke and Kaye 2006a. The questions were:

1) Are trends in slickspot peppergrass abundance correlated with weather, alterations in slickspot condition or disturbance?
2) What factors degrade slickspots?
3) What factors degrade the habitat surrounding slickspots?

Since both HII and HIP data are used, and the field methods for data collection differ slightly between these programs, rigorous statistical methods could not be applied, but trends were identified. Data from 1998 through 2002 from the HII program and from 2004 from the HIP program were included in the analyses.

Two trend analyses were conducted. One analysis included a smaller number or transects that had been monitored in 1998 – 2002 and 2004. The second analysis included a larger number of transects, but was restricted to 1998 – 2001 and 2004. Those transects that had no recorded slickspot peppergrass in all years were excluded. Again, PRISM climate data were used for each transect location.

This report is very similar to the earlier report by Menke and Kaye (2006a) with the primary difference due to the addition of data from the 2002 HII survey and the 2004 HIP survey. Because 2002 was unusual in that relatively few transects were surveyed, Menke and Kaye conducted several analyses in 2 different ways – either including 2002 and thereby reducing the number of transects considered in all years, or excluding 2002 and considering a larger number of transects. Furthermore, because of changes in HIP methodology and data collected, some analyses were conducted only on the 2004 data.

Statistical Analyses

The decreasing trend in slickspot peppergrass abundance identified in Menke and Kaye (2006a) was not as pronounced when data from 2004 was included. Spring precipitation accounted for 89% of the variation in slickspot peppergrass abundance. Abundance was greater in years with more spring precipitation. The influence of temperature was not nearly as strong. No statistically significant relationship between previous fires and slickspot peppergrass were identified. Again, slickspot condition and plant community measures were not compared directly with slickspot peppergrass abundance using the HII data, so no conclusions were drawn regarding the relationship between any changes in these measures through time and slickspot peppergrass abundance. The abundance data from 2004 was compared to other measures taken in that year. Slickspot peppergrass abundance was not correlated with slickspot soil crust cover, weedy species cover, total livestock print cover, or penetrating print cover. However, flowering plant abundance was positively correlated with soil crust cover, but not with livestock print cover or weed species cover. Although grazing and past fires did not correlate positively or negatively with slickspot peppergrass abundance, these factors did alter slickspot conditions and the surrounding plant communities.

Critique

(1) All comments for Menke and Kaye 2006a apply here. Expanding on Comment (2) (for Menke and Kaye 2006a), it is still clear that the observation in 1998 has strong influence even though 2 observations have been added to the regression analysis. To assess the influence, we removed the 1998 observation and re-ran the regression on the remaining data. With that change, R^2 decreased from 0.90 to 0.39 and the p-value increased from 0.004 to 0.26. We repeat our conclusion that Menke and Kaye's analysis does not provide convincing evidence of a relationship between abundance and spring precipitation.

(2) We note a relatively minor inconsistency with the previous report (Menke and Kaye 2006a). In particular, in the more recent report, Menke and Kaye state in Methods that they compared *abundance* (presumably absolute abundance) on burned and unburned transects using the Kruskal-Wallis test, and that they also compared *proportional change in abundance* on these transects using ANOVA. In the earlier report, absolute abundance

was not evaluated, while proportional change in abundance was evaluated using the Kruskal-Wallis test rather than ANOVA. The Kruskal-Wallis test would be appropriate in either case. ANOVA is fairly robust to violations of the normality assumption so it would probably lead to correct conclusions for an analysis of proportional change in abundance. While such proportions are not likely to be truly normally distributed, they would be much closer to normal than absolute abundances.

(3) The numbers of slickspot peppergrass increased in 2004 compared to 1999 through 2002. Visual inspection of the "rough census" area (Figure 3-1) and special use plot data (Figure 3-4) from the OTA shows similar changes through time, with 1998 and 2004 being "good" years with many of the interim years showing lower abundance. However, when subsequent years are considered on these two data plots, 1998 and 2004 do not stand out as particularly high. The negative trend in abundance observed over the period of 1998 through 2004 does not appear to be supported when subsequent years are included. Furthermore, no formal test of trend accompanied this analysis.

Summary
This study was very similar to an earlier study (Menke and Kaye 2006a). A few methodological differences with the earlier study were not well-explained. Otherwise, given the questions that were asked and the ways that the data were managed, the statistical procedures were chosen and used appropriately. However, the conclusions that slickspot peppergrass abundance was decreasing over time and that abundance depended on spring precipitation were not well-supported by the results.

Unnasch 2008
This report focuses on the HIP data collected from 2004 through 2007. Since the 2004 slickspot peppergrass abundance data are categorical in that individual plants were not counted, but rather abundance within slickspots was categorized (e.g., 51 – 100 plants), but the 2005 through 2007 abundance data are count data in that individual plants within the slickspot was counted. In one analysis of abundance, only the count data from 2005 through 2007 are analyzed. In the second analysis, the 2005 through 2007 data are converted into categorical data, and all four years are analyzed. Excluding 2004 allowed Unnasch to use methods based on continuously distributed data. To include that year, Unnasch categorized the count data from 2005 – 2007 so that it resembled the data from 2004, and then used methods based on categorical data.

Statistical Analyses
Analyses of 2005 – 2007 Data
Count data from 2005 – 2007 were not normally distributed. To conduct analyses relying on normal distribution theory, Unnasch log-transformed the data, dealing with 0's by adding 1 to all observations before taking the natural logarithm.

Abundance differences among years
Unnasch recognized the repeated measures nature of the data, due to the fact that HIP surveys consisted of observations made on the same transects repeatedly over time. Thus, to test for among-year differences in log-transformed abundance, he used repeated measures analysis of variance (ANOVA).

Unnasch found a significant difference in abundance among the years. In subsequent multiple comparison tests, he found a significant decrease in abundance from 2005 to 2006 and a non-significant increase from 2006 to 2007. Abundance in 2007 was significantly lower than in 2005. These results held for separate analyses of all plants, reproductive plants only, and rosettes only (except that rosette abundance in 2007 was not significantly lower than in 2005).

As an alternative to repeated measures ANOVA, untransformed data were analyzed using the Kruskal-Wallis test (a non-parametric analog of ANOVA) with pairwise comparisons between years based on the Mann-Whitney test (a non-parametric analog of the standard *t*-test). Results from the nonparametric tests generally paralleled the ANOVA results, though there were fewer significant differences (no significant tests for rosettes), which was attributed to the fact that the Kruskal-Wallis and Mann-Whitney tests did not account for the repeated measures character of the data. Specifically, the nonparametric procedures, found differences again between 2005 and 2006, but the differences were less apparent between 2005 and 2007. Again, no statistical differences were noted between 2006 and 2007.

Relationship between rosettes and reproductives

Linear regression was used to examine the relationship between the number of reproductive plants and the number of rosettes in the previous year. Results indicated that the relationship was highly significant.

Relationship between abundance and precipitation

Monthly precipitation data were obtained from PRISM, and summaries were calculated for winter (December – February), spring (March – May), and the dormant season (December – May). Abundance (of reproductives, rosettes, and total plants, considered separately) was regressed on each of the 3 seasonal summaries of precipitation. No significant relationships were found.

Analysis of 2004 – 2007 Data

Data from the period 2005 – 2007 were transformed to categories representing ranges of values (e.g., 51 – 100 plants). Furthermore, the slickspot was treated as the sample unit because using the transect as the sample (as in the other analyses) led to categories that were poorly represented or were complete empty. Data from all years (2004 – 2007) were analyzed using McNemar's test. The test examined changes in category membership between successive pairs of years (2004 – 2005, 2005 – 2006, and 2006 – 2007). Significant changes (representing change in abundance) were found in each case. Direction of change (i.e., increase or decrease in abundance) was inferred from examining each of the tables representing category membership in both years.

Critique

(1) Log-transformation to achieve approximate normality is appropriate. Adding the value 1 to all observations overcomes the problem that the logarithm of 0 is undefined; this is a fairly common practice. However, there are no theoretical justifications for using any particular value, say, 0.1 instead of 1, though 1 is a "natural" choice with count data. In some cases, analyses may be sensitive to the choice of value that is added.

(2) Repeated measures ANOVA on log-transformed data represents a reasonable choice for analysis. Log-transformation apparently resulted in approximately normal distributions. Furthermore, ANOVA is robust to non-normality. Repeated measures analysis is appropriate given the potential for temporal correlations in the data.

(3) Unnasch correctly noted that the Kruskal-Wallis and Mann-Whitney tests used to examine differences in abundance among years did not account for the temporal correlations, and he attributed the results (fewer significant differences than for ANOVA) to that fact. Certainly, not accounting for correlation structure could influence results. It may also be true that fewer significant results were found because the non-parametric tests are less powerful (less likely to detect differences) than their normal counterparts. It should also be noted that other non-parametric tests do account for dependencies in data. The Friedman and Quade tests (Hollander and Wolfe, 1999) are alternatives to the Kruskal-Wallis tests. While these alternatives do not specifically address temporal dependencies, they would be more appropriate than the Kruskal-Wallis which assumes that observations are completely independent. Also, these tests have associated multiple comparison procedures that would obviate the need for the Mann-Whitney test (which, like the Kruskal-Wallis, assumes independent observations).

(4) Linear regression was used to examine the relationship between rosettes and reproductives as well as the relationships between abundance and precipitation. Unnasch does not clearly state whether untransformed or log-transformed abundances were used in these analyses. One might assume that log-transformed abundance data were used given the recognition that the count data were not normally distributed. Regression of abundance on precipitation did not account for potential temporal correlation in the data (annual counts on the same transect, even in the presence of a precipitation effect, may be more similar to each other than are counts on different transects). Repeated measures analysis would have been appropriate for these data.

(5) All the analyses of the data for 2005 – 2007 dealt with non-normality of abundance data either by log-transformation (assumed in the case of linear regression) followed by procedures based on normal distribution theory, or by use of non-parametric procedures. Both approaches are valid. However, current statistical practice offers analysis methods for count data, such as the slickspot peppergrass abundance data, that are both more appropriate and more powerful than the methods used by Unnasch. In particular, generalized linear models (McCullagh and Nelder, 1989) extend the linear model approach – typified by ANOVA and standard regression – to other distributions in addition to the normal distribution. In particular, log-linear models based on the Poisson and negative binomial distributions are well-suited to count data. In recent years, generalized linear models have been extended to account for dependencies in data, such as those that might arise from repeated measures or spatial associations. However, it is certainly true that these newer approaches are less accessible to non-statisticians than are methods based on the normal distribution.

(6) The test for differences among all years (2004 – 2007) using categorical data was referred to as "McNemar's test" by Unnasch. Strictly speaking, McNemar's test is designed for binomial data (2 alternative categories), thus the test actually used would more appropriately be named the "marginal homogeneity test" which is designed for multinomial data (more than 2 categories). Otherwise, the test is valid for examining

differences in pairs of years. Of greater importance is the fact that the individual slickspot was treated as the sample unit, whereas, based on the design of the HIP surveys, the transect is the actual sample unit. Using the slickspot rather than the transect was a convenience for the implementation of this test. However, doing so inflated the sample size and thereby made it more likely that significant results would be found. Another issue in Unnasch's approach is that categorization of the 2005 – 2007 count data leads to loss of information. Unfortunately, the difference in survey methodology between 2004 and 2005 – 2007 makes any analysis of the combined data more difficult. An alternative approach would create continuous data from the categories used in 2004 by selecting the midpoint of the range category to represent the unknown count. This approach imputes precision in the 2004 data that does not truly exist. However, in doing so, no information would be lost from the 2005 – 2007 data and, as equally important, would allow analysis methods for continuous data, as used for the 2005 – 2007 data alone.

Summary

This appears to be a well-conducted analysis. Most procedures were used appropriately, though in a few cases alternative methods would have been more appropriate. The author's conclusions were well-supported by the results in most cases.

Salo 2008

This report analyzes the impacts of livestock use on slickspot peppergrass for the years 2005 through 2007 using HIP slickspot peppergrass abundance data. A single research question is initially stated: Is there a relationship between tripped livestock triggers (penetrating livestock trampling constituting more than 10% of a slickspot) and slickspot peppergrass abundance? The selection of a trigger of 10% appears arbitrary in that no supporting evidence is provided for its selection.

This one question is then broken down into the impacts between slickspots with greater than 10% cover of penetrating prints (a "tripped trigger") and those without, making the same comparison in the following years, or two years later. The latter two comparisons concerned potential delayed effects of livestock trampling. The magnitude of the change is also considered.

Statistical Methods

For the analysis, abundance was log-transformed (after adding 1 to all observations). In addition, for the analyses of delayed effects, both abundance and change in abundance (from the year of the trampling assessment) were examined. Analysis of variance (ANOVA) was used to test differences in abundance (or changes in abundance) between triggered and untriggered slickspots. No significant differences were found.

Critique

(1) No justification of choosing a trigger of 10% cover of penetrating prints is presented. Without a justification of the trigger, it is not possible to evaluate how tripping the trigger should impact slickspot peppergrass abundance.
(2) See Comment (1) for Unnasch 2008.
(3) ANOVA conducted in cases where there are 2 groups, rather than 3 or more groups, is more appropriately referred to as a "two-sample independent *t*-test". However, the

underlying mathematics are the same, and the tests (by whatever names a software package might use) yield equivalent results.

(4) Several methodological details are unclear. Is the slickspot or the transect treated as the sample unit? Are sample units paired in some way? Several of Salo's comments refer to comparisons of slickspots with and without triggers "on the same transect". That would suggest a paired comparison in which the transect is the sample unit. However, the use of ANOVA (i.e., two-sample *t*-test) would not be appropriate for such paired data. If slickspots were not paired, what do the reported sample sizes refer to? If they refer to combined (both triggered and untriggered units), it would be more informative to know the sample sizes for both types of units. In general, it is not possible to comment on the results (whether they are meaningful or not) because the presentation of methods is too vague.

(5) Regarding use of normal theory statistics (ANOVA, *t*-tests), see Comment (5) for Unnasch 2008.

(6) The results are presented in a much abbreviated format that lacks sufficient detail to evaluate how the analyses were performed. For example, the numbers of slickspots with and without tripped triggers is not presented so it is not possible to determine whether there were sufficient numbers of impacted and unimpacted slickspots for a robust test. Without a more detailed presentation of the results, the conclusion of no relationship between the selected trigger and slickspot peppergrass abundance cannot be evaluated.

(7) Since the trigger selected is not justified, and because the presentation of the results lacks sufficient detail, the implications of penetrating prints on slickspot peppergrass abundance cannot be determined from this report.

Summary
Details of statistical methodology are not clearly presented. As a consequence, it is not possible to evaluate the results and the conclusions.

Literature Cited
Menke, C.A. and T.N. Kaye. 2006a. *Lepidium papilliferum* (Slickspot peppergrass) Habitat Integrity Index Data Analysis (1998 – 2001). A Cooperative Project between the Bureau of Land Management, the Idaho Fish and Game Idaho Conservation Data Center and Institute for Applied Ecology. 27 pp.

Menke, C.A. and T.N. Kaye. 2006b. *Lepidium papilliferum* (Slickspot peppergrass): Evaluation of Trends (1998 – 2004) and Analysis of 2004 Habitat Integrity and Population Monitoring Data. A Cooperative Project between the Bureau of Land Management, the Idaho Fish and Game Idaho Conservation Data Center and Institute for Applied Ecology. 21 pp.

Salo, C. 2008. Relationship between tripped livestock triggers and *Lepidium papilliferum* abundance. Unpublished report. 11 pp.

Unnasch, R.S. 2008. *Lepidium papilliferum* (Slickspot peppergrass): Evaulation of Trends 2004 – 2007. Final Report prepared for Idaho Department of Fish and Game, Idaho Conservation Data Center. 17 pp.

Appendix A: Metadata for Orchard Training Areas GIS Vegetation Layer

Identification_Information:
Citation:
Citation_Information:
Originator: EMO / USGS
Publication_Date: 2003
Title: finalagsmooth
Geospatial_Data_Presentation_Form: raster digital data

Description:
Abstract:
Erdas Imagine raster format Final 3 X 3 Smoothed Composite Vegetation from Veg2000 analysis.
These data derived from an annually constrained temporal analysis.

This is the final detailed raster. See related products:
finalag1.img - this file detailed final veg classification

finalag13x3smooth - 3X3 smoothing filter applied (this is prefered general use classification)

finalag1ShrubNonShrub - Reclass of finalag1 to shrub nonshrub classes

finalag13x3ShrubNonShrub - Reclass of finalag13x3Smooth to Shrub nonshrub classes. This is preferred general use shrubNonShrub classification)
Purpose: Used for vegetaion analysis/representation, and Research and Analysis.
Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: 2000
Currentness_Reference: 2000
Status:
Progress: Complete
Maintenance_and_Update_Frequency: Irregular
Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate: -116.445906
East_Bounding_Coordinate: -115.814677
North_Bounding_Coordinate: 43.488652
South_Bounding_Coordinate: 43.010100
Keywords:
Theme:
Theme_Keyword_Thesaurus: None

Theme_Keyword: Vegetation
Theme_Keyword: Veg Classification
Theme_Keyword: Veg Type
Theme_Keyword: Composite Vegetation
Place:
Place_Keyword_Thesaurus: None
Place_Keyword: Idaho
Place_Keyword: GFTA
Place_Keyword: Orchard Training Area
Place_Keyword: Gowen Field Training Area
Access_Constraints: None. Please cite source when using.
Use_Constraints: Environmental Management Office, State of Idaho Military Division claims no responsibility for uses outside our direct control.
Point_of_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Idaho Military Division
Contact_Person: Nick Nydegger
Contact_Position: GIS Systems
Contact_Voice_Telephone: 208-422-4182
Contact_Facsimile_Telephone: 208-422-4169
Contact_Electronic_Mail_Address: nydeggen@id.ngb.army.mil;shaffers@id.ngb.army.mil
Hours_of_Service: M-F 8-5
Security_Information:
Security_Classification_System: Standard
Security_Classification: Unclassified
Native_Data_Set_Environment: Version 6.0 (Build 6001) Service Pack 1; ESRI ArcCatalog 9.2.6.1500
Data_Quality_Information:
Attribute_Accuracy:
Logical_Consistency_Report: Consistent as intended
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report: 0.5 Pixel size = > 25m
Lineage:
Source_Information:
Source_Scale_Denominator: Landsat L5/L7
Type_of_Source_Media: digital tape media
Process_Step:
Process_Description:
Composite Image derived from analysis of Landsat L5/L7 data.
Goal was to identify the best month for the identification of each individual plant species. Use Signature dataset and supervised classification within ERDAS Imagine on each dataset of interest. Used Separability index and Classification error matrix to select key month for species identification. Hierarchial entry used to build composite image from source classifications.

Smoothing filters applied in related datasets. 3 X 3 Majority filter used to smooth finalag1 detailed classification.
Process_Date: 2003
Process_Step:
Process_Description: Metadata imported.
Source_Used_Citation_Abbreviation: S:\NickSDSWork\MetaMover\DOQMeta1.xml
Process_Step:
Process_Description: Metadata imported.
Source_Used_Citation_Abbreviation: S:\F44116a1.tif.xml
Process_Step:
Process_Description: Metadata imported.
Source_Used_Citation_Abbreviation:
S:\MyGISProjects\Veg2000Final\Veg2000FinalImages\finalag1.img.xml
Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Raster
Raster_Object_Information:
Raster_Object_Type: Grid Cell
Row_Count: 2105
Column_Count: 2028
Vertical_Count: 1
Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Grid_Coordinate_System:
Grid_Coordinate_System_Name: Universal Transverse Mercator
Universal_Transverse_Mercator:
UTM_Zone_Number: 11
Transverse_Mercator:
Scale_Factor_at_Central_Meridian: 0.999600
Longitude_of_Central_Meridian: -117.000000
Latitude_of_Projection_Origin: 0.000000
False_Easting: 500000.000000
False_Northing: 0.000000
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: row and column
Coordinate_Representation:
Abscissa_Resolution: 25.000000
Ordinate_Resolution: 25.000000
Planar_Distance_Units: meters
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: Geodetic Reference System 80
Semi-major_Axis: 6378137.000000
Denominator_of_Flattening_Ratio: 298.257222
Entity_and_Attribute_Information:

Detailed_Description:
  Entity_Type:
    Entity_Type_Label: finalagsmooth.vat
  Attribute:
    Attribute_Label: Opacity
  Attribute:
    Attribute_Label: Rowid
    Attribute_Definition: Internal feature number.
    Attribute_Definition_Source: ESRI
    Attribute_Domain_Values:
      Unrepresentable_Domain: Sequential unique whole numbers that are automatically generated.
  Attribute:
    Attribute_Label: VALUE
  Attribute:
    Attribute_Label: COUNT
  Attribute:
    Attribute_Label: RED
  Attribute:
    Attribute_Label: GREEN
  Attribute:
    Attribute_Label: BLUE
  Attribute:
    Attribute_Label: CLASS_NAMES
  Attribute:
    Attribute_Label: Value
  Attribute:
    Attribute_Label: Count
  Attribute:
    Attribute_Label: Class_names
  Attribute:
    Attribute_Label: Red
  Attribute:
    Attribute_Label: Green
  Attribute:
    Attribute_Label: Blue
  Attribute:
    Attribute_Label: OPACITY
Distribution_Information:
  Resource_Description: Downloadable Data
  Standard_Order_Process:
    Digital_Form:
      Digital_Transfer_Information:
        Transfer_Size: 1.060
Metadata_Reference_Information:

Metadata_Date: 20081226
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: REQUIRED: The organization responsible for the metadata information.
Contact_Person: REQUIRED: The person responsible for the metadata information.
Contact_Address:
Address_Type: REQUIRED: The mailing and/or physical address for the organization or individual.
City: REQUIRED: The city of the address.
State_or_Province: REQUIRED: The state or province of the address.
Postal_Code: REQUIRED: The ZIP or other postal code of the address.
Contact_Voice_Telephone: REQUIRED: The telephone number by which individuals can speak to the organization or individual.
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time
Metadata_Extensions:
Online_Linkage: http://www.esri.com/metadata/esriprof80.html
Profile_Name: ESRI Metadata Profile

Key to Veg 2000 data

Unclassified	- These are unclassified areaas.
ARTR	-Artemisia tridentata – Big Sagebrush
ATCO	-Atriplex confertifolia - Shadscale
BRTE	-Bromus tectorum – Cheatgrass
CELA	-Ceratoides lanata – Winterfat
CHVI	-Chrysothamnus visidiflores – Rabbitbrush
POA	-Poa Sandbergii – Sandberg's Bluegrass
EXAN	-Exotic Annuals – Exotic invader
MiscWater	- Miscellaneous Water
PrimAg	- Primary Agriculture (active during the analysis)
SecAg	- Secondary Agriculture (inactive but previously farmed)
SnakeRiver	- Snake River proper
Cinder	- Cindered Areas (volcanic)
Bareground	- Bare Ground Areas
Playa	- Playa areas (ephemeral ponds)

Appendix B: Metadata for GAP Ecological Systems, USGS Mapping Zone 18

Identification_Information:

Citation:

Citation_Information:

Originator:

Institute for Natural Resources, Oregon State University, Corvallis, Oregon for the USGS GAP Program

Publication_Date: November, 2007

Title: GAP Ecological Systems, USGS Mapping Zone 18

Geospatial_Data_Presentation_Form: Existing Land Cover/Vegetation Map

Online_Linkage:

Description:

Abstract:

Multi-season satellite imagery (Landsat ETM+) from 1999-2001 were used in conjunction with digital elevation model (DEM) derived datasets (e.g. elevation, landform, aspect, etc.) to model natural and semi-natural vegetation. The minimum mapping unit for this dataset is approximately 1 hectare. Landcover classes are drawn from NatureServe's Ecological System concept. For the majority of classes, a decision tree classifier was used to discriminate landcover types, while a minority of classes (e.g. urban classes, burn scars, etc.) were mapped using other techniques.

Purpose:

The digital landcover dataset may be used for various purposes with user's discretion. Specifically, this dataset was created for regional terrestrial biodiversity assessment. These data are not intended to be used at scales larger than 1:100,000.

Time_Period_of_Content:

Time_Period_Information:

Single_Date/Time:

Calendar_Date: 1999 - 2001

Currentness_Reference: Imagery from 1999 - 2001

Status:

Progress: Complete

Maintenance_and_Update_Frequency: As needed

Spatial_Domain:

Bounding_Coordinates:

West_Bounding_Coordinate: -1,873,935

East_Bounding_Coordinate: -1,164,375

North_Bounding_Coordinate: 2,656,665

South_Bounding_Coordinate: 2,151,825

Keywords:

Theme:

Theme_Keyword: Vegetation Map

Theme_Keyword: Land Cover Map

Theme_Keyword: Ecological Systems
Place:
Place_Keyword: Southern Idaho
Place_Keyword: Pacific Northwest
Access_Constraints: none.
Use_Constraints:
Appropriate scale for these data is 1: 100,000 smaller. The user assumes responsiblity when using this dataset.
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
*Contact_Person:*Anne Davidson
Contact_Organization: USGS GAP Program
Contact_Position: Senior GIS/Remote Sensing Specialist
Contact_Voice_Telephone: (208) 885-3720
Contact_Electronic_Mail_Address: adavidson@uidaho.edu
Contact_Instructions:
USGS/BRD/Gap Analysis Program 530 S. Asbury St., Suite 1 Moscow, ID 83843
Native_Data_Set_Environment:
Microsoft Windows XP Version 5.1 (Build 2600) Service Pack 2; ESRI ArcCatalog 9.0.0.535

Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report:
For a full description of the accuracy assesment for this data layer, the user is directed to the Zone 18 final report available from the USGS GAP office (<http://www.gap.uidaho.edu>)
Positional_Accuracy:
Horizontal_Positional_Accuracy:
Horizontal_Positional_Accuracy_Report: Positional accuracy is within 1 TM pixel, 30 meters.
Lineage:
Process_Step:
Process_Description:
For a full description of analytical steps in the creation of this data layer, please refer to the final report.

Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Raster
Raster_Object_Information:
Raster_Object_Type: Pixel
Row_Count: 16828
Column_Count: 23652

Vertical_Count: 1

Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Map_Projection:
Map_Projection_Name: Albers Conical Equal Area
Albers_Conical_Equal_Area:
Standard_Parallel: 29.500000
Standard_Parallel: 45.500000
Longitude_of_Central_Meridian: -96.000000
Latitude_of_Projection_Origin: 23.000000
False_Easting: 0.000000
False_Northing: 0.000000
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: row and column
Coordinate_Representation:
Abscissa_Resolution: 30.000000
Ordinate_Resolution: 30.000000
Planar_Distance_Units: meters
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: Geodetic Reference System 80
Semi-major_Axis: 6378137.000000
Denominator_of_Flattening_Ratio: 298.257222

Entity_and_Attribute_Information:
Detailed_Description:
Entity_Type:
Entity_Type_Label: GAP Ecological Systems
Attribute:
Attribute_Label: ObjectID
Attribute_Definition: Internal feature number.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain:
Sequential unique whole numbers that are automatically generated.
Attribute:
Attribute_Label: Value
Attribute_Definition: Numerical Code for Ecological System
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: 1
Enumerated_Domain_Value_Definition: Open Water

Enumerated_Domain_Value_Definition_Source: NLCD 2001 Land Cover Class Definitions
All areas of open water, generally with less than 25% cover of vegetation or soil.

Enumerated_Domain:
Enumerated_Domain_Value: 2
Enumerated_Domain_Value_Definition: CRP
Enumerated_Domain_Value_Definition_Source: NLCD 2001 Land Cover Class Definitions
Lands enrolled in the Conservation Reserve Program.

Enumerated_Domain:
Enumerated_Domain_Value: 3
Enumerated_Domain_Value_Definition: Developed, Open Space
Enumerated_Domain_Value_Definition_Source: NLCD 2001 Land Cover Class Definitions
Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.

Enumerated_Domain:
Enumerated_Domain_Value: 4
Enumerated_Domain_Value_Definition: Developed, Low Intensity
Enumerated_Domain_Value_Definition_Source: NLCD 2001 Land Cover Class Definitions
Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.

Enumerated_Domain:
Enumerated_Domain_Value: 5
Enumerated_Domain_Value_Definition: Developed, Medium Intensity
Enumerated_Domain_Value_Definition_Source: NLCD 2001 Land Cover Class Definitions
Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.

Enumerated_Domain:
Enumerated_Domain_Value: 6
Enumerated_Domain_Value_Definition: Developed, High Intensity)
Enumerated_Domain_Value_Definition_Source: NLCD 2001 Land Cover Class Definitions

Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to100 percent of the total cover.

Enumerated_Domain:
Enumerated_Domain_Value: 7
Enumerated_Domain_Value_Definition: Barren Land (Rock/Sand/Clay)
Enumerated_Domain_Value_Definition_Source: NLCD 2001 Land Cover Class Definitions
Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.

Enumerated_Domain:
Enumerated_Domain_Value: 8
Enumerated_Domain_Value_Definition: Quarries Strip Mines and Gravel Pits
Enumerated_Domain_Value_Definition_Source:
Areas of known strip mining or quarry activit

Enumerated_Domain:
Enumerated_Domain_Value: 9
Enumerated_Domain_Value_Definition: Unconsolidated Shore
Enumerated_Domain_Value_Definition_Source: NLCD 2001 Land Cover Class Definitions
Unconsolidated material such as silt, sand, or gravel that is subject to inundation and redistribution due to the action of water. Characterized by substrates lacking vegetation except for pioneering plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce a number of landforms representing this class.

Enumerated_Domain:
Enumerated_Domain_Value: 10
Enumerated_Domain_Value_Definition: Orchards/Vineyards
Enumerated_Domain_Value_Definition_Source:
Areas used for growing grapes, apples and other high structure crops. Should be recoded to Value 13 in final drafts

Enumerated_Domain:
Enumerated_Domain_Value: 11
Enumerated_Domain_Value_Definition: Pasture/Hay
Enumerated_Domain_Value_Definition_Source: NLCD 2001 Land Cover Class Definitions
Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.

Enumerated_Domain:
Enumerated_Domain_Value: 12
Enumerated_Domain_Value_Definition: Cultivated Cropland
Enumerated_Domain_Value_Definition_Source: NLCD 2001 Land Cover Class Definitions
Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.

Enumerated_Domain:
Enumerated_Domain_Value: 13
Enumerated_Domain_Value_Definition: High Structure Agriculture
Enumerated_Domain_Value_Definition_Source:
Areas used for growing grapes, apples and other high structure crops

Enumerated_Domain:
Enumerated_Domain_Value: 14
Enumerated_Domain_Value_Definition: Western Great Plains Badland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system is found within the northern Great Plains region of the United States and Canada with some of the better known and extensive examples in North and South Dakota. In contrast to Western Great Plains Cliff and Outcrop (CES303.665), this system is typified by extremely dry and easily eroded, consolidated clay soils with bands of sandstone or isolated consolidates and little to no cover of vegetation (usually less than 10% but can be as high as 20%). Vegetated patches within the badlands system may have cover higher than 20%. In north-central Montana, badlands often are a mosaic of bare substrate with small patches of grasses and/or shrubs that may exceed 10% cover. In those areas with vegetation, species can include scattered individuals of many dryland shrubs or herbaceous taxa, including Grindelia squarrosa, Gutierrezia sarothrae (especially with overuse and grazing), Sarcobatus vermiculatus, Atriplex gardneri, Artemisia pedatifida, Eriogonum spp., Muhlenbergia cuspidata, Pseudoroegneria spicata, and Arenaria hookeri. Patches of Artemisia spp. can also occur. This system can occur where the land lies well above its local base level or below and is created by several factors, including elevation, rainfall, carving action of streams, and parent material.

Enumerated_Domain:
Enumerated_Domain_Value: 15
Enumerated_Domain_Value_Definition: Temperate Pacific Intertidal Mudflat
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
Coastal mudflats are found along the north Pacific Coast from Cook Inlet, Alaska, south to central California. Mudflats form a narrow band along oceanic inlets, and are more

extensive at the mouths of larger rivers. Algae are the dominant vegetation on mudflats where little vascular vegetation is present due to the daily (in some cases twice daily) tidal flooding of salt or brackish water. Characteristic species include Vaucheria longicaulis and Enteromorpha spp. The dominant processes are tectonic uplift or subsidence, isostatic rebound and sediment deposition.

Enumerated_Domain:
*Enumerated_Domain_Value:*16
Enumerated_Domain_Value_Definition: North Pacific Alpine and Subalpine Bedrock and Scree
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This system includes all the exposed rock and rubble above the forest line (subalpine parkland and above) in the North Pacific mountain ranges. This ecological system is restricted to the highest elevations in the Cascade Range, from southwestern British Columbia south into northern California. It is composed of barren and sparsely vegetated alpine substrates, typically including both bedrock outcrops and scree slopes, with nonvascular- (lichen-) dominated communities. Exposure to desiccating winds, rocky and sometimes unstable substrates, and a short growing season limit plant growth. There can be sparse cover of forbs, grasses, lichens, shrubs and small trees.

Enumerated_Domain:
Enumerated_Domain_Value: 17
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Volcanic Rock and Cinder Land
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system occurs in the intermountain western U.S. and is limited to barren and sparsely vegetated volcanic substrates (generally <10% plant cover) such as basalt lava (malpais), basalt dikes with associated colluvium, basalt cliff faces and uplifted "backbones," tuff, cinder cones or cinder fields. It may occur as large-patch, small-patch and linear (dikes) spatial patterns. Vegetation is variable and includes a variety of species depending on local environmental conditions, e.g., elevation, age and type of substrate. At montane and foothill elevations scattered *Pinus ponderosa, Pinus flexilis*, or *Juniperus* spp. trees may be present. Shrubs such as *Ephedra* spp., *Atriplex canescens, Eriogonum corymbosum, Eriogonum ovalifolium*, and *Fallugia paradoxa* are often present on some lava flows and cinder fields. Species typical of sand dunes such as *Andropogon hallii* and *Artemisia filifolia* may be present on cinder substrates

Enumerated_Domain:
*Enumerated_Domain_Value:*18
Enumerated_Domain_Value_Definition: Rocky Mountain Cliff, Canyon and Massive Bedrock
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org

This ecological system of barren and sparsely vegetated landscapes (generally <10% plant cover) is found from foothill to subalpine elevations on steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous (intrusives), sedimentary, and metamorphic bedrock types. It is located throughout the Rocky Mountains and northeastern Cascade Ranges in North America. Also included are unstable scree and talus slopes that typically occur below cliff faces. In general these are the dry sparsely vegetated places on a landscape. The biota on them reflect what is surrounding them, unless it is an extreme parent material. There may be small patches of dense vegetation, but it typically includes scattered trees and/or shrubs. Characteristic trees includes species from the surrounding landscape, such as *Pseudotsuga menziesii, Pinus ponderosa, Pinus flexilis, Populus tremuloides, Abies concolor, Abies lasiocarpa*, or *Pinus edulis* and *Juniperus* spp. at lower elevations. There may be scattered shrubs present, such as species of *Holodiscus, Ribes, Physocarpus, Rosa, Juniperus*, and *Jamesia americana, Mahonia repens, Rhus trilobata*, or *Amelanchier alnifolia*. Soil development is limited, as is herbaceous cover.

Enumerated_Domain:
Enumerated_Domain_Value: 19
Enumerated_Domain_Value_Definition: North American Alpine Ice Field
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This widespread ecological system is composed of unvegetated landscapes of annual/perennial ice and snow at the highest elevations, where snowfall accumulation exceeds melting. The primary ecological processes include snow/ice retention, wind desiccation, and permafrost. The snowpack/ice field never melts or, if so, then for only a few weeks. The alpine substrate/ice field ecological system is part of the alpine mosaic consisting of alpine bedrock and scree, tundra dry meadow, wet meadow, fell-fields, and dwarf-shrubland.

Enumerated_Domain:
Enumerated_Domain_Value: 20
Enumerated_Domain_Value_Definition: Rocky Mountain Alpine Bedrock and Scree
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system is restricted to the highest elevations of the Rocky Mountains, from Alberta and British Columbia south into New Mexico, west into the highest mountain ranges of the Great Basin. It is composed of barren and sparsely vegetated alpine substrates, typically including both bedrock outcrop and scree slopes, with nonvascular- (lichen) dominated communities. Exposure to desiccating winds, rocky and sometimes unstable substrates, and a short growing season limit plant growth. There can be sparse cover of forbs, grasses, lichens and low shrubs.

Enumerated_Domain:
Enumerated_Domain_Value: 21
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Shale Badlands

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
Summary: This widespread ecological system of the Intermountain western U.S. is composed of barren and sparsely vegetated substrates (<10% plant cover) typically derived from marine shales but also includes substrates derived from siltstones and mudstones (clay). In southern Wyoming , the shales are not marine in origin, but often have bentonite, derived from volcanic ash deposition that occurred during several eruptions of the Yellowstone volcanic fields. Landforms are typically rounded hills and plains that form a rolling topography. The harsh soil properties and high rate of erosion and deposition are driving environmental variables supporting sparse dwarf-shrubs, e.g., Atriplex corrugata, Atriplex gardneri, Artemisia pedatifida, and herbaceous vegetation.

Enumerated_Domain:
Enumerated_Domain_Value: 22
Enumerated_Domain_Value_Definition: Northern Pacific Avalanche Chute Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system includes active volcanic landscapes dominated by ash, pyroclastic deposits, lava, landslides and other exposed bare mineral and rock. Periodic eruptions and earthquakes are the primary processes maintaining a primarily barren environment. Decades of inactivity slowly provide opportunity for development of other systems, such as North American Alpine Ice Field (CES300.728), or primary successional stages of surrounding vegetated systems to develop.

Enumerated_Domain:
Enumerated_Domain_Value: 23
Enumerated_Domain_Value_Definition: Western Great Plains Cliff and Outcrop
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This system includes cliffs and outcrops throughout the Western Great Plains Division. Substrate can range from sandstone and limestone, which can often form bands in the examples of this system. Vegetation is restricted to shelves, cracks and crevices in the rock. However, this system differs from Western Great Plains Badlands (CES303.663) in that often the soil is slightly developed and less erodible, and some grass and shrub species can occur at greater than 10%. Common species in this system include short shrubs such as *Rhus trilobata* and *Artemisia longifolia* and mixedgrass species such as *Bouteloua curtipendula* and *Bouteloua gracilis* and *Calamovilfa longifolia*. Drought and wind erosion are the most common natural dynamics affecting this system..

Enumerated_Domain:
Enumerated_Domain_Value: 24
Enumerated_Domain_Value_Definition: Inter-Mountain Basin Wash
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org

This barren and sparsely vegetated (generally <10% plant cover) ecological system is restricted to intermittently flooded streambeds and banks that are often lined with shrubs such as Sarcobatus vermiculatus, Ericameria nauseosa, Fallugia paradoxa, Artemisia tridentata ssp. tridentata, and/or Artemisia cana ssp. cana (in more northern and mesic stands) that form relatively dense stringers in open dry uplands. Grayia spinosa may dominate in the Great Basin. Shrubs form a continuous or intermittent linear canopy in and along drainages but do not extend out into flats. Typically it includes patches of saltgrass meadow where water remains for the longest periods. In parts of Wyoming, stringers or patches of Artemisia tridentata ssp. tridentata are large and distinct enough from surrounding upland vegetation due to the influence of the wash that they can be classified separately. However, small intermittent washes may also be included with adjacent uplands if vegetation is not different enough floristically or structurally from uplands (e.g., just a little denser canopy). Soils are variable but are generally less alkaline than those found in the playa system. Desert scrub species (e.g., Acacia greggii, Prosopis spp.) that are common in the Mojave, Sonoran and Chihuahuan desert washes are not present. This type can occur in limited portions of the southwestern Great Plains.

Enumerated_Domain:
Enumerated_Domain_Value: 25
Enumerated_Domain_Value_Definition: North Pacific Montane Massive Bedrock, Cliff and Talus
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system is found from foothill to subalpine elevations and includes barren and sparsely vegetated landscapes (generally <10% plant cover) of steep cliff faces, narrow canyons, and larger rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. Also included are unstable scree and talus that typically occur below cliff faces. The dominant process is drought and other extreme growing conditions created by exposed rock or unstable slopes typically associated with steep slopes. Fractures in the rock surface and less steep or more stable slopes may be occupied by small patches of dense vegetation, typically scattered trees and/or shrubs. Characteristic trees includes *Chamaecyparis nootkatensis, Tsuga* spp., *Thuja plicata, Pseudotsuga menziesii*, or *Abies* spp. There may be scattered shrubs present, such as *Acer circinatum, Alnus* spp., and *Ribes* spp. Soil development is limited as is herbaceous cover. Mosses or lichens may be very dense, well-developed and display cover well over 10%.

Enumerated_Domain:
Enumerated_Domain_Value: 26
Enumerated_Domain_Value_Definition: North Pacific Costal Cliff and Bluff
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system includes unvegetated or sparsely vegetated rock cliffs and very steep bluffs of glacial deposits along the Pacific Ocean and associated marine and estuarine inlets. It is restricted to degrading slopes from southwestern British Columbia

south into central Oregon. It is composed of barren and sparsely vegetated substrates, typically including exposed sediments, bedrock, and scree slopes. Exposure to waves, eroding and desiccating winds, slope failures and sheet erosion create gravelly to rocky substrates that are often unstable. There can be sparse cover of forbs, grasses, lichens and low shrubs.

Enumerated_Domain:
Enumerated_Domain_Value: 27
Enumerated_Domain_Value_Definition: North Pacific Serpentine Barren
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This uncommon ecological system is found in the east and west Cascades. It is usually found on steep slopes with loosely consolidated soils and harsh soil chemical conditions (large rock outcrops and gravelly soil), although exposed ridges occur. This system occurs primarily in the Wenatchee Mountains in the east Cascades between 760 and 2100 m elevation (2500-7000 feet) on thin rocky, ultramafic (peridotite, serpentinite) soils of varying extent up to several square km. Most sites support often stunted conifers, typically stress-tolerant species. Not all ultramafic outcrops support a distinct vegetation. Only those with very low Ca:Mg ratio impact biotic composition, whereas others reflect increased influence of soil drought on ultramafic material. These systems are highly variable and are described here to include barren slopes to patches of nearly closed forests. Low-elevation sites support *Pseudotsuga menziesii, Pinus ponderosa*, and *Pinus monticola* trees with a sparse ground cover with *Aspidotis densa, Arctostaphylos nevadensis*, and *Pseudoroegneria spicata*. Higher elevations have *Pinus contorta var. latifolia, Pinus albicaulis, Abies lasiocarpa*, and *Tsuga mertensiana* with *Juniperus communis, Ledum glandulosum, Vaccinium scoparium, Poa curtifolia*, and *Festuca viridula*.

Enumerated_Domain:
Enumerated_Domain_Value: 28
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Active and Stabilized Dune
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system occurs in the Intermountain western U.S. on basins, valleys and plains. Often it is composed of a mosaic of migrating, bare dunes; anchored dunes with sparse to moderately dense vegetation (<10-30% canopy cover); and stabilized dunes. The system is defined by the presence of migrating dunes or, where the dunes are entirely anchored or stabilized, evidence that the substrate is eolian and not residual, that the vegetation is early- or mid-seral, and that the substrate is likely to become actively migrating again with disturbance or increased aridity. In the Colorado Plateau, there are many small active and partially vegetated dunes along some of the larger washes and playas (where sand is blown out of wash and forms dunes) and some larger dunes such as Coral Pink Dunes in southwestern Utah. Substrates are usually eolian sand, but small dunes composed of silt and clay downwind from playas in the Wyoming Basins (which

usually support greasewood vegetation) also are included here. Species occupying these environments are often adapted to shifting, coarse-textured substrates (usually quartz sand) and form patchy or open grasslands, shrublands or steppe, and occasionally woodlands. Vegetation varies and may be composed of *Achnatherum hymenoides, Artemisia filifolia, Artemisia tridentata ssp. tridentata, Atriplex canescens, Ephedra* spp., *Chrysothamnus viscidiflorus, Coleogyne ramosissima, Ericameria nauseosa, Hesperostipa comata, Leymus flavescens, Muhlenbergia pungens, Psoralidium lanceolatum, Purshia tridentata, Redfieldia flexuosa, Sporobolus airoides, Sarcobatus vermiculatus, Tetradymia tetrameres*, or *Tiquilia* spp. Herbaceous species such as *Achnatherum hymenoides, Redfieldia flexuosa*, and *Psoralidium lanceolatum* are characteristic of early-seral vegetation through much of this system's range. Shrubs are commonly dominant on mid- to late-seral stands, and *Ericameria nauseosa* can be found at any stage.

Enumerated_Domain:
Enumerated_Domain_Value: 29
Enumerated_Domain_Value_Definition: Mediterranean California Northern Coastal Dune
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This coastal system occurs in scattered locations from Point Conception, California, north to Coos Bay, Oregon. Coastal dunes include beaches, foredunes, sand spits, and active to stabilizing backdunes and sandsheets derived from quartz or gypsum sands. The mosaic of sparse to dense vegetation in dune systems is driven by sand deposition, erosion, and lateral movement. Coastal dunes often front portions of inlets and tidal marshes. They may also occur as extensive dune fields dominating large coastal bays. Dune vegetation typically includes herbaceous, succulent, and low-shrub species with varying degrees of tolerance for salt spray, wind and sand abrasion, and substrate stability. Dune succession is highly variable, so species composition can vary significantly between occurrences. Generally, these dune systems can be dominated by *Leymus mollis, Abronia latifolia, Ambrosia chamissonis, Baccharis pilularis, Calystegia soldanella, Artemisia pycnocephala, Ericameria ericoides, Eriogonum latifolium, Camissonia cheiranthifolia*, and *Carpobrotus chilensis (= Carpobrotus aequilateralus)*. Disturbance processes include dune blowouts caused by wind and occasional wave overwash during storm tidal surges.

Enumerated_Domain:
Enumerated_Domain_Value: 30
Enumerated_Domain_Value_Definition: Mediterranean California Serpentine Barrens
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This uncommon system is found in the central and southern Sierra Nevada, Central and Northern Coast Ranges, and Klamath Ranges at elevations between 150 to 1800 m (450-5500 feet), where serpentine outcrops and related soils are common. Not all serpentinite outcrops support distinct vegetation. Only those with very low Ca:Mg ratio impact biotic

composition. This system is usually found on steep slopes with loosely consolidated soils and harsh soil chemical conditions (large rock outcrops and gravelly soil). There is typically a very low cover (<10%) of herbaceous species, including *Streptanthus* spp., *Hesperolinon* spp., *Allium falcifolium, Allium cratericola, Asclepias solanoana, Eriogonum ursinum*, and *Eriogonum nudum*.

Enumerated_Domain:
Enumerated_Domain_Value: 31
Enumerated_Domain_Value_Definition: North Pacific Coastal Cliff and Bluff
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
Found from foothill to subalpine elevations of the Klamath Range, these are barren and sparsely vegetated landscapes (<10% plant cover) of steep cliff faces, bald ridgetops and shoulder outcrops, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock. Vegetative cover is dominated by forbs, grasses, mosses, or lichens. This also includes unstable scree and talus slopes typically occurring below cliff faces. Scattered vegetation may include *Pseudotsuga menziesii* and *Acer macrophyllum* along with herbaceous and nonvascular species such as *Achnatherum lemmonii (= Stipa lemmonii), Achnatherum occidentale (= Stipa occidentalis), Elymus elymoides (= Sitanion hystrix), Sedum oregonense*, and *Racomitrium ericoides (= Racomitrium canescens var. ericoides)*. Soil development is limited as is herbaceous cover.

Enumerated_Domain:
Enumerated_Domain_Value: 32
Enumerated_Domain_Value_Definition: Sierra Nevada Cliff and Canyon
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
Found from foothill to subalpine elevations throughout the Sierra Nevada and nearby mountain ranges, these are barren and sparsely vegetated areas (<10% plant cover) of steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock. This system also includes unstable scree and talus slopes typically occurring below cliff faces. Scattered vegetation may include *Abies magnifica, Pseudotsuga menziesii, Pinus contorta var. murrayana, Pinus ponderosa, Pinus jeffreyi, Populus tremuloides*, or *Pinus monophylla, Juniperus osteosperma*, and *Cercocarpus ledifolius* at lower elevations. There may be shrubs including species of *Arctostaphylos* or *Ceanothus*. Soil development is limited as is herbaceous cover.

Enumerated_Domain:
Enumerated_Domain_Value: 33
Enumerated_Domain_Value_Definition: Mediterranean California Alpine Bedrock and Scree
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org

This system occurs in limited alpine environments mostly concentrated in the Sierra Nevada, but also on Mount Shasta and as far south as the Peninsular Ranges and White Mountains. Alpine elevations begin around 3500 m (10,600 feet) in the southern mountain ranges and 2700 m (8200 feet) in the southern Cascades. These are barren and sparsely vegetated alpine substrates, typically including both bedrock outcrops and scree slopes, with nonvascular (lichen)-dominated communities. This also encompasses a limited area of "alpine desert" with unstable sandy substrates and scattered individuals of *Astragalus* spp., *Arabis* spp., *Draba* spp., and *Oxytropis* spp., which mostly fall to the east of the Sierra Nevada crest. Exposure to desiccating winds, rocky and sometimes unstable substrates, and a short growing season limit plant growth.

Enumerated_Domain:
Enumerated_Domain_Value: 34
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Cliff and Canyon
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system is found from foothill to subalpine elevations and includes barren and sparsely vegetated landscapes (generally <10% plant cover) of steep cliff faces, narrow canyons, and smaller rock outcrops of various igneous, sedimentary, and metamorphic bedrock types. Also included is vegetation of unstable scree and talus slopes that typically occurs below cliff faces. Widely scattered trees and shrubs may include *Abies concolor, Pinus edulis, Pinus flexilis, Pinus monophylla, Juniperus* spp., *Artemisia tridentata, Purshia tridentata, Cercocarpus ledifolius, Ephedra* spp., *Holodiscus discolor*, and other species often common in adjacent plant communities.

Enumerated_Domain:
Enumerated_Domain_Value: 35
Enumerated_Domain_Value_Definition: Columbia Plateau Ash and Tuff Badland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system of the Columbia Plateau region is composed of barren and sparsely vegetated substrates (<10% plant cover) typically derived from highly eroded volcanic ash and tuff. Landforms are typically rounded hills and plains that form a rolling topography. The harsh soil properties and high rate of erosion and deposition are driving environmental variables supporting sparse dwarf-shrubs and forbs. Characteristic species include *Grayia spinosa, Artemisia tridentata, Salvia dorrii, Achnatherum* sp., *Eriogonum* sp., *Sarcobatus vermiculatus, Purshia tridentata*, and *Atriplex confertifolia*. Characteristic forbs are short-lived annuals, including *Cleome, Mentzelia, Camissonia*, and *Mimulus* species, although these habitats often support endemic perennial forbs.

Enumerated_Domain:
Enumerated_Domain_Value: 36
Enumerated_Domain_Value_Definition: North Pacific Maritime Coastal Sand Dune and Strand

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
Coastal sand dunes are found throughout the northern Pacific Coast, from south-central Alaska to the central Oregon coast (roughly Coos Bay). This system covers large areas of the southern Washington and central Oregon coasts. Coastal dunes include beach strand (not the beach itself but sparsely or densely vegetated areas behind the beach), foredunes, sand spits, and active to stabile backdunes and sandsheets derived from quartz or gypsum sands. The mosaic of sparse to dense vegetation in dune systems is driven by sand deposition, erosion, and lateral movement. Disturbance processes include dune blowouts caused by wind and occasional wave overwash during storm tidal surges. Coastal dunes often front portions of inlets and tidal marshes. Dune vegetation typically includes herbaceous, succulent, shrub, and tree species with varying degrees of tolerance for salt spray, wind and sand abrasion, and substrate stability. Dune succession is highly variable, so species composition can vary significantly among occurrences. These dunes can be dominated by *Leymus arenarius (= Elymus arenarius), Festuca rubra, Leymus mollis*, or various forbs adapted to salty dry conditions. *Gaultheria shallon* and *Vaccinium ovatum* are major shrub species. Forested portions of dunes are included within this system and are characterized (at least in the south) by *Pinus contorta var. contorta* early in succession, *Picea sitchensis* somewhat later in the sere, and in some cases *Tsuga heterophylla* later still. *Pseudotsuga menziesii* sometimes codominates in Oregon. Disturbance processes include dune blowouts caused by wind and occasional wave overwash during storm tidal surges. Late-sere forests, dominating stabilized dune systems where active dune processes are nearly absent and that compositionally represent the adjacent matrix system, are excluded from this dune system. Interdunal wetlands occur commonly within the matrix of this system and sometimes are extensive in deflation plains or old dune troughs, but are considered part of various separate wetland ecological systems depending on their hydrology, and are not part of this upland system.

Enumerated_Domain:
Enumerated_Domain_Value: 37
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Playa
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system is composed of barren and sparsely vegetated playas (generally <10% plant cover) found in the intermountain western U.S. Salt crusts are common throughout, with small saltgrass beds in depressions and sparse shrubs around the margins. These systems are intermittently flooded. The water is prevented from percolating through the soil by an impermeable soil subhorizon and is left to evaporate. Soil salinity varies greatly with soil moisture and greatly affects species composition. Characteristic species may include *Allenrolfea occidentalis, Sarcobatus vermiculatus, Grayia spinosa, Puccinellia lemmonii, Leymus cinereus, Distichlis spicata*, and/or *Atriplex* spp.

Enumerated_Domain:
Enumerated_Domain_Value: 38

Enumerated_Domain_Value_Definition: North Pacific Oak Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system is limited to the southern portions of the North Pacific region. It occurs primarily in the Puget Trough and Willamette Valley but trickles down into the Klamath ecoregion and into California. This system is associated with dry, predominantly low-elevation sites and/or sites that experienced frequent presettlement fires. In the Willamette Valley, soils are mesic yet well-drained, and the type is clearly large patch in nature. In the Puget Lowland and Georgia Basin, this system is primarily found on dry sites, typically either shallow bedrock soils or deep gravelly glacial outwash soils. It occurs on various soils in the interior valleys of the Klamath Mountains, and on shallow soils of "bald hill" toward the coast. Even where more environmentally limited, the system is strongly associated with a pre-European settlement, low-severity fire regime. Succession in the absence of fire tends to favor increased shrub dominance in the understory, increased tree density, and increased importance of conifers, with the end result being conversion to a conifer forest. The vegetation ranges from savanna and woodland to forest dominated by deciduous broadleaf trees, mostly *Quercus garryana*. Codominance by the evergreen conifer *Pseudotsuga menziesii* is common, and *Pinus ponderosa* is important in some stands. In the south, common associates also include *Quercus kelloggii* and *Arbutus menziesii*. This system merges into Mediterranean California Lower Montane Black Oak-Conifer Forest and Woodland (CES206.923) on sites that support more conifer cover, and into Mediterranean California Mixed Oak Woodland (CES206.909) in the southern portion of its distribution. This system is borderline between small patch and large patch in its dynamics.

Enumerated_Domain:
Enumerated_Domain_Value: 39
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Western Larch Savanna
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system is restricted to the interior montane zone of the Pacific Northwest in northern Idaho and adjacent Montana, Washington, Oregon, and in southeastern interior British Columbia. It also appears in the east Cascades of Washington. Winter snowpacks typically melt off in early spring at lower elevations. Elevations range from 680 to 2195 m (2230-7200 feet), and sites include drier, lower montane settings of toeslopes and ash deposits. This system is composed of open-canopied "savannas" of the deciduous conifer *Larix occidentalis*, which may have been initiated following stand-replacing crownfires of other conifer systems, but are maintained by a higher frequency, surface-fire regime. These savannas are found in settings where low-intensity, high-frequency fires create open larch woodlands, often with the undergrowth dominated by low-growing *Arctostaphylos uva-ursi, Calamagrostis rubescens, Linnaea borealis, Spiraea betulifolia, Vaccinium caespitosum*, or *Xerophyllum tenax*. Less frequent or absence of fire creates mixed-dominance stands with often shrubby undergrowth; *Vaccinium caespitosum* is common, and taller shrubs can include *Acer glabrum,*

Ceanothus velutinus, Shepherdia canadensis, Physocarpus malvaceus, Rubus parviflorus, or *Vaccinium membranaceum*. Fire suppression has led to invasion of the more shade-tolerant tree species *Abies grandis, Abies lasiocarpa, Picea engelmannii*, or *Tsuga* spp. and loss of much of the single-story canopy woodlands.

Enumerated_Domain:
Enumerated_Domain_Value: 40
Enumerated_Domain_Value_Definition: Rocky Mountain Aspen Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This widespread ecological system is more common in the southern and central Rocky Mountains but occurs in the montane and subalpine zones throughout much of the western U.S. and north into Canada. An eastern extension occurs along the Rocky Mountains foothill front and in mountain "islands" in Montana (Big Snowy and Highwood mountains), and the Black Hills of South Dakota. In California, this system is only found on the east side of the Sierra Nevada adjacent to the Great Basin. Large stands are found in the Inyo and White mountains, while small stands occur on the Modoc Plateau. Elevations generally range from 1525 to 3050 m (5000-10,000 feet), but occurrences can be found at lower elevations in some regions. Distribution of this ecological system is primarily limited by adequate soil moisture required to meet its high evapotranspiration demand. Secondarily, it is limited by the length of the growing season or low temperatures. These are upland forests and woodlands dominated by *Populus tremuloides* without a significant conifer component (<25% relative tree cover). The understory structure may be complex with multiple shrub and herbaceous layers, or simple with just an herbaceous layer. The herbaceous layer may be dense or sparse, dominated by graminoids or forbs. In California, *Symphyotrichum spathulatum (= Aster occidentalis)* is a common forb. Associated shrub species include *Symphoricarpos* spp., *Rubus parviflorus, Amelanchier alnifolia*, and *Arctostaphylos uva-ursi*. Occurrences of this system originate and are maintained by stand-replacing disturbances such as avalanches, crown fire, insect outbreak, disease and windthrow, or clearcutting by man or beaver, within the matrix of conifer forests. It differs from Northwestern Great Plains Aspen Forest and Parkland (CES303.681), which is limited to plains environments.

Enumerated_Domain:
Enumerated_Domain_Value: 41
Enumerated_Domain_Value_Definition: Western Great Plains Dry Bur Oak Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This system is dominated by *Quercus macrocarpa* and is found in upland areas in the northern part of the Western Great Plains. It often occurs as small to large patches on buttes, escarpments, and in foothill zones, usually on northerly-facing slopes. Other species, such as *Tilia americana* (not in the Dakotas), *Populus tremuloides, Juniperus virginiana*, and *Fraxinus* spp., may be present. The herbaceous layer can vary from sparsely to moderately vegetated and is composed of prairie grasses or woodland *Carex*

spp. Shrub associates can include *Prunus virginiana, Corylus cornuta, Amelanchier alnifolia*, or *Symphoricarpos* spp. Historically, higher cover of grass species occurred as these stands were more open due to more frequent fires. Few good examples of this system likely remain because of past timber harvesting and heavy grazing. Where it occurs at elevations above 915 m (3000 feet), *Pinus ponderosa* woodlands are probably adjacent.

Enumerated_Domain:
Enumerated_Domain_Value: 42
Enumerated_Domain_Value_Definition: California Coastal Redwood Forest
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This system occurs from the Klamath Mountains south to Monterey Bay, California. At its northern extent, it transitions into southern examples of the coastal Sitka spruce and western hemlock systems that extend into coastal Alaska. However, the coastal redwood system generally can be found in areas of lower rainfall but still within the fog belt. In the northern portion, it occurs on upland slopes and in riparian zones and on riverine terraces that are flooded approximately every 50-100 years. In the southern portion of the range, annual precipitation may be as little as 50 cm, and the system is limited to coves and ravines. It is commonly found on moderately well-drained marine sediments (non-metamorphosed siltstones, sandstones, etc.). This system forms the tallest forests in North America, with individuals reaching 100 m high (tallest being 106-110 m [350-360 feet]). Typically, mature stands of *Sequoia sempervirens* produce a deep shade, so understories can be limited, but coarse woody debris from past disturbance can be quite large. *Pseudotsuga menziesii* is the common associate among the large trees. *Tsuga heterophylla* is found in old-growth stands, and *Lithocarpus densiflorus* occurs as a subcanopy in almost all stands (possibly as a result of fire suppression). The moist, coastal *Chamaecyparis lawsoniana* stands from southwestern Oregon and northwestern California, often mixed with *Sequoia sempervirens, Pseudotsuga menziesii*, or *Tsuga heterophylla*, are included in this system, as ecologically they function in the same way and have the same overall floristic composition. Shade-tolerant understory species include *Rubus parviflorus, Oxalis oregana, Aralia californica, Mahonia nervosa (= Berberis nervosa), Gaultheria shallon*, and many ferns, such as *Blechnum spicant, Polystichum* spp., and *Polypodium* spp. Historically, ground fires likely exposed mineral soil for redwood seed germination. Less frequent disturbance can result in increases in *Tsuga heterophylla* in northern occurrences, as it is sensitive to fire and is a decreaser with fire and flood. Fire suppression has tended to result in increasing abundance of *Lithocarpus densiflorus, Umbellularia californica, Alnus rubra, Arbutus menziesii*, and *Acer macrophyllum*; all respond favorably to fire, flood, wind and slides, becoming more abundant in areas of frequent disturbance.

Enumerated_Domain:
Enumerated_Domain_Value: 43
Enumerated_Domain_Value_Definition: Columbia Plateau Western Juniper Woodland and Savanna

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This woodland system is found along the northern and western margins of the Great Basin, from southwestern Idaho, along the eastern foothills of the Cascades, south to the Modoc Plateau of northeastern California. Elevations range from under 200 m along the Columbia River in central Washington to over 1500 m. Generally soils are medium-textured, with abundant coarse fragments, and derived from volcanic parent materials. In central Oregon, the center of distribution, all aspects and slope positions occur. Where this system grades into relatively mesic forest or grassland habitats, these woodlands become restricted to rock outcrops or escarpments with excessively drained soils. *Pinus monophylla* is not present in this region, so *Juniperus occidentalis* is the only tree species, although *Pinus ponderosa* or *Pinus jeffreyi* may be present in some stands. *Cercocarpus ledifolius* may occasionally codominate. *Artemisia tridentata* is the most common shrub; others are *Purshia tridentata, Ericameria nauseosa, Chrysothamnus viscidiflorus, Ribes cereum*, and *Tetradymia* spp. Graminoids include *Carex filifolia, Festuca idahoensis, Poa secunda*, and *Pseudoroegneria spicata*. These woodlands are generally restricted to rocky areas where fire frequency is low. Throughout much of its range, fire exclusion and removal of fine fuels by grazing livestock have reduced fire frequency and allowed *Juniperus occidentalis* seedlings to colonize adjacent alluvial soils and expand into the shrub-steppe and grasslands. *Juniperus occidentalis* savanna may occur on the drier edges of the woodland where trees are intermingling with or invading the surrounding grasslands and where local edaphic or climatic conditions favor grasslands over shrublands.

Enumerated_Domain:
Enumerated_Domain_Value: 44
Enumerated_Domain_Value_Definition: East Cascades Mesic Montane Mixed-Conifer Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system occurs on the upper east slopes of the Cascades in Washington, south of Lake Chelan and south to Mount Hood in Oregon. Elevations range from 610 to 1220 m (2000-4000 feet) in a very restricted range occupying less than 5% of the forested landscape in the east Cascades. This system is associated with a submesic climate regime with annual precipitation ranging from 100 to 200 cm (40-80 inches) and maximum winter snowpacks that typically melt off in spring at lower elevations. This ecological system is composed of variable montane coniferous forests typically below Pacific silver fir forests along the crest east of the Cascades. This system also includes montane forests along rivers and slopes, and in mesic "coves" which were historically protected from wildfires. Most occurrences of this system are dominated by a mix of *Pseudotsuga menziesii* with *Abies grandis* and/or *Tsuga heterophylla*. Several other conifers can dominate or codominate, including *Thuja plicata, Pinus contorta, Pinus monticola*, and *Larix occidentalis*. *Abies grandis* and other fire-sensitive, shade-tolerant species dominate forests on many sites once dominated by *Pseudotsuga menziesii* and *Pinus ponderosa*, which were formerly maintained by wildfire. They are very productive forests

in the eastern Cascades which have been priority stands for timber production. *Mahonia nervosa, Linnaea borealis, Paxistima myrsinites, Acer circinatum, Spiraea betulifolia, Symphoricarpos hesperius, Cornus nuttallii, Rubus parviflorus*, and *Vaccinium membranaceum* are common shrub species. The composition of the herbaceous layer reflects local climate and degree of canopy closure and contains species more restricted to the Cascades, for example, *Achlys triphylla, Anemone deltoidea*, and *Vancouveria hexandra*. Typically, stand-replacement fire-return intervals are 150-500 years with moderate-severity fire-return intervals of 50-100 years.

Enumerated_Domain:
Enumerated_Domain_Value: 45
Enumerated_Domain_Value_Definition: Great Basin Pinyon-Juniper Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system occurs on dry mountain ranges of the Great Basin region and eastern foothills of the Sierra Nevada. It is typically found at lower elevations ranging from 1600-2600 m. These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus and ridges. Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of pinyon-juniper woodlands to relatively narrow altitudinal belts on mountainsides. Woodlands dominated by a mix of *Pinus monophylla* and *Juniperus osteosperma*, pure or nearly pure occurrences of *Pinus monophylla*, or woodlands dominated solely by *Juniperus osteosperma* comprise this system. *Cercocarpus ledifolius* is a common associate. On the east slope of the Sierras in California, *Pinus jeffreyi* and *Juniperus occidentalis var. australis* may be components of these woodlands. Understory layers are variable. Associated species include shrubs such as *Arctostaphylos patula, Artemisia arbuscula, Artemisia nova, Artemisia tridentata, Cercocarpus ledifolius, Cercocarpus intricatus, Coleogyne ramosissima, Quercus gambelii, Quercus turbinella*, and bunch grasses *Hesperostipa comata, Festuca idahoensis, Pseudoroegneria spicata, Leymus cinereus (= Elymus cinereus)*, and *Poa fendleriana*. This system occurs at lower elevations than Colorado Plateau Pinyon-Juniper Woodland (CES304.767) where sympatric.

Enumerated_Domain:
Enumerated_Domain_Value: 46
Enumerated_Domain_Value_Definition: Klamath-Siskiyou Lower Montane Serpentine Mixed Conifer Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This system occurs throughout the Klamath - Siskiyou region below 1500 m (4550 feet) elevation on thin, rocky, ultramafic (gabbro, peridotite, serpentinite) soils below winter snow accumulations and typically experiences hot and dry summers. Soils are not always rocky; they can be loamy, up to 76 cm (30 inches) in depth, and can be heavy clay. Not all ultramafic outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. These systems are highly variable and spotty in distribution. These sites are more productive and can support large-statured (dbh, height) trees,

although they tend to be widely spaced. Common species include *Pseudotsuga menziesii, Pinus sabiniana, Pinus lambertiana, Pinus jeffreyi, Pinus attenuata, Lithocarpus densiflorus var. echinoides, Calocedrus decurrens , Arctostaphylos* spp., *Quercus vacciniifolia*, and *Xerophyllum tenax*. Perennial grasses such as *Festuca idahoensis* may also be characteristic. *Chamaecyparis lawsoniana* communities can occur within occurrences of this system in mesic and linear riparian zones. Herbaceous-dominated serpentine fens (and bogs) are treated in Mediterranean California Serpentine Fen (CES206.953).

Enumerated_Domain:
Enumerated_Domain_Value: 47
Enumerated_Domain_Value_Definition: Klamath-Siskiyou Upper Montane Serpentine Mixed Conifer Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This system occurs throughout the Klamath - Siskiyou region above 1500 m (4550 feet) elevation on thin, rocky, ultramafic (gabbro, peridotite, serpentinite) soils in dry-mesic conditions. Not all ultramafic outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. Although ultramafics may be relatively dry and have a moderate to high grass component, they do not burn often where the serpentine syndrome [see Kruckeberg (1984)] is severe. The problem is not just the calcium:magnesium ratio, but heavy metals and sometimes high clay content limit biomass production. These systems are highly variable and spotty in distribution. Common species include *Pinus monticola, Pinus balfouriana, Quercus vacciniifolia, Pinus jeffreyi, Ceanothus pumilus, Arctostaphylos* spp., *Lithocarpus densiflorus var. echinoides, Abies X shastensis (= Abies magnifica var. shastensis*), and *Chamaecyparis nootkatensis*. Stands of stunted (up to 40 feet) but straight *Pinus contorta* are also possible. *Chamaecyparis lawsoniana* communities can occur in this system in mesic and linear riparian zones. Herbaceous-dominated serpentine fens (and bogs) are treated in Mediterranean California Serpentine Fen (CES206.953).

Enumerated_Domain:
Enumerated_Domain_Value: 48
Enumerated_Domain_Value_Definition: Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
These mixed-conifer forests, always with at least two species codominating, occur on all aspects in lower montane zones (600-1800 m elevation in northern California; 1200-2150 m in southern California). This system occurs in a variety of topo-edaphic positions, such as upper slopes at higher elevations, canyon sideslopes, ridgetops, and south- and west-facing slopes which burn relatively frequently. Often, several conifer species co-occur in individual stands. *Pseudotsuga menziesii, Pinus ponderosa*, and *Calocedrus decurrens* are the most common conifers. Other conifers that can occasionally be present include *Pinus jeffreyi, Pinus attenuata*, and *Pinus lambertiana* (not as common in this as in

Mediterranean California Mesic Mixed Conifer Forest and Woodland (CES206.915)). Common subcanopy trees include *Quercus chrysolepis* and *Quercus kelloggii*. *Arbutus menziesii* and *Lithocarpus densiflorus* may be common with the oaks in northern areas. *Pseudotsuga macrocarpa* and *Pinus coulteri* can be present but are not dominant species in this system in the Transverse Ranges of southern California. Codominant *Abies concolor - Calocedrus decurrens* communities in southern California are also included in this system. Understories are variable, except in the Sierra Nevada where in some stands there can be dense understory mats of *Chamaebatia foliolosa* (and other low, spreading shrubs) which foster relatively high-frequency, low-intensity ground fires. In Oregon, shrubs such as *Holodiscus discolor, Toxicodendron rydbergii, Mahonia nervosa, Mahonia aquifolium*, and *Symphoricarpos mollis* are common in addition to graminoids such as *Festuca californica, Elymus glaucus*, and *Danthonia californica*. In the north, where *Calocedrus decurrens* and *Pinus ponderosa* drop out, this system shifts to North Pacific Dry Douglas-fir-(Madrone) Forest and Woodland (CES204.845).

Enumerated_Domain:
Enumerated_Domain_Value: 49
Enumerated_Domain_Value_Definition: Mediterranean California Mesic Mixed Conifer Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system occurs in cool ravines and north-facing slopes (typically with 100-150 cm annual precipitation; 50% as snow). It is found from 800-1000 m (2400-3000 feet) elevation in the Sierra Nevada and 1250-2200 m (3800-6700 feet) in the Klamath Mountains. The most characteristically co-occurring conifers are *Abies concolor var. lowiana, Calocedrus decurrens*, and *Pinus lambertiana*. *Pinus jeffreyi, Pinus ponderosa*, and *Pseudotsuga menziesii* occur frequently but are not dominant. In limited locations in the central Sierra Nevada, *Sequoiadendron giganteum* dominates, usually with *Abies concolor*, and at the highest elevations also with *Abies magnifica*. *Acer macrophyllum* is common in lower elevation mesic pockets; *Chrysolepis chrysophylla* also occurs in the western Klamaths. Common understory species include *Corylus cornuta, Cornus nuttallii*, and at higher elevations *Chrysolepis sempervirens*. In areas of recent fire or other disturbance, *Arctostaphylos patula, Ceanothus integerrimus, Ceanothus cordulatus, Ceanothus parvifolius*, and *Ribes* spp. are more common. Fire of highly variable patch size and return interval maintains the structure of these woodlands

Enumerated_Domain:
Enumerated_Domain_Value: 50
Enumerated_Domain_Value_Definition: Mediterranean California Mixed Oak Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system is found throughout the Sierra Nevada and Coast Range foothills and lower montane elevations from 600-1600 m (1800-4850 feet) on steep, rocky slopes where snow and cold temperatures occur. Fire frequency and intensity drive composition of this system, with *Quercus chrysolepis* dominant with less frequent fires. With frequent

annual burning (at lower elevations and on warmer sites), this system is an open to dense woodland of large oaks with well-developed grassy understories of native perennial bunchgrass. The predominant oaks with the higher frequency fires include *Quercus kelloggii* and *Quercus garryana*, with *Quercus garryana var. garryana* codominant in the central and northern Coast Ranges and *Quercus garryana var. breweri* often codominant in the northwestern Coast Ranges as well as portions of the Sierra Nevada. *Quercus chrysolepis* becomes dominant with less frequent fires (but in Oregon this species is not important and occurs in a different system, either Mediterranean California Mixed Evergreen Forest (CES206.919) or Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland (CES206.916)). The perennial bunchgrass component includes *Festuca idahoensis, Festuca californica, Elymus glaucus*, and *Danthonia californica* (close to the coast). A variety of native forbs also occur. Other characteristic species include *Toxicodendron diversilobum, Juniperus occidentalis*, and *Ceanothus cuneatus*. This system is similar to North Pacific Oak Woodland (CES204.852) but does not include a conifer component, and *Quercus garryana* is not the only oak.

Enumerated_Domain:
Enumerated_Domain_Value: 51
Enumerated_Domain_Value_Definition: Mediterranean California Lower Montane Black Oak-Conifer Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system is found throughout California's middle and inner North Coast Ranges, as well as the southern and eastern Klamath Mountains from 600-1600 m (1800-4850 feet) elevation, and the lower slopes of the western Sierra Nevada. It occurs in valleys and lower slopes on a variety of parent materials, including granitics, metamorphic and Franciscan metasedimentary parent material and deep, well-developed soils. It is characterized by woodlands or forests of Pinus ponderosa with one or more oaks, including Quercus kelloggii, Quercus garryana, Quercus wislizeni, or Quercus chrysolepis. Pseudotsuga menziesii may co-occur with Pinus ponderosa, particularly in the North Coast Ranges and Klamath Mountains. On most sites, the oaks are dominant, forming a dense subcanopy under a more open canopy of the conifers. On many sites, Quercus kelloggii is the dominant; in late-seral stands on more mesic sites, conifers such as Pinus ponderosa or Pseudotsuga menziesii will form a persistent emergent canopy over the oak. Stands may have shrubby understories (in the Klamath Mountains and Sierra Nevada) and, more rarely, grassy understories (in North Coast Ranges). Common shrubs include Arctostaphylos viscida, Arctostaphylos manzanita, Ceanothus integerrimus, and Toxicodendron diversilobum. Grasses can include Festuca californica, Festuca idahoensis, and Melica spp. Historical fire in this system was likely high frequency but of low intensity. Conifer species, such as Pseudotsuga menziesii, become more abundant with wildfire suppression.

Enumerated_Domain:
Enumerated_Domain_Value: 52
Enumerated_Domain_Value_Definition: California Montane Jeffrey Pine Woodland

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
These forests are found on relatively xeric sites in mountains and plateaus from southern Oregon (600-1830 m [1800-5000 feet] elevation) south into the Sierra Nevada, throughout the Transverse Ranges of California, and into northern Baja California (1200-2740 m [4000-8300 feet]), Mexico. While the two dominant pines tend to segregate by soil fertility and temperature regimes, they may co-occur in certain areas (e.g., Modoc Plateau). These stands are more common on the east side of the Sierra Nevada, although they do occur on the west side. Ponderosa pine and/or Jeffery pine on the west slope with other conifer species are part of Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland (CES206.916). These are sites where *Pinus ponderosa* and/or *Pinus jeffreyi* are the predominant conifers and other tree species do not occur in high abundance, if at all. *Pinus jeffreyi* is more tolerant of colder, drier and poorer sites and replaces *Pinus ponderosa* as the dominant at higher elevations. In the north, *Pinus jeffreyi* may be replaced by *Pinus washoensis* (Carson Range and Warner Mountains). Throughout California, pure stands of ponderosa pine are relatively uncommon. Only on the Modoc Plateau do these pines co-occur in mixed stands. *Juniperus occidentalis* (both var. *australis* [in the south] and var. *occidentalis*) can co-occur in these stands but typically is not dominant. On moister and cooler sites, *Abies concolor* can be present in some stands. There can be well-developed shrub understories with strong Great Basin affinities; species can include *Artemisia tridentata, Purshia tridentata, Symphoricarpos rotundifolius var. parishii (= Symphoricarpos parishii), Arctostaphylos patula, Ceanothus cordulatus, Ceanothus prostratus, Ceanothus integerrimus, Chrysolepis sempervirens, Eriogonum wrightii, Quercus vacciniifolia*, and *Lupinus elatus*. *Cercocarpus ledifolius* is common on steeper slopes throughout the range. Historically, frequent localized ground fires maintained these systems. Stands of ponderosa pine on the east side of the Cascades transition into East Cascades Oak-Ponderosa Pine Forest and Woodland (CES204.085), or Northern Rocky Mountain Ponderosa Pine Woodland and Savanna (CES306.030) north of the Warm Springs Reservation of central Oregon.

Enumerated_Domain:
Enumerated_Domain_Value: 53
Enumerated_Domain_Value_Definition: Mediterranean California Red Fir Forest
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system includes high-elevation (1600-2700 m [4850-9000 feet]) forests and woodlands dominated by *Abies magnifica (= var. magnifica), Abies X shastensis (= Abies magnifica var. shastensis)*, and/or *Abies procera*. This system is typically found on deep, well-drained soils throughout this elevation zone from the central Sierra Nevada north and west into southern Oregon. Heavy snowpack is a major source of soil moisture throughout the growing season. The limiting factors can be either cold-air drainages or ponding, or coarser soils (pumice versus ash, for example). Other conifers that can occur in varying mixtures with *Abies magnifica* include *Pinus contorta var. murrayana, Pinus monticola, Tsuga mertensiana, Pinus jeffreyi*, and *Abies concolor*. At warmer and lower sites of the North Coast Ranges and Sierra Nevada, *Abies concolor* can codominate with

Abies magnifica. *Pinus contorta* in Oregon indicates lower productivity where it intergrades with *Abies X shastensis*. This system ranges from dry to moist, and some sites have mesic indicator species, such as *Ligusticum grayi* or *Thalictrum fendleri*. Common understory species include *Quercus vacciniifolia, Ribes viscosissimum, Chrysolepis sempervirens, Ceanothus cordulatus* (in seral stands), *Vaccinium membranaceum, Symphoricarpos mollis*, and *Symphoricarpos rotundifolius*. Characteristic forbs include *Eucephalus breweri*, *Pedicularis semibarbata*, and *Hieracium albiflorum*. This system commonly occurs above mixed conifer forests with *Abies concolor* and overlaps in elevation with forests and woodlands of *Pinus contorta var. murrayana*. On volcanic sites of lower productivity, stands may be more open woodland in structure and with poor-site understory species such as *Wyethia mollis*. Driving ecological processes include occasional blow-down, insect outbreaks and stand-replacing fire.

Enumerated_Domain:
Enumerated_Domain_Value: 54
Enumerated_Domain_Value_Definition: Mediterranean California Subalpine Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system occurs on ridges and rocky slopes around timberline at 2900 m (9500 feet) elevation in the southern Sierra Nevada and Transverse and Peninsular ranges, up to 3500 m (11,500 feet) in the Sierra Nevada, and 2450 m (8000 feet) in the southern Cascades. Tree species often occur as krummholz growth forms with a wind-pruned, prostrate, and/or shrublike appearance, but in more protected sites they form true woodland physiognomy. Stands are dominated by *Pinus albicaulis* and/or *Pinus contorta var. murrayana*; other important conifers and locally dominant species include *Pinus balfouriana* (only in the Klamath Mountains and southern Sierra Nevada where it may replace *Pinus albicaulis*), *Pinus flexilis* (but only in small patches on the eastern flank of the Sierra Nevada escarpment when it does occur), *Pinus monticola* (not in Transverse or Peninsular ranges), and *Juniperus occidentalis var. australis* (mostly in the central and southern Sierra Nevada but not in the Klamath Mountains). Important shrubs include *Arctostaphylos nevadensis, Chrysolepis sempervirens*, and *Holodiscus discolor (= Holodiscus microphyllus)*. Grasses and forbs include *Carex rossii, Carex filifolia, Poa wheeleri, Eriogonum incanum, Penstemon newberryi*, and *Penstemon davidsonii*. Due to landscape position and very thin soils, these are harsh sites exposed to desiccating winds with ice and snow blasts, and rocky substrates. In addition, a short growing season limits plant growth. The highest tree diversity occurs in the Klamath Mountains, with sometimes five or more conifers sharing codominance in one stand.

Enumerated_Domain:
Enumerated_Domain_Value: 55
Enumerated_Domain_Value_Definition: Mediterranean California Mesic Serpentine Woodland and Chaparral
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org

This ecological system occurs in Mediterranean California in the north and south Coast Ranges and the northern Sierra Nevada, on cool northerly and concave slopes and toeslopes with thin, rocky, ultramafic (gabbro, peridotite, serpentinite) soils. Not all ultramafic outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. These systems are highly variable and spotty in distribution, and the composition of individual stands can be very diverse, especially the shrubs (often individual species have low cover). *Cupressus sargentii, Pinus sabiniana, Garrya congdonii, Quercus durata, Umbellularia californica*, and *Frangula californica ssp. tomentella (= Rhamnus tomentella ssp. tomentella)* are characteristic. Common associates include *Heteromeles arbutifolia, Adenostoma fasciculatum*, and the California endemics *Arctostaphylos viscida ssp. pulchella* and *Ceanothus jepsonii*. In some settings *Arctostaphylos glauca, Styrax rediviva (= Styrax officinalis)*, or *Cercocarpus montanus var. glaber (= Cercocarpus betuloides)* can be common. Occasionally, *Chamaecyparis lawsoniana* may be present. Common grasses and forbs can include *Melica torreyana, Festuca idahoensis, Iris* spp., and locally endemic serpentine forbs (*Senecio* spp. and others). Structurally, this system is sometimes woodland in character, but it can also be an arborescent chaparral, depending on fire history. Herbaceous-dominated serpentine fens (and bogs) are treated in Mediterranean California Serpentine Fen (CES206.953).

Enumerated_Domain:
Enumerated_Domain_Value: 56
Enumerated_Domain_Value_Definition: North Pacific Dry Douglas-fir-(Madrone) Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This system is most common in the Puget Trough - Willamette Valley ecoregion but also occurs in adjacent ecoregions. It occupies small patches associated with dry sites or larger areas in prairie landscapes. This system historically had moderate- to low-severity fires moderately frequently. Historically, these communities were either part of larger forested landscapes or occupied sheltered topographic positions in prairie-dominated landscapes. They now also occur on some sites that formerly supported prairies or tall shrublands (Corylus cornuta) with scattered trees. In the mountains, this type occurs locally on dry sites within dry to mesic (for the coastal areas) climates up to about 1220 m (4000 feet) elevation. This is a forest or woodland primarily dominated by the long-lived conifer Pseudotsuga menziesii. The evergreen broadleaf Arbutus menziesii, the short-lived conifer Pinus contorta, the broadleaf deciduous Acer macrophyllum, and the shade-tolerant conifer Abies grandis are local dominant or codominant species. These sites are too dry and warm or have been too frequently and extensively burned for anything more than small amounts of Tsuga heterophylla or Thuja plicata to be present as regeneration. Arbutus menziesii dominance is favored by high-severity fires on sites where it occurs, and Pseudotsuga menziesii can be locally eliminated by logging and hot fire or repeated high-severity fires. Calocedrus decurrens is absent. Abies grandis can be an important subcanopy or sapling tree, especially in and around the Willamette Valley and in the driest portions of the Georgia Basin (Coastal Douglas-fir Zone).

Enumerated_Domain:
Enumerated_Domain_Value: 57
*Enumerated_Domain_Value_Definition:*North Pacific Hypermaritime Sitka Spruce Forest
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.natureserve.org
This ecological system is restricted to the hypermaritime climatic areas near the Pacific Coast, along a fog belt from Point Arena, California, north to the Kenai Peninsula, Alaska. These forests are restricted to areas within 25 km of saltwater and are most abundant along the coast of Vancouver Island, southern and northern portions of coastal British Columbia, the Olympic Peninsula of Washington, and the islands of southeastern Alaska. Sites occupied include the outermost coastal fringe where salt spray is prominent, riparian terraces and valley bottoms near the coast where there is major fog accumulation, and in the northern half of its range starting in central British Columbia, steep, well-drained productive slopes not directly adjacent to the outer coast but within the hypermaritime zone. Annual precipitation ranges from 65 to 550 cm, with the majority falling as rain. Winter rains can be heavy. In the southern portion of its range, summer drought does occur, but it is typically short in duration and ameliorated by frequent, dense coastal fog and cloud cover. This forest type also dominates lower elevations (to 350 m) on the leeward side of the Queen Charlotte Islands in British Columbia. In Alaska, this system occurs along a coastal belt below 1000 m (3000 feet) elevation on deep, acidic soils derived from marine sediments, but stands can also occur at higher elevations along stream channels, snow avalanche paths, mass-wasting slopes, or loess deposits. In Washington and Oregon, it is found mostly below 300 m elevation. It also occurs as a very narrow strip or localized patches along the southern Washington, Oregon and northern California coasts. Stands are typically dominated or codominated by *Picea sitchensis* but often have a mixture of other conifers present, such as *Tsuga heterophylla, Thuja plicata*, or *Chamaecyparis nootkatensis*. *Tsuga heterophylla* is very often codominant. In the southern extent (in Oregon, but not in California), *Chamaecyparis lawsoniana, Abies grandis, Pseudotsuga menziesii, Acer circinatum, Alnus rubra, Acer macrophyllum*, and *Frangula purshiana (= Rhamnus purshiana)* are occasional associates, while *Chamaecyparis nootkatensis* is completely absent. Wet coastal environments that support stands of *Chamaecyparis lawsoniana* in the absence of *Picea sitchensis* are also part of this system. The understory is rich with shade-tolerant shrubs and ferns, including *Gaultheria shallon, Vaccinium ovatum, Polystichum munitum, Dryopteris* spp., and *Blechnum spicant*, as well as a high diversity of mosses and lichens. The disturbance regime is mostly small-scale windthrow or other gap mortality processes (though there are occasional widespread intense windstorms) and very few fires, the latter mainly in Oregon.

Enumerated_Domain:
Enumerated_Domain_Value: 58
Enumerated_Domain_Value_Definition: North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org

This ecological system comprises much of the major lowland forests of western Washington, northwestern Oregon, eastern Vancouver Island, and the southern Coast Ranges in British Columbia. In southwestern Oregon, it becomes local and more small-patch in nature. It occurs throughout low-elevation western Washington, except on extremely dry or moist to very wet sites. In Oregon, it occurs on the western slopes of the Cascades, around the margins of the Willamette Valley, and in the Coast Ranges. These forests occur on the drier to intermediate moisture habitats and microhabitats within the Western Hemlock Zone of the Pacific Northwest. Climate is relatively mild and moist to wet. Mean annual precipitation is mostly 90-254 cm (35-100 inches) (but as low as 20 inches in the extreme rainshadow) falling predominantly as winter rain. Snowfall ranges from rare to regular, and summers are relatively dry. Elevation ranges from sea level to 610 m (2000 feet) in northern Washington to 1067 m (3500 feet) in Oregon. Topography ranges from relatively flat glacial tillplains to steep mountainous terrain. This is generally the most extensive forest in the lowlands on the west side of the Cascades and forms the matrix within which other systems occur as patches. Throughout its range it occurs in a mosaic with North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest (CES204.002); in dry areas it occurs adjacent to or in a mosaic with North Pacific Dry Douglas-fir-(Madrone) Forest and Woodland (CES204.845), and at higher elevations it intermingles with either North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest (CES204.098) or North Pacific Mesic Western Hemlock-Silver Fir Forest (CES204.097).

Overstory canopy is dominated by *Pseudotsuga menziesii*, with *Tsuga heterophylla* generally present in the subcanopy or as a canopy dominant in old-growth stands. *Abies grandis, Thuja plicata*, and *Acer macrophyllum* codominants are also represented. In the driest climatic areas, *Tsuga heterophylla* may be absent, and *Thuja plicata* takes its place as a late-seral or subcanopy tree species. *Gaultheria shallon, Mahonia nervosa, Rhododendron macrophyllum, Linnaea borealis, Achlys triphylla*, and *Vaccinium ovatum* typify the poorly to well-developed shrub layer. *Acer circinatum* is a common codominant with one or more of these other species. The fern *Polystichum munitum* can be codominant with one or more of the evergreen shrubs on sites with intermediate moisture availability (mesic). If *Polystichum munitum* is thoroughly dominant or greater than about 40-50% cover, then the stand is probably in the more moist North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest (CES204.002). Young stands may lack *Tsuga heterophylla* or *Thuja plicata*, especially in the Puget Lowland. *Tsuga heterophylla* is generally the dominant regenerating tree species. Other common associates include *Acer macrophyllum, Abies grandis*, and *Pinus monticola*. In southwestern Oregon, *Pinus lambertiana, Calocedrus decurrens*, and occasionally *Pinus ponderosa* may occur in these forests. Soils are generally well-drained and are mesic to dry for much of the year. This is in contrast to North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest (CES204.002), which occurs on sites where soils remain moist to subirrigated for much of the year and fires were less frequent. Fire is (or was) the major natural disturbance. In the past (pre-1880), fires were less commonly high-severity, typically mixed-severity or moderate-severity, with natural return intervals of 100 years or less in the driest areas, to a few hundred years in areas with more moderate to wet climates. In the drier climatic areas (central Oregon Cascades, Puget Lowlands, Georgia Basin), this system was typified by a (mixed) moderate-severity fire regime involving occasional stand-replacing fires and more frequent moderate-severity fires. This fire regime would create a complex mosaic of stand structures across the landscape.

Enumerated_Domain:
Enumerated_Domain_Value: 59
Enumerated_Domain_Value_Definition: North Pacific Maritime Mesic Subalpine Parkland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system occurs throughout the mountains of the Pacific Northwest, from the southern Cascades of Oregon to the mountains of south-central Alaska. It occurs at the transition zone of forest to alpine, forming a subalpine forest-meadow ecotone. Clumps of trees to small patches of forest interspersed with low shrublands and meadows characterize this system. Krummholz often occurs near the upper elevational limit of this type where it grades into alpine vegetation. Associations include woodlands, forested and subalpine meadow types. It occurs on the west side of the Cascade Mountains where deep, late-lying snowpack is the primary environmental factor. Major tree species are *Tsuga mertensiana, Abies amabilis, Chamaecyparis nootkatensis*, and *Abies lasiocarpa*. This system includes British Columbia Hypermaritime and Maritime Parkland (*Tsuga mertensiana*). Dominant dwarf-shrubs include *Phyllodoce empetriformis, Cassiope mertensiana*, and *Vaccinium deliciosum*. Dominant herbaceous species include *Lupinus arcticus ssp. subalpinus, Valeriana sitchensis, Carex spectabilis*, and *Polygonum bistortoides*. There is very little disturbance, either windthrow or fire. The major process controlling vegetation is the very deep long-lasting snowpacks (deepest in the North Pacific region) limiting tree regeneration. Trees get established only in favorable microsites (mostly adjacent to existing trees) or during drought years with low snowpack. It is distinguished from more interior dry parkland primarily by the presence of *Tsuga mertensiana* or *Abies amabilis* and absence or paucity of *Pinus albicaulis* and *Larix lyallii*.

Enumerated_Domain:
Enumerated_Domain_Value: 60
Enumerated_Domain_Value_Definition: North Pacific Maritime Mesic-Wet Douglas-fir-Western Hemlock Forest
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is a significant component of the lowland and low montane forests of western Washington, northwestern Oregon, and southwestern British Columbia. It occurs throughout low-elevation western Washington, except on extremely dry sites and in the hypermaritime zone near the outer coast where it is rare. In Oregon, it

occurs on the western slopes of the Cascades, around the margins of the Willamette Valley, and on the west side of the Coast Ranges, and is reduced to locally small patches in southwestern Oregon. In British Columbia, it occurs on the eastern (leeward) side of Vancouver Island, commonly and rarely on the windward side, and in the southern Coast Ranges. These forests occur on moist habitats and microhabitats, mainly lower slopes or valley landforms, within the Western Hemlock Zone of the Pacific Northwest. They differ from North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest (CES204.001) primarily in having more hydrophilic undergrowth species, moist to subirrigated soils, high abundance of shade- and moisture-tolerant canopy trees, as well as higher stand productivity, due to higher soil moisture and lower fire frequency. Climate is relatively mild and moist to wet. Mean annual precipitation is mostly 90-254 cm (35-100 inches) (but as low as 20 inches in the extreme rainshadow) predominantly as winter rain. Snowfall ranges from rare to regular (but consistent winter snowpacks are absent or minimal), and summers are relatively dry. Elevation ranges from sea level to 610 m (2000 feet) in northern Washington to 1067 m (3500 feet) in Oregon. Topography ranges from relatively flat glacial tillplains to steep mountainous terrain. This is an extensive forest in the lowlands on the west side of the Cascades. In some wetter climatic areas, it forms the matrix within which other systems occur as patches, especially riparian wetlands. In many rather drier climatic areas, it occurs as small to large patches within a matrix of North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest (CES204.001); in dry areas, it can occur adjacent to or in a mosaic with North Pacific Dry Douglas-fir-(Madrone) Forest and Woodland (CES204.845), and at higher elevations it intermingles with either North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest (CES204.098) or North Pacific Mesic Western Hemlock-Silver Fir Forest (CES204.097).

Overstory canopy is dominated by *Pseudotsuga menziesii, Tsuga heterophylla*, and/or *Thuja plicata*, as well as *Chamaecyparis lawsoniana* in western Oregon, away from the coast. *Pseudotsuga menziesii* is usually at least present to more typically codominant or dominant. *Acer macrophyllum* and *Alnus rubra* (the latter primarily where there has been historic logging disturbance) are commonly found as canopy or subcanopy codominants, especially at lower elevations. In a natural landscape, small patches can be dominated in the canopy by these broadleaf trees for several decades after a severe fire. *Polystichum munitum, Oxalis oregana, Rubus spectabilis*, and *Oplopanax horridus* typify the poorly to well-developed herb and shrub layers. *Gaultheria shallon, Mahonia nervosa, Rhododendron macrophyllum*, and *Vaccinium ovatum* are often present but are generally not as abundant as the aforementioned indicators; except where *Chamaecyparis lawsoniana* is a canopy codominant, they may be the dominant understory. *Acer circinatum* is a very common codominant as a tall shrub. Forested stands with abundant *Lysichiton americanus*, an indicator of seasonally flooded or saturated soils, belong in North Pacific Coniferous Swamp (CES204.867). Stands included are best represented on lower mountain slopes of the coastal ranges with high precipitation, long frost-free periods, and low fire frequencies. Young stands may lack *Tsuga heterophylla* or *Thuja plicata*, especially in the Puget Lowland. *Tsuga heterophylla* is generally the dominant regenerating tree species. Other common associates include *Abies grandis*, which can be a codominant especially in the Willamette Valley - Puget Trough - Georgia Basin ecoregion. Soils are moist to somewhat wet but not saturated for much of the year and are well-drained to somewhat poorly drained. Typical soils for *Polystichum* sites would be deep, fine- to moderately coarse-textured, and for *Oplopanax* sites, soils typically have an impermeable layer at a moderate depth. Both types of soils are well-watered from upslope sources, seeps, or hyperheic sources. This is in contrast to North Pacific Maritime Dry-Mesic Douglas-fir-Western Hemlock Forest (CES204.001), which occurs on well-drained soils, south-facing slopes, and dry ridges and slopes where soils remain mesic to dry for much of the year. Fire is (or was) the major natural disturbance in all but the wettest climatic areas. In the past (pre-1880), fires were less commonly high-severity, typically mixed-severity or moderate-severity, with natural return intervals of a few hundred to several hundred years. This system was formerly supported by occasional, stand-replacing fires. More frequent moderate-severity fires would generally not burn these moister microsites.

Enumerated_Domain:
Enumerated_Domain_Value: 61
Enumerated_Domain_Value_Definition: North Pacific Mountain Hemlock Forest
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This forested ecological system occurs throughout the mountains of the North Pacific, from the southern Cascades of Oregon north to southeastern Alaska. It is the predominant forest of subalpine elevations in the coastal mountains of British Columbia, southeastern Alaska, western Washington and western Oregon. On the leeward side of the Cascades, this is usually a dense canopy composed of *Abies lasiocarpa* and *Tsuga mertensiana*, with some *Picea engelmannii* or *Abies amabilis*. These occur between 1275 and 1675 m elevation. It also occurs on mountain slopes on the outer coastal islands of British Columbia and Alaska. It lies between the Western Hemlock, Pacific Silver Fir, or Shasta Red Fir zones and the Subalpine Parkland or Alpine Tundra Zone, at elevations ranging from 300 to 2300 m (1000-7500 feet). The lower and upper elevational limits decrease from south to north and from east to west. The climate is generally characterized by short, cool summers, rainy autumns and long, cool, wet winters with heavy snow cover for 5-9 months. The heavy snowpack is ubiquitous, but at least in southern Oregon and perhaps the northern Rocky Mountains and eastern Cascades, summer drought is more significant. These more summer-dry climatic areas also have occasional high-severity fires with return intervals of 400-600 years (J. Kertis pers. comm. 2006, K. Kopper pers. comm. 2006) unlike the majority of the range of the system which experiences fires very rarely or never. *Tsuga mertensiana* and *Abies amabilis* are the characteristic dominant tree species over most of the range. *Abies amabilis* is absent from southern Oregon and less abundant than elsewhere in the central Oregon Cascades and the eastern slopes of the Cascades. *Chamaecyparis nootkatensis* is abundant in the more coastal portions, while *Abies lasiocarpa* is found inland and becomes increasingly common near the transition to the Subalpine Fir-Engelmann Spruce Zone. In the Cascades of central to southern Oregon, *Abies X shastensis* is typically present and often codominant. *Tsuga heterophylla* often occurs at lower elevations in this system but is much less abundant than *Tsuga*

mertensiana. On drier sites *Abies lasiocarpa* and *Pinus contorta* can be the first forests to develop after stand-replacing fire. These early-seral stages, with lodgepole pine dominant in the upper canopy, could be classified and mapped as Rocky Mountain Lodgepole Pine Forest (CES306.820) but should be considered part of this system if other tree species listed above are present, as it will succeed as a mixed pine type, then mountain hemlock becomes characteristic. *Picea sitchensis* and *Thuja plicata* are occasionally present, especially on the outer coast of Alaska. Deciduous trees are rare. Parklands (open woodlands or sparse trees with dwarf-shrub or herbaceous vegetation) are not part of this system but of North Pacific Maritime Mesic Subalpine Parkland (CES204.837).

Enumerated_Domain:
Enumerated_Domain_Value: 62
Enumerated_Domain_Value_Definition: North Pacific Mesic Western Hemlock-Silver Fir Forest
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This forested system occurs only in the Pacific Northwest mountains entirely west of the Cascade Crest from coastal British Columbia to Washington. It generally occurs in an elevational band between *Pseudotsuga menziesii - Tsuga heterophylla* or hypermaritime zone forests and *Tsuga mertensiana* forests. It dominates mid-montane maritime climatic zones on the windward side of Vancouver Island, the Olympic Peninsula, and wettest portions of the North Cascades in Washington (north of Snoqualmie River). Windthrow is a common small-scale disturbance in this system, and gap creation and succession are important processes. Stand-replacement fires are relatively infrequent to absent, with return intervals of several hundred or more years. More mixed-severity fires occur in the southern parts of this system, so that forest structure, patch size and proportions will be different from northern stands. Further north, stand-replacing fires are also infrequent but are a more common fire event. A somewhat variable winter snowpack that typically lasts for 2-6 months is characteristic. The climatic zone within which it occurs is sometimes referred to as the "rain-on-snow" zone because of the common occurrence of major winter rainfall on an established snowpack. *Tsuga heterophylla* and/or *Abies amabilis* dominate the canopy of late-seral stands, and *Chamaecyparis nootkatensis* can be codominant, especially at higher elevations. *Thuja plicata* is also common and sometimes codominates in British Columbia. *Pseudotsuga menziesii* is relatively rare to absent in this system, as opposed to the similar but drier North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest (CES204.098). The major understory dominant species is *Vaccinium ovalifolium*. Understory species that help distinguish this system from the drier silver fir system (they are much more common here) include *Oxalis oregana, Blechnum spicant*, and *Rubus pedatus*.

Enumerated_Domain:
Enumerated_Domain_Value: 63
Enumerated_Domain_Value_Definition: Mediterranean California Mixed Evergreen Forest

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs from the Santa Cruz Mountains (and locally in the Santa Lucia Mountains), California, north into southwestern Oregon throughout the outer and middle Coast Ranges on Franciscan Formation soils (metasedimentary sandstones, schists, and shales) with moderate to high rainfall. This system occurs just inland from the redwood belt of this region. It also occurs in southern California in more mesic, protected, cooler sites of the Transverse and Peninsular ranges. Historic fire frequency in this system was higher than for redwood-dominated systems (every 50-100 years). It is characterized by mixes of coniferous and broad-leaved evergreen trees. Characteristic trees include *Pseudotsuga menziesii, Quercus chrysolepis, Lithocarpus densiflorus, Arbutus menziesii, Umbellularia californica*, and *Chrysolepis chrysophylla*. On the eastern fringe of this system, in the western Siskiyous, other conifers occur such as *Pinus ponderosa* and *Chamaecyparis lawsoniana*. In southern California (Transverse and Peninsular ranges), *Pseudotsuga macrocarpa* replaces *Pseudotsuga menziesii* but co-occurs with *Quercus chrysolepis* and sometimes *Quercus agrifolia*. *Calocedrus decurrens* is occasional. In the southern portion of the range, *Lithocarpus densiflorus, Arbutus menziesii, Umbellularia californica*, and *Chrysolepis chrysophylla* become less important or are absent. In the Santa Lucia Mountains, stands of *Abies bracteata* are included in this system and are an unusual and unique component. These stands are a mixture of *Abies bracteata* and *Quercus chrysolepis*. The more northerly stands tend to have dense or diverse shrub understories, with *Corylus cornuta, Vaccinium ovatum, Rhododendron macrophyllum, Gaultheria shallon, Quercus sadleriana, Mahonia nervosa*, and *Toxicodendron diversilobum* being common. Southern stands are less diverse and more sparse; *Toxicodendron diversilobum* is the most constant shrub, with *Ribes* spp. occasionally present, along with much *Polystichum munitum*. Especially in the south, stands are restricted to fire-protected sites (extremely steep, northerly, mesic slopes and coves) where fires from adjacent chaparral systems do not carry.

Enumerated_Domain:
Enumerated_Domain_Value: 64
Enumerated_Domain_Value_Definition: Northern California Mesic Subalpine Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs on ridges and rocky slopes around timberline at 2600 m (7900 feet) elevation in the central Sierra Nevada and 2450 m (8000 feet) in the southern Cascades. These woodlands are found on concave or mesic slopes in areas with long-lasting snowpack and better soil development than other drier and more exposed subalpine woodlands. The tree canopy is characterized by *Tsuga mertensiana* and may include *Abies magnifica, Abies procera, Pinus albicaulis*, and *Pinus monticola*. Mesic-site shrubs will include *Cassiope mertensiana, Phyllodoce breweri, Phyllodoce empetriformis, Vaccinium membranaceum*, and others. *Juniperus communis* is found in most stands of the northern Sierra Nevada. *Penstemon davidsonii*, as well as patches of grasses, sedges, and forbs grade into adjacent meadows.

Enumerated_Domain:
Enumerated_Domain_Value: 65
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is composed of highly variable montane coniferous forests found in the interior Pacific Northwest, from southernmost interior British Columbia, eastern Washington, eastern Oregon, northern Idaho, western and north-central Montana, and south along the east slope of the Cascades in Washington and Oregon. In central Montana it occurs on mountain islands (the Snowy Mountains). This system is associated with a submesic climate regime with annual precipitation ranging from 50 to 100 cm, with a maximum in winter or late spring. Winter snowpacks typically melt off in early spring at lower elevations. Elevations range from 460 to 1920 m. Most occurrences of this system are dominated by a mix of *Pseudotsuga menziesii* and *Pinus ponderosa* (but there can be one without the other) and other typically seral species, including *Pinus contorta, Pinus monticola* (not in central Montana), and *Larix occidentalis* (not in central Montana). *Picea engelmannii* (or *Picea glauca* or their hybrid) becomes increasingly common towards the eastern edge of the range. The nature of this forest system is a matrix of large patches dominated or codominated by one or combinations of the above species; *Abies grandis* (a fire-sensitive, shade-tolerant species not occurring in central Montana) has increased on many sites once dominated by *Pseudotsuga menziesii* and *Pinus ponderosa*, which were formerly maintained by low-severity wildfire. Presettlement fire regimes may have been characterized by frequent, low-intensity ground fires that maintained relatively open stands of a mix of fire-resistant species. Under present conditions the fire regime is mixed severity and more variable, with stand-replacing fires more common, and the forests are more homogeneous. With vigorous fire suppression, longer fire-return intervals are now the rule, and multi-layered stands of *Pseudotsuga menziesii, Pinus ponderosa*, and/or *Abies grandis* provide fuel "ladders," making these forests more susceptible to high-intensity, stand-replacing fires. They are very productive forests which have been priorities for timber production. They rarely form either upper or lower timberline forests. Understories are dominated by graminoids, such as *Pseudoroegneria spicata, Calamagrostis rubescens, Carex geyeri*, and *Carex rossii*, that may be associated with a variety of shrubs, such as *Acer glabrum, Juniperus communis, Physocarpus malvaceus, Symphoricarpos albus, Spiraea betulifolia*, or *Vaccinium membranaceum* on mesic sites. *Abies concolor* and *Abies grandis X concolor* hybrids in central Idaho (the Salmon Mountains) are included here but have very restricted range in this area. *Abies concolor* and *Abies grandis* in the Blue Mountains of Oregon are probably hybrids of the two and mostly *Abies grandis*.

Enumerated_Domain:
Enumerated_Domain_Value: 66
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Mesic Montane Mixed Conifer Forest

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs in the northern Rockies of western Montana west into northeastern Washington and southern British Columbia. These are vegetation types dominated by *Tsuga heterophylla* and *Thuja plicata* in most cases, found in areas influenced by incursions of mild, wet, Pacific maritime air masses. Much of the annual precipitation occurs as rain, but where snow does occur, it can generally be melted by rain during warm winter storms. Occurrences generally are found on all slopes and aspects but grow best on sites with high soil moisture, such as toeslopes and bottomlands. At the periphery of its distribution, this system is confined to moist canyons and cooler, moister aspects. Generally these are moist, non-flooded or upland sites that are not saturated yearlong. Along with *Tsuga heterophylla* and *Thuja plicata, Pseudotsuga menziesii* commonly shares the canopy, and *Pinus monticola, Pinus contorta, Abies grandis, Taxus brevifolia*, and *Larix occidentalis* are major associates. Mesic *Abies grandis* associations are included in this system, and *Abies grandis* is often the dominant in these situations; *Tsuga heterophylla* and *Thuja plicata* can both be absent. *Cornus nuttallii* may be present in some situations. *Picea engelmannii, Abies lasiocarpa*, and *Pinus ponderosa* may be present but only on the coldest or warmest and driest sites. *Linnaea borealis, Paxistima myrsinites, Alnus incana, Acer glabrum, Spiraea betulifolia, Symphoricarpos hesperius (= Symphoricarpos mollis ssp. hesperius), Cornus canadensis, Rubus parviflorus, Menziesia ferruginea*, and *Vaccinium membranaceum* are common shrub species. The composition of the herbaceous layer reflects local climate and degree of canopy closure; it is typically highly diverse in all but closed-canopy conditions. Important forbs and ferns include *Actaea rubra, Anemone piperi, Aralia nudicaulis, Asarum caudatum, Clintonia uniflora, Coptis occidentalis, Thalictrum occidentale, Tiarella trifoliata, Trientalis borealis, Trillium ovatum, Viola glabella, Gymnocarpium dryopteris, Polystichum munitum*, and *Adiantum pedatum*. Typically, stand-replacement, fire-return intervals are 150-500 years, with moderate-severity fire intervals of 50-100 years.

Enumerated_Domain:
Enumerated_Domain_Value: 67
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Mesic Montane Mixed Conifer Forest
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs in the northern Rockies of western Montana west into northeastern Washington and southern British Columbia. These are vegetation types dominated by *Tsuga heterophylla* and *Thuja plicata* in most cases, found in areas influenced by incursions of mild, wet, Pacific maritime air masses. Much of the annual precipitation occurs as rain, but where snow does occur, it can generally be melted by rain during warm winter storms. Occurrences generally are found on all slopes and aspects but grow best on sites with high soil moisture, such as toeslopes and bottomlands. At the periphery of its distribution, this system is confined to moist canyons and cooler, moister aspects. Generally these are moist, non-flooded or upland sites that are not

saturated yearlong. Along with *Tsuga heterophylla* and *Thuja plicata, Pseudotsuga menziesii* commonly shares the canopy, and *Pinus monticola, Pinus contorta, Abies grandis, Taxus brevifolia*, and *Larix occidentalis* are major associates. Mesic *Abies grandis* associations are included in this system, and *Abies grandis* is often the dominant in these situations; *Tsuga heterophylla* and *Thuja plicata* can both be absent. *Cornus nuttallii* may be present in some situations. *Picea engelmannii, Abies lasiocarpa*, and *Pinus ponderosa* may be present but only on the coldest or warmest and driest sites. *Linnaea borealis, Paxistima myrsinites, Alnus incana, Acer glabrum, Spiraea betulifolia, Symphoricarpos hesperius (= Symphoricarpos mollis ssp. hesperius), Cornus canadensis, Rubus parviflorus, Menziesia ferruginea*, and *Vaccinium membranaceum* are common shrub species. The composition of the herbaceous layer reflects local climate and degree of canopy closure; it is typically highly diverse in all but closed-canopy conditions. Important forbs and ferns include *Actaea rubra, Anemone piperi, Aralia nudicaulis, Asarum caudatum, Clintonia uniflora, Coptis occidentalis, Thalictrum occidentale, Tiarella trifoliata, Trientalis borealis, Trillium ovatum, Viola glabella, Gymnocarpium dryopteris, Polystichum munitum*, and *Adiantum pedatum*. Typically, stand-replacement, fire-return intervals are 150-500 years, with moderate-severity fire intervals of 50-100 years.

Enumerated_Domain:
Enumerated_Domain_Value: 68
Enumerated_Domain_Value_Definition:NatureServe-Ecological Systems www.NatureServe.org Rocky Mountain Foothill Limber Pine - Juniper Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs in foothill and lower montane zones in the Rocky Mountains from northern Montana south to central Colorado and on escarpments across Wyoming extending out into the western Great Plains. Elevation ranges from 1000-2400 m. It occurs generally below continuous forests of Pseudotsuga menziesii or Pinus ponderosa and can occur in large stands well within the zone of continuous forests in the northeastern Rocky Mountains. It is restricted to shallow soils and fractured bedrock derived from a variety of parent material, including limestone, sandstone, dolomite, granite and colluvium. Soils have a high rock component (typically over 50% cover) and are coarse- to fine-textured, often gravelly and calcareous. Slopes are typically moderately steep to steep. At higher elevations, it is limited to the most xeric aspects on rock outcrops, and at lower elevations to the relatively mesic north aspects. Fire is infrequent and spotty because rocky substrates prevent a continuous vegetation canopy needed to spread. Vegetation is characterized by an open-tree canopy or patchy woodland that is dominated by either Pinus flexilis, Juniperus osteosperma, or Juniperus scopulorum. Pinus edulis is not present. A sparse to moderately dense short-shrub layer, if present, may include a variety of shrubs, such as Arctostaphylos uva-ursi, Artemisia nova, Artemisia tridentata, Cercocarpus ledifolius, Cercocarpus montanus, Dasiphora fruticosa ssp. floribunda, Ericameria nauseosa, Juniperus horizontalis, Purshia tridentata, Rhus trilobata, Rosa woodsii, Shepherdia canadensis (important in Montana stands), Symphoricarpos albus, or Symphoricarpos oreophilus. Herbaceous layers are generally

sparse, but range to moderately dense, and are typically dominated by perennial graminoids such as Bouteloua gracilis, Festuca idahoensis, Festuca campestris, Danthonia intermedia, Leucopoa kingii, Hesperostipa comata, Koeleria macrantha, Piptatherum micranthum, Poa secunda, or Pseudoroegneria spicata. Within this ecological system, there may be small patches of grassland or shrubland composed of some of the above species. In Wyoming, some limber pine stands are found up to 2440 m (8000 feet) elevation and are still included in this system.

Enumerated_Domain:
Enumerated_Domain_Value: 69
Enumerated_Domain_Value_Definition: Rocky Mountain Lodgepole Pine Forest
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is widespread in upper montane to subalpine elevations of the Rocky Mountains, Intermountain West region, north into the Canadian Rockies and east into mountain "islands" of north-central Montana. These are subalpine forests where the dominance of *Pinus contorta* is related to fire history and topo-edaphic conditions. Following stand-replacing fires, *Pinus contorta* will rapidly colonize and develop into dense, even-aged stands. Most forests in this ecological system occur as early- to mid-successional forests which developed following fires. This system includes *Pinus contorta*-dominated stands that, while typically persistent for >100-year time frames, may succeed to spruce-fir; in the southern and central Rocky Mountains it is seral to Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland (CES306.828). More northern occurrences are seral to Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland (CES306.830). Soils supporting these forests are typically well-drained, gravelly, coarse-textured, acidic, and rarely formed from calcareous parent materials. These forests are dominated by *Pinus contorta* with shrub, grass, or barren understories. Sometimes there are intermingled mixed conifer/*Populus tremuloides* stands, with the latter occurring with inclusions of deeper, typically fine-textured soils. The shrub stratum may be conspicuous to absent; common species include *Arctostaphylos uva-ursi, Ceanothus velutinus, Linnaea borealis, Mahonia repens, Purshia tridentata, Spiraea betulifolia, Spiraea douglasii, Shepherdia canadensis, Vaccinium caespitosum, Vaccinium scoparium, Vaccinium membranaceum, Symphoricarpos albus*, and *Ribes* spp. In southern interior British Columbia, this system is usually an open lodgepole pine forest found extensively between 500 and 1600 m elevation in the Columbia Range. In the Interior Cedar Hemlock and Interior Douglas-fir zones, *Tsuga heterophylla* or *Pseudotsuga menziesii* may present.

Enumerated_Domain:
Enumerated_Domain_Value: 70
Enumerated_Domain_Value_Definition:NatureServe-Ecological Systems www.NatureServe.org Southern Rocky Mountian Dry-Mesic Montane Mixed Conifer Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org

This is a highly variable ecological system of the montane zone of the Rocky Mountains. It occurs throughout the southern Rockies, north and west into Utah, Nevada, Wyoming and Idaho. These are mixed-conifer forests occurring on all aspects at elevations ranging from 1200 to 3300 m. Rainfall averages less than 75 cm per year (40-60 cm), with summer "monsoons" during the growing season contributing substantial moisture. The composition and structure of the overstory are dependent upon the temperature and moisture relationships of the site and the successional status of the occurrence. Pseudotsuga menziesii and Abies concolor are most frequent, but Pinus ponderosa may be present to codominant. Pinus flexilis is common in Nevada. Pseudotsuga menziesii forests occupy drier sites, and Pinus ponderosa is a common codominant. Abies concolor-dominated forests occupy cooler sites, such as upper slopes at higher elevations, canyon sideslopes, ridgetops, and north- and east-facing slopes which burn somewhat infrequently. Picea pungens is most often found in cool, moist locations, often occurring as smaller patches within a matrix of other associations. As many as seven conifers can be found growing in the same occurrence, and there are a number of cold-deciduous shrub and graminoid species common, including Arctostaphylos uva-ursi, Mahonia repens, Paxistima myrsinites, Symphoricarpos oreophilus, Jamesia americana, Quercus gambelii, and Festuca arizonica. This system was undoubtedly characterized by a mixed-severity fire regime in its "natural condition," characterized by a high degree of variability in lethality and return interval.

Enumerated_Domain:
Enumerated_Domain_Value: 71
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Ponderosa Pine Woodland and Savanna
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This inland Pacific Northwest ecological system occurs in the foothills of the northern Rocky Mountains in the Columbia Plateau region and west along the foothills of the Modoc Plateau and eastern Cascades into southern interior British Columbia. These woodlands and savannas occur at the lower treeline/ecotone between grasslands or shrublands and more mesic coniferous forests typically in warm, dry, exposed sites. Elevations range from less than 500 m in British Columbia to 1600 m in the central Idaho mountains. Occurrences are found on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. This ecological system generally occurs on glacial till, glacio-fluvial sand and gravel, dune, basaltic rubble, colluvium, to deep loess or volcanic ash-derived soils, with characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, rockiness, and periods of drought during the growing season. In the Oregon "pumice zone" this system occurs as matrix-forming, extensive woodlands on rolling pumice plateaus and other volcanic deposits. These woodlands in the eastern Cascades, Okanagan and northern Rockies regions receive winter and spring rains, and thus have a greater spring "green-up" than the drier woodlands in the central Rockies. *Pinus ponderosa* (primarily *var. ponderosa*) is the predominant conifer; *Pseudotsuga menziesii* may be present in the tree canopy but is usually absent. In southern interior British

Columbia, *Pseudotsuga menziesii* or *Pinus flexilis* may form woodlands or fire-maintained savannas with and without *Pinus ponderosa var. ponderosa* at the lower treeline transition into grassland or shrub-steppe. The understory can be shrubby, with *Artemisia tridentata, Arctostaphylos patula, Arctostaphylos uva-ursi, Cercocarpus ledifolius, Physocarpus malvaceus, Purshia tridentata, Symphoricarpos oreophilus* or *Symphoricarpos albus, Prunus virginiana, Amelanchier alnifolia*, and *Rosa* spp. common species. Understory vegetation in the true savanna occurrences is predominantly fire-resistant grasses and forbs that resprout following surface fires; shrubs, understory trees and downed logs are uncommon. These more open stands support grasses such as *Pseudoroegneria spicata, Hesperostipa* spp., *Achnatherum* spp., dry *Carex* species (*Carex inops*), *Festuca idahoensis*, or *Festuca campestris*. The more mesic portions of this system may include *Calamagrostis rubescens* or *Carex geyeri*, species more typical of Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest (CES306.805). Mixed fire regimes and ground fires of variable return intervals maintain these woodlands typically with a shrub-dominated or patchy shrub layer, depending on climate, degree of soil development, and understory density. This includes the northern race of Interior Ponderosa Pine old-growth (USFS Region 6, USFS Region 1). Historically, many of these woodlands and savannas lacked the shrub component as a result of 3- to 7-year fire-return intervals.

Enumerated_Domain:
Enumerated_Domain_Value: 72
Enumerated_Domain_Value_Definition: Southern Rocky Mountain Ponderosa Pine
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This very widespread ecological system is most common throughout the cordillera of the Rocky Mountains, from the Greater Yellowstone region south. It is also found in the Colorado Plateau region, west into scattered locations of the Great Basin. Its easternmost extent in Wyoming is in the Bighorn Mountains. These woodlands occur at the lower treeline/ecotone between grassland or shrubland and more mesic coniferous forests typically in warm, dry, exposed sites. Elevations range from less than 1900 m in northern Wyoming to 2800 m in the New Mexico mountains. Occurrences are found on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. This ecological system generally occurs on soils derived from igneous, metamorphic, and sedimentary material, with characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, rockiness, and periods of drought during the growing season. Northern Rocky Mountain Ponderosa Pine Woodland and Savanna (CES306.030) in the eastern Cascades, Okanogan, and northern Rockies regions receives winter and spring rains, and thus has a greater spring "green-up" than the drier woodlands in the central Rockies. Pinus ponderosa (primarily var. scopulorum and var. brachyptera) is the predominant conifer; Pseudotsuga menziesii, Pinus edulis, Pinus contorta, Populus tremuloides, and Juniperus spp. may be present in the tree canopy. The understory is usually shrubby, with Artemisia nova, Artemisia tridentata, Arctostaphylos patula, Arctostaphylos uva-ursi, Cercocarpus montanus, Purshia stansburiana, Purshia tridentata, Quercus gambelii, Symphoricarpos

spp., Prunus virginiana, Amelanchier alnifolia (less so in Montana), and Rosa spp. common species. Pseudoroegneria spicata, Pascopyrum smithii, and species of Hesperostipa, Achnatherum, Festuca, Muhlenbergia, and Bouteloua are some of the common grasses. Mixed fire regimes and ground fires of variable return intervals maintain these woodlands, depending on climate, degree of soil development, and understory density.

Enumerated_Domain:
Enumerated_Domain_Value: 73
Enumerated_Domain_Value_Definition: Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
Engelmann spruce and subalpine fir forests comprise a substantial part of the subalpine forests of the Cascades and Rocky Mountains from southern British Columbia east into Alberta, and south into New Mexico and the Intermountain region. They also occur on mountain "islands" of north-central Montana. They are the matrix forests of the subalpine zone, with elevations ranging from 1275 m in its northern distribution to 3355 m in the south (4100-11,000 feet). They often represent the highest elevation forests in an area. Sites within this system are cold year-round, and precipitation is predominantly in the form of snow, which may persist until late summer. Snowpacks are deep and late-lying, and summers are cool. Frost is possible almost all summer and may be common in restricted topographic basins and benches. Despite their wide distribution, the tree canopy characteristics are remarkably similar, with *Picea engelmannii* and *Abies lasiocarpa* dominating either mixed or alone. *Pseudotsuga menziesii* may persist in occurrences of this system for long periods without regeneration. *Pinus contorta* is common in many occurrences, and patches of pure *Pinus contorta* are not uncommon, as well as mixed conifer/*Populus tremuloides* stands. In some areas, such as Wyoming, *Picea engelmannii*-dominated forests are on limestone or dolomite, while nearby codominated spruce-fir forests are on granitic or volcanic rocks. Upper elevation examples may have more woodland physiognomy, and *Pinus albicaulis* can be a seral component. What have been called "ribbon forests" or "tree islands" by some authors are included here; they can be found at upper treeline in many areas of the Rockies, including the central and northern ranges in Colorado and the Medicine Bow and Bighorn ranges of Wyoming. These are more typically islands or ribbons of trees, sometimes with a krummholz form, with open-meadow areas in a mosaic. These patterns are controlled by snow deposition and wind-blown ice. Xeric species may include *Juniperus communis, Linnaea borealis, Mahonia repens*, or *Vaccinium scoparium*. In the Bighorn Mountains, *Artemisia tridentata* is a common shrub. More northern occurrences often have taller, more mesic shrub and herbaceous species, such as *Empetrum nigrum, Rhododendron albiflorum*, and *Vaccinium membranaceum*. Disturbance includes occasional blowdown, insect outbreaks and stand-replacing fire. Mean return interval for stand-replacing fire is 222 years as estimated in southeastern British Columbia.

Enumerated_Domain:

Enumerated_Domain_Value: 74
Enumerated_Domain_Value_Definition: Rocky Mountain Subalpine Mesic-Wet Spruce-Fir Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This is a high-elevation system of the Rocky Mountains, dry eastern Cascades and eastern Olympic Mountains dominated by Picea engelmannii and Abies lasiocarpa. It extends westward into the northeastern Olympic Mountains and the northeastern side of Mount Rainier in Washington, and as far east as mountain "islands" of north-central Montana. Picea engelmannii is generally more important in southern forests than those in the Pacific Northwest. Occurrences are typically found in locations with cold-air drainage or ponding, or where snowpacks linger late into the summer, such as north-facing slopes and high-elevation ravines. They can extend down in elevation below the subalpine zone in places where cold-air ponding occurs; northerly and easterly aspects predominate. These forests are found on gentle to very steep mountain slopes, high-elevation ridgetops and upper slopes, plateau-like surfaces, basins, alluvial terraces, well-drained benches, and inactive stream terraces. In the northern Rocky Mountains of northern Idaho and Montana, Tsuga mertensiana occurs as small to large patches within the matrix of this mesic spruce-fir system and only in the most maritime of environments (the coldest and wettest of the more Continental subalpine fir forests). In the Olympics and northern Cascades, the climate is more maritime than typical for this system, but due to the lower snowfall in these rainshadow areas, summer drought may be more significant than snowpack in limiting tree regeneration in burned areas. Picea engelmannii is rare in these areas. Mesic understory shrubs include Menziesia ferruginea, Vaccinium membranaceum, Rhododendron albiflorum, Amelanchier alnifolia, Rubus parviflorus, Ledum glandulosum, Phyllodoce empetriformis, and Salix spp. Herbaceous species include Actaea rubra, Maianthemum stellatum, Cornus canadensis, Erigeron eximius, Gymnocarpium dryopteris, Rubus pedatus, Saxifraga bronchialis, Tiarella spp., Lupinus arcticus ssp. subalpinus, Valeriana sitchensis, and graminoids Luzula glabrata var. hitchcockii or Calamagrostis canadensis. Disturbances include occasional blowdown, insect outbreaks (30-50 years), mixed-severity fire, and stand-replacing fire (every 150-500 years). The more summer-dry climatic areas also have occasional high-severity fires.

Enumerated_Domain:
Enumerated_Domain_Value: 75
Enumerated_Domain_Value_Definition: Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs throughout the Rocky Mountains, south of Montana, on dry, rocky ridges and slopes near upper treeline above the matrix spruce-fir forest. It extends down to the lower montane in the northeastern Great Basin mountains where dominated by *Pinus flexilis*. Sites are harsh, exposed to desiccating winds, with rocky substrates and a short growing season that limit plant growth. Higher-elevation occurrences are found well into the subalpine-alpine transition on wind-blasted, mostly

west-facing slopes and exposed ridges. Calcareous substrates are important for *Pinus flexilis*-dominated communities in the northern Rocky Mountains and possibly elsewhere. The open tree canopy is often patchy and is strongly dominated by *Pinus flexilis* or *Pinus aristata* with the latter restricted to southern Colorado, northern New Mexico and the San Francisco Mountains in Arizona. In the Wyoming Rockies and northern Great Basin, *Pinus albicaulis* is found in some occurrences, but is a minor component. Other trees such as *Juniperus* spp., *Pinus contorta, Pinus ponderosa*, or *Pseudotsuga menziesii* are occasionally present. *Arctostaphylos uva-ursi, Cercocarpus ledifolius, Juniperus communis, Mahonia repens, Purshia tridentata, Ribes montigenum*, or *Vaccinium* spp. may form an open shrub layer in some stands. The herbaceous layer, if present, is generally sparse and composed of xeric graminoids, such as *Calamagrostis purpurascens, Festuca arizonica, Festuca idahoensis, Festuca thurberi*, or *Pseudoroegneria spicata*, or more alpine plants.

Enumerated_Domain:
Enumerated_Domain_Value: 76
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Subalpine Dry Parkland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system of the northern Rockies, Cascade Mountains, and northeastern Olympic Mountains is typically a high-elevation mosaic of stunted tree clumps, open woodlands, and herb- or dwarf-shrub-dominated openings, occurring above closed forest ecosystems and below alpine communities. It includes open areas with clumps of Pinus albicaulis, as well as woodlands dominated by Pinus albicaulis. In the Cascade Mountains and northeastern Olympic Mountains, the tree clump pattern is one manifestation, but it can also have woodlands with open canopy, without a tree clump/opening patchiness to them; in fact, that is quite common with whitebark pine. In interior British Columbia, it occurs between 1000 and 2100 m elevation. The upper and lower elevational limits, due to climatic variability and differing topography, vary considerably. Landforms include ridgetops, mountain slopes, glacial trough walls and moraines, talus slopes, landslides and rockslides, and cirque headwalls and basins. Some sites have little snow accumulation because of high winds and sublimation. In this harsh, often wind-swept environment, trees are often stunted and flagged from damage associated with wind and blowing snow and ice crystals, especially at the upper elevations of the type. The stands or patches often originate when Picea engelmannii or Pinus albicaulis colonize a sheltered site such as the lee side of a rock. Abies lasiocarpa can then colonize in the shelter of the Picea engelmannii and may form a dense canopy by branch layering. The climate is typically very cold in winter and dry in summer. In the Cascades and Olympic Mountains, the climate is more maritime in nature and wind is not as extreme, but summer drought is a more important process than in the related maritime mesic subalpine parkland system. Fire is known to occur infrequently in this system, at least where woodlands are present. In the Cascades and Olympics, Abies lasiocarpa sometimes dominates the tree layer without Pinus albicaulis, though in this dry parkland Tsuga mertensiana and Abies amabilis are largely absent. In the northern Washington Cascades,

Larix lyallii occurs in this system, and the distinction between it and Northern Rocky Mountain Subalpine Larch Woodland (CES306.808) is less distinct than in the Rockies. Other woody species include shrubs and dwarf-shrubs, such as Phyllodoce glanduliflora, Phyllodoce empetriformis, Kalmia polifolia, Ribes montigenum, Salix brachycarpa, Salix glauca, Salix planifolia, Vaccinium membranaceum, and Vaccinium scoparium, that may be present to codominant. The herbaceous layer is sparse under dense shrub canopies or may be dense where the shrub canopy is open or absent.

Enumerated_Domain:
Enumerated_Domain_Value: 77
Enumerated_Domain_Value_Definition: Middle Rocky Mountain Montane Douglas-fir Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs throughout the middle Rocky Mountains of central and southern Idaho (Lemhi, Beaverhead and Lost River ranges), south and east into the greater Yellowstone region, and south and east into the Wind River, Gros Ventre and Bighorn ranges of Wyoming. It extends north into Montana on the east side of the Continental Divide, north to about the McDonald Pass area, and also into the Rocky Mountain Front region of Montana. This is a *Pseudotsuga menziesii*-dominated system without the maritime floristic composition; these are forests and woodlands occurring in the central Rockies where the southern monsoon influence is less and maritime climate regime is not important. This system includes extensive *Pseudotsuga menziesii* forests, occasionally with *Pinus flexilis* on calcareous substrates, and *Pinus contorta* at higher elevations. True firs, such as *Abies concolor, Abies grandis*, and *Abies lasiocarpa*, are absent in these occurrences, but *Picea engelmannii* can occur in some stands. Understory components include shrubs such as *Physocarpus malvaceus, Juniperus communis, Symphoricarpos oreophilus*, and *Mahonia repens*, and graminoids such as *Calamagrostis rubescens, Carex rossii*, and *Leucopoa kingii*. The fire regime is of mixed severity with moderate frequency. This system often occurs at the lower treeline immediately above valley grasslands, or sagebrush steppe and shrublands. Sometimes there may be a "bath-tub ring" of *Pinus ponderosa* at lower elevations or *Pinus flexilis* between the valley non-forested and the solid *Pseudotsuga menziesii* forest. In the Wyoming Basins, this system occurs as isolated stands of *Pseudotsuga menziesii*, with *Artemisia tridentata, Pseudoroegneria spicata, Leucopoa kingii*, and *Carex rossii*.

Enumerated_Domain:
Enumerated_Domain_Value: 78
Enumerated_Domain_Value_Definition: Rocky Mountain Poor Site Lodgepole Pine Forest
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is widespread but patchy in distribution in upper montane to subalpine elevations of the Rocky Mountains and Intermountain region. These are subalpine forests, occasionally found in the montane zone, where the dominance of Pinus

contorta is related to topo-edaphic conditions and nutrient-poor soils. These include excessively well-drained pumice deposits, glacial till and alluvium on valley floors where there is cold-air accumulation, warm and droughty shallow soils over fractured quartzite bedrock, and shallow moisture-deficient soils with a significant component of volcanic ash. Pumice soils at lower elevations of the pumice zone of Oregon support this system. Soils on these sites are typically well-drained, gravelly, coarse-textured, acidic, and rarely formed from calcareous parent materials. Following stand-replacing fires, Pinus contorta will rapidly colonize and develop into dense, even-aged stands and then persist on these sites that are too extreme for other conifers to establish. In some cases, stands are open to dense and may be multi-aged, not just even-aged. These forests are dominated by Pinus contorta with shrub, grass, or barren understories. Sometimes there are intermingled mixed conifer/Populus tremuloides stands, with the latter occurring with inclusions of deeper, typically fine-textured soils. In central Oregon, Pseudotsuga menziesii, Pinus ponderosa, and Abies concolor may be present, and Populus tremuloides may be present as small patches. The shrub stratum may be conspicuous to absent; common species include Arctostaphylos uva-ursi, Artemisia tridentata, Juniperus communis, Ceanothus velutinus, Linnaea borealis, Mahonia repens, Purshia tridentata, Spiraea betulifolia, Shepherdia canadensis, Vaccinium scoparium, Symphoricarpos albus, and Ribes spp. Some open stands with very sparse understories can experience a form of mixed-severity burning via cigarette burning along downed logs (insufficient fuels between logs to carry fire). Depending on the arrangement and loading of logs to living trees, either mortality or fire-scarring may occur.

Enumerated_Domain:
Enumerated_Domain_Value: 79
Enumerated_Domain_Value_Definition: California Coastal Closed-Cone Conifer Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
Small occurrences of this system may be found in scattered locations along California's entire coastline and onto the Channel Islands. They are found on marine sedimentary, non-metamorphosed features, often with podsols on sterile sandstone. These forests and woodlands are limited to coastal areas with moderate maritime climate and likely receive more annual precipitation than nearby coastal chaparral. Highly localized endemic tree species include *Cupressus macrocarpa, Cupressus goveniana*, and *Cupressus abramsiana* in scattered groves along coastal Mendocino, San Mateo, Santa Cruz, and Monterey counties. *Pinus contorta var. contorta, Pinus contorta var. bolanderi, Pinus muricata, Pinus torreyana*, and *Pinus radiata* are dominant or codominant in these and other occurrences. These occurrences can also include pygmy woodland expressions where nearly lateritic subsoil underlies acidic sands (ancient marine terraces). Stunted and twisted *Pinus contorta var. contorta* stands along the Oregon coast (often called pygmy forests) are also part of this system. Other associated plant species include *Arctostaphylos nummularia, Ledum groenlandicum, Vaccinium ovatum, Gaultheria shallon, Rhododendron macrophyllum*, and *Morella californica (= Myrica californica).*

The lichen and moss component of this system is very diverse, includes *Cladonia* spp, and can be abundant in these communities.

Enumerated_Domain:
Enumerated_Domain_Value: 80
Enumerated_Domain_Value_Definition: Sierran-Intermontane Desert Western White Pine-White Fir Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This interior Pacific Northwest ecological system occurs on the Modoc Plateau and Warner Mountains of California, north into the Fremont National Forest along the east slope of the southern Cascades in Oregon, and may also occur in isolated high-elevation ranges of northern Nevada. These forests and woodlands range from just above the zone of ponderosa pine in the montane zone, to the upper montane zone. Elevations range from 1370 m to over 2135 m (4500-7000 feet). Occurrences are found on all slopes and aspects, although more frequently on drier areas, including northwest- and southeast-facing slopes, but also occurs on northerly slopes and ridges. This ecological system generally occurs on basalts, andesite, glacial till, basaltic rubble, colluvium, or volcanic ash-derived soils, and sometimes on granitics (Carson Range). These soils have characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, rockiness, and periods of drought during the growing season. Climatically, this system occurs somewhat in the rainshadow of the Sierras and Cascades and has a more continental regime, similar to the northern Great Basin. This system tends to be more woodland than forest in character, and the undergrowth is more open and drier, with little shrub or herbaceous cover. Tree regeneration is less prolific than in other mixed-montane conifer systems of the Cascades, Sierras and California Coast Ranges. *Pinus monticola* is the dominant conifer in most places, but *Abies concolor var. lowiana* is usually present, at least in the understory, and occasionally as the dominant in the canopy, replacing *Pinus monticola*, particularly at lower elevations, and *Pinus ponderosa* is also often present. In the Warner Mountains, the *Abies concolor var. lowiana* stands range from 1675 to 2135 m (5500-7000 feet) in elevation, and the mixed *Pinus monticola - Abies concolor* is usually above 2135 m (7000 feet). Mixed stands with *Pinus contorta*, in moister locations, as well as *Pinus jeffreyi* and sometimes *Populus tremuloides* occasionally occur. Southern stands (around Babbitt Peak and in the Carson Range) can sometime have *Abies magnifica* in them, sometimes replacing *Abies concolor*. These forests and woodlands are marked by the absence of *Pseudotsuga menziesii, Pinus lambertiana*, and *Calocedrus decurrens*, and the generally drier, continental climatic conditions. In addition, the overall floristic affinities are with the Great Basin rather than Pacific Northwest. Understories are typically open, with moderately low shrub cover and diversity, and include *Arctostaphylos patula, Arctostaphylos nevadensis, Chrysolepis sempervirens, Ceanothus* sp., and *Ribes viscosissimum*. Common herbaceous taxa include *Arnica cordifolia, Festuca* sp., *Poa nervosa, Carex inops, Pyrola picta*, and *Hieracium albiflorum*. In openings, *Wyethia mollis* can be abundant.

Enumerated_Domain:
Enumerated_Domain_Value: 81
Enumerated_Domain_Value_Definition: North Pacific Hypermaritime Western Red-cedar-Western Hemlock Forest
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
These forests occupy the outer coastal portions of British Columbia, southeastern Alaska, and Washington. Its center of distribution is the northern coast of British Columbia, as *Thuja plicata* approaches its northernmost limit in the southern half of southeastern Alaska. These forests occur mainly on islands but also fringe the mainland. They are never more than 25 km from saltwater; elevation ranges from 0 to 600 m. The climate is hypermaritime, with cool summers, very wet winters, abundant fog, and without a major snowpack (unlike the western hemlock-silver fir system). These forests very rarely burn and are more influenced by gap disturbance processes and intense windstorms than by fire. The terrain is mostly gentle, of low topographic relief, and often rocky. Soils typically have a distinct humus layer overlying mineral horizons or bedrock, and where the system is best developed in central British Columbia, the humus layers are very thick (mean 17-35 cm). Soils are often imperfectly drained. The forests are often open and scrubby but can be closed. *Thuja plicata* and *Tsuga heterophylla* are the dominant tree species throughout, and *Chamaecyparis nootkatensis* joins them from northern Vancouver Island north. *Pinus contorta* and *Tsuga mertensiana* can be abundant in some locations in the central and northern portion of the range. *Abies amabilis* is widespread (except in southern Washington) and can be common but is not dominant. In Washington, nearly pure stands of *Tsuga heterophylla* are common and seem to be associated with microsites most exposed to intense windstorms. A shrub layer of *Gaultheria shallon, Vaccinium ovalifolium*, and *Menziesia ferruginea* is usually well-developed. The fern *Blechnum spicant* in great abundance is typical of hypermaritime conditions. *Oxalis oregana* is important in the understory of moist sites in Washington. The abundance of *Thuja plicata* in relation to other conifers is one of the diagnostic characters of these forests; the other is the low abundance of *Pseudotsuga menziesii* and *Picea sitchensis*. Where these forests are best developed they occur in a mosaic with forested wetlands, bogs, and Sitka spruce forests (the latter in riparian areas and on steep, more productive soils).

Enumerated_Domain:
Enumerated_Domain_Value: 82
Enumerated_Domain_Value_Definition: North Pacific Dry-Mesic Silver Fir-Western Hemlock-Douglas-fir Forest
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This forested system occurs only in the Pacific Northwest mountains, primarily west of the Cascade Crest. It generally occurs in an elevational band between *Pseudotsuga menziesii - Tsuga heterophylla* forests and *Tsuga mertensiana* forests. It dominates mid-montane dry to mesic maritime and some submaritime climatic zones from northwestern British Columbia to northwestern Oregon. In British Columbia and in the Olympic

Mountains, this system occurs on the leeward side of the mountains only. In the Washington Cascades, it occurs on both windward and leeward sides of the mountains (in other words, it laps over the Cascade Crest to the "eastside"). Stand-replacement fires are regular with mean return intervals of about 200-500 years. Fire frequency tends to decrease with increasing elevation and continentality but still remains within this typical range. A somewhat variable winter snowpack that typically lasts for 2-6 months is characteristic. The climatic zone within which it occurs is sometimes referred to as the "rain-on-snow" zone because of the common occurrence of major winter rainfall on an established snowpack. *Tsuga heterophylla* and/or *Abies amabilis* dominate the canopy of late-seral stands, though *Pseudotsuga menziesii* is usually also common because of its long life span, and *Chamaecyparis nootkatensis* can be codominant, especially at higher elevations. *Abies procera* forests (usually mixed with silver fir) are included in this system and occur in the Cascades from central Washington to central Oregon and rarely in the Coast Range of Oregon. *Pseudotsuga menziesii* is a common species (unlike the mesic western hemlock-silver fir forest system) that regenerates after fires and therefore is frequent as a codominant, except at the highest elevations; the prevalence of this species is an important indicator in relation to the related climatically wetter North Pacific Mesic Western Hemlock-Silver Fir Forest (CES204.097). *Abies lasiocarpa* sometimes occurs as a codominant on the east side of the Cascades and in submaritime British Columbia. Understory species that tend to be more common or unique in this type compared to the wetter North Pacific Mesic Western Hemlock-Silver Fir Forest (CES204.097) include *Achlys triphylla, Mahonia nervosa, Xerophyllum tenax, Vaccinium membranaceum, Rhododendron macrophyllum*, and *Rhododendron albiflorum*. *Vaccinium ovalifolium*, while still common, only dominates on more moist sites within this type, unlike in the related type where it is nearly ubiquitous.

Enumerated_Domain:
Enumerated_Domain_Value: 83
Enumerated_Domain_Value_Definition: East Cascades Oak-Ponderosa Pine Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This narrowly restricted ecological system appears at or near lower treeline in foothills of the eastern Cascades in Washington and Oregon within 65 km (40 miles) of the Columbia River Gorge. It also appears in the adjacent Columbia Plateau ecoregion. Elevations range from 460 to 1920 m. Most occurrences of this system are dominated by a mix of *Quercus garryana* and *Pinus ponderosa* or *Pseudotsuga menziesii*. Isolated, taller *Pinus ponderosa* or *Pseudotsuga menziesii* over *Quercus garryana* trees characterize parts of this system. Clonal *Quercus garryana* can create dense patches across a grassy landscape or can dominate open woodlands or savannas. The understory may include dense stands of shrubs or, more often, be dominated by grasses, sedges or forbs. Shrub-steppe shrubs may be prominent in some stands and create a distinct tree / shrub / sparse grassland habitat, including *Purshia tridentata, Artemisia tridentata, Artemisia nova*, and *Chrysothamnus viscidiflorus*. Understories are generally dominated by herbaceous species, especially graminoids. Mesic sites have an open to closed sodgrass understory

dominated by *Calamagrostis rubescens, Carex geyeri, Carex rossii, Carex inops*, or *Elymus glaucus*. Drier savanna and woodland understories typically contain bunchgrass steppe species such as *Festuca idahoensis* or *Pseudoroegneria spicata*. Common exotic grasses that often appear in high abundance are *Bromus tectorum* and *Poa bulbosa*. These woodlands occur at the lower treeline/ecotone between *Artemisia* spp. or *Purshia tridentata* steppe or shrubland and *Pinus ponderosa* and/or *Pseudotsuga menziesii* forests or woodlands. In the Columbia River Gorge, this system appears as small to large patches in transitional areas in the Little White Salmon and White Salmon river drainages in Washington and Hood River, Rock Creek, Moiser Creek, Mill Creek, Threemile Creek, Fifteen Mile Creek, and White River drainages in Oregon. *Quercus garryana* can create dense patches often associated with grassland or shrubland balds within a closed *Pseudotsuga menziesii* forest landscape. Commonly the understory is shrubby and composed of *Ceanothus integerrimus, Holodiscus discolor, Symphoricarpos albus*, and *Toxicodendron diversilobum*. Fire plays an important role in creating vegetation structure and composition in this habitat. Decades of fire suppression have led to invasion by *Pinus ponderosa* along lower treeline and by *Pseudotsuga menziesii* in the gorge and other oak patches on xeric sites in the east Cascade foothills. In the past, most of the habitat experienced frequent low-severity fires that maintained woodland or savanna conditions. The mean fire-return interval is 20 years, although variable. Soil drought plays a role, maintaining an open tree canopy in part of this dry woodland habitat.

Enumerated_Domain:
Enumerated_Domain_Value: 84
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Aspen Mixed Conifer Forest-Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
Small occurrences of this system may be found in scattered locations along California's entire coastline and onto the Channel Islands. They are found on marine sedimentary, non-metamorphosed features, often with podsols on sterile sandstone. These forests and woodlands are limited to coastal areas with moderate maritime climate and likely receive more annual precipitation than nearby coastal chaparral. Highly localized endemic tree species include *Cupressus macrocarpa, Cupressus goveniana*, and *Cupressus abramsiana* in scattered groves along coastal Mendocino, San Mateo, Santa Cruz, and Monterey counties. *Pinus contorta var. contorta, Pinus contorta var. bolanderi, Pinus muricata, Pinus torreyana*, and *Pinus radiata* are dominant or codominant in these and other occurrences. These occurrences can also include pygmy woodland expressions where nearly lateritic subsoil underlies acidic sands (ancient marine terraces). Stunted and twisted *Pinus contorta var. contorta* stands along the Oregon coast (often called pygmy forests) are also part of this system. Other associated plant species include *Arctostaphylos nummularia, Ledum groenlandicum, Vaccinium ovatum, Gaultheria shallon, Rhododendron macrophyllum*, and *Morella californica (= Myrica californica).* The lichen and moss component of this system is very diverse, includes *Cladonia* spp, and can be abundant in these communities.

Enumerated_Domain:
Enumerated_Domain_Value: 85
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs in hills and mountain ranges of the Intermountain West basins from the eastern foothills of the Sierra Nevada northeast to the foothills of the Bighorn Mountains. It typically occurs from 600 m to over 2650 m in elevation on rocky outcrops or escarpments and forms small- to large-patch stands in forested areas. Most stands occur as shrublands on ridges and steep rimrock slopes, but they may be composed of small trees in steppe areas. Scattered junipers or pines may also occur. This system includes both woodlands and shrublands dominated by *Cercocarpus ledifolius*. *Artemisia tridentata ssp. vaseyana, Purshia tridentata*, with species of *Arctostaphylos, Ribes*, or *Symphoricarpos* are often present. Undergrowth is often very sparse and dominated by bunch grasses, usually *Pseudoroegneria spicata* and *Festuca idahoensis*. *Cercocarpus ledifolius* is a slow-growing, drought-tolerant species that generally does not resprout after burning and needs the protection from fire that rocky sites provide.

Enumerated_Domain:
Enumerated_Domain_Value: 86
Enumerated_Domain_Value_Definition: North Pacific Broadleaf Landslide Forest and Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
These forests and shrublands occur throughout the northern Pacific mountains and lowlands, becoming less prominent in the northern half of this region. They occur on steep slopes and bluffs that are subject to mass movements on a periodic basis. They are found in patches of differing age associated with different landslide events. The vegetation is deciduous broadleaf forests, woodlands, or shrublands, sometimes with varying components of conifers. *Alnus rubra* and *Acer macrophyllum* are the major tree species. *Rubus spectabilis, Rubus parviflorus, Ribes bracteosum*, and *Oplopanax horridus* are some of the major shrub species. Shrublands tend to be smaller in extent than woodlands or forests. Small patches of sparsely vegetated areas or herbaceous-dominated vegetation (especially *Petasites frigidus*) also often occur as part of this system. On earthflows, once stable, vegetation may succeed to dominance by conifers.

Enumerated_Domain:
Enumerated_Domain_Value: 87
Enumerated_Domain_Value_Definition: Western Great Plains Wooded Draw and Ravine
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is typically found associated with permanent or ephemeral streams and may occur on steep northern slopes or within canyon bottoms that do not experience periodic flooding, although soil moisture and topography allow greater than

normal moisture conditions compared to the surrounding areas. Occurrences can be either tree-dominated or predominantly shrubland. *Fraxinus* spp. with *Ulmus rubra* or *Ulmus americana* typically dominate this system, although in some areas of the western Great Plains steppe province, *Juniperus scopulorum* can dominate the canopy. *Populus tremuloides, Betula papyrifera*, or *Acer negundo* are commonly present in portions of the northwestern Great Plains, for example in areas of central and eastern Montana. In south-central portions of the Great Plains, *Quercus macrocarpa* can also be present. Component shrubs can include *Cornus sericea, Crataegus douglasii, Crataegus chrysocarpa, Crataegus succulenta, Elaeagnus commutata, Prunus virginiana, Rhus* spp., *Rosa woodsii, Shepherdia argentea, Symphoricarpos occidentalis*, or *Viburnum lentago*. Common grasses can include *Calamagrostis stricta, Carex* spp., *Pascopyrum smithii, Piptatherum micranthum, Pseudoroegneria spicata*, or *Schizachyrium scoparium*. This system was often subjected to heavy grazing and trampling by both domestic animals and wildlife and can be heavily degraded in some areas. In addition, exotic species such as *Ulmus pumila* and *Elaeagnus angustifolia* can invade these systems.

Enumerated_Domain:
Enumerated_Domain_Value: 88
Enumerated_Domain_Value_Definition: North Pacific Wooded Volcanic Flowage
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is found from foothill to subalpine elevations and includes woodland to sparsely vegetated landscapes (generally >10% plant cover) on recent lava flows, excessively well-drained lahars, debris avalanches and pyroclastic flows. The characteristic feature of this system is the substrate limiting characteristic that creates an environment for a more open vegetation than the surrounding closed matrix forest. Examples are recent lava flows (3500-8200 years ago) on the north side of Mount Adams (andecite) and the big lava beds (basalt) south of Indian Heaven west of Mount Adams, Washington, and lahars (200-2000 years old) at Old Maid Flat west of Mount Hood, Oregon. These areas support open to sparse tree cover; characteristic species include *Pseudotsuga menziesii, Pinus contorta, Pinus monticola*, and *Abies lasiocarpa*. Tree cover can range from scattered (5%) up to 70% or occasionally even more. There may be scattered to dense shrubs present, such as *Acer circinatum, Vaccinium membranaceum, Arctostaphylos uva-ursi* (very characteristic), *Mahonia nervosa, Amelanchier alnifolia*, and *Xerophyllum tenax*. Soil development is limited, and mosses and lichens often cover the soil or rock surface.

Enumerated_Domain:
Enumerated_Domain_Value: 89
Enumerated_Domain_Value_Definition: North Pacific Lowland Mixed Hardwood Conifer Forest and Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
These Lowland mixed hardwood – conifer forested systems occur throughout the Pacific Northwest. They occur on valley terraces, margins, and slopes at low elevations in the

mountains of the Pacific Northwest Coast and interior valleys west of the high Cascade Mountains. These forests are composed of large conifers, including *Pseudotsuga menziesii, Thuja plicata, Abies grandis, Tsuga heterophylla* and/or *Picea sitchensis*, with deciduous hardwood trees present and usually codominant. Cover of deciduous hardwoods ranges from 20 – 70%. Major broadleaf dominant species are *Acer macrophyllum, Quercus garryana, Alnus rubra, Frangula purshiana, and Cornus nuttalii*. Conifers tend to increase with succession in the absence of major disturbance, although the hardwoods, particularly *Acer macrophyllum*, persists in the overstory. The understory often is characterized by deciduous shrubs such as *Acer circinatum, Corylus cornuta, Oemleria ceraasiformus, Rubus ursinus, Symphoricarpos albus* and *Toxicododendron diversilobum*, but evergreen shrubs (*Gaultheria shallon, Mahonia nervosa*) and forbs (*Polystichum munitum, Oxalis oregana*) can be dominant.

Enumerated_Domain:
Enumerated_Domain_Value: 90
Enumerated_Domain_Value_Definition: Columbia Plateau Scabland Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is found in the Columbia Plateau region and forms extensive low shrublands. These xeric shrublands occur under relatively extreme soil-moisture conditions. Substrates are typically shallow lithic soils with limited water-holding capacity over fractured basalt. Because of poor drainage through basalt, these soils are often saturated from fall to spring by winter precipitation but typically dry out completely to bedrock by midsummer. Total vegetation cover is typically low, generally less than 50% and often much less than that. Vegetation is characterized by an open dwarf-shrub canopy dominated by *Artemisia rigida* along with other shrub and dwarf-shrub species, particularly *Eriogonum* spp. Other shrubs are uncommon in this system; mixes of *Artemisia rigida* and other *Artemisia* species typically belong to different ecological systems than this. Low cover of perennial bunch grasses, such as *Danthonia unispicata, Elymus elymoides, Festuca idahoensis*, or primarily *Poa secunda*, as well as scattered forbs, including species of *Allium, Antennaria, Balsamorhiza, Lomatium, Phlox*, and *Sedum*, characterize these sites. Individual sites can be dominated by grasses and semi-woody forbs, such as *Stenotus stenophyllus*. Annuals may be seasonally abundant, and cover of moss and lichen is often high in undisturbed areas (1-60% cover).

Enumerated_Domain:
Enumerated_Domain_Value: 91
Enumerated_Domain_Value_Definition: Inter-Mountian Basins Mat Saltbrush Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs on gentle slopes and rolling plains in the northern Colorado Plateau and Uinta Basin on Mancos shale and arid, windswept basins and plains across parts of Wyoming. It is also found in eastern Wyoming in Great Plains areas, and may extend north into Montana and Canada. Substrates are shallow, typically saline, alkaline, fine-textured soils developed from shale or alluvium and may be associated with

shale badlands. Infiltration rate is typically low. These landscapes typically support dwarf-shrublands composed of relatively pure stands of Atriplex spp., such as Atriplex corrugata (in Colorado and Utah) or Atriplex gardneri (Wyoming and Montana into Canada). Other dominant or codominant dwarf-shrubs may include Artemisia longifolia, Artemisia pedatifida (very important in Wyoming, rare in Colorado stands), or Picrothamnus desertorum, sometimes with a mix of other low shrubs, such as Krascheninnikovia lanata or Tetradymia spinosa. Atriplex confertifolia or Atriplex canescens may be present but do not codominate. Artemisia tridentata ssp. wyomingensis can occur in patches within this system. The herbaceous layer is typically sparse. Scattered perennial forbs occur, such as Xylorhiza glabriuscula and Sphaeralcea grossulariifolia; perennial grasses Achnatherum hymenoides, Bouteloua gracilis (not in Wyoming), Elymus elymoides, Elymus lanceolatus ssp. lanceolatus, Pascopyrum smithii, Poa secunda, or Sporobolus airoides may dominate the herbaceous layer. In less saline areas, there may be inclusions of grasslands dominated by Hesperostipa comata, Leymus salinus, Pascopyrum smithii, or Pseudoroegneria spicata. In Wyoming and possibly elsewhere, inclusions of non-saline, gravelly barrens or rock outcrops dominated by cushion plants such as Arenaria hookeri and Phlox hoodii without dwarf-shrubs may be present (these are not restricted to this system). Annuals are seasonally present and may include Eriogonum inflatum, Plantago tweedyi, Monolepis nuttalliana, and the introduced annual grass Bromus tectorum. In Montana, Atriplex gardneri also occurs associated with badlands, and determining which system it falls into may be difficult.

Enumerated_Domain:
Enumerated_Domain_Value: 92
Enumerated_Domain_Value_Definition: Mediterranean California Alpine Fell-Field
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs in limited alpine environments mostly concentrated in the Sierra Nevada but also on Mount Shasta and as far south as the Peninsular Ranges and White Mountains. Alpine elevations begin around 3500 m (10,600 feet) in the southern mountain ranges and 2700 m (8200 feet) in the southern Cascades. Wind scours fell-fields free of snow in the winter, exposing the plants to severe environmental stress. These systems typically have immature soils. Most fell-field plants are cushioned or matted, frequently succulent, flat to the ground in rosettes, and often densely hairy and thickly cutinized. Common species include *Ribes cereum, Leptodactylon pungens, Ericameria discoidea, Castilleja nana, Minuartia nuttallii (= Arenaria nuttallii), Phlox condensata, Draba densifolia, Oxyria digyna*, and *Aquilegia pubescens*. Plants cover 15-50%, while exposed rock makes up the rest. Fell-fields are usually nested within or adjacent to alpine tundra dry meadows.

Enumerated_Domain:
Enumerated_Domain_Value: 93
Enumerated_Domain_Value_Definition: North Pacific Dry and Mesic Alpine Dwarf-Shrubland, Fell-field and Meadow

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system occurs above the environmental limit of trees, at the highest elevations of the mountain regions of the Pacific Northwest Coast. It is confined to the coldest, wind-blown areas above treeline and above the subalpine parkland. This system is found at elevations above 2350 m (7200 feet) in the Klamath Mountains and Cascades north into the Cascade and Coastal mountains of British Columbia. It is commonly comprised of a mosaic of plant communities with characteristic species including *Cassiope mertensiana, Phyllodoce empetriformis, Phyllodoce glanduliflora, Luetkea pectinata, Saxifraga tolmiei*, and *Carex* spp. It occurs on slopes and depressions where snow lingers, the soil has become relatively stabilized, and the water supply is more or less constant. Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost, and a short growing season. This system includes all vegetated areas in the alpine zone of the North Pacific. Typically it is a mosaic of dwarf-shrublands, fell-fields, tundra (sedge turfs), and sparsely vegetated snowbed communities. Small patches of krummholz (shrub-form trees) are also part of this system and occur at the lower elevations. Communities are dominated by graminoids, foliose lichens, dwarf-shrubs, and/or forbs. Vegetation cover ranges from about 5 or 10% (snowbeds) to nearly 100%. The alpine tundra of the northern Cascades has floristic affinities with many mountain regions in western North America. The strongest relationships are with the Arctic and Cordilleran regions to the north and east.

Enumerated_Domain:
Enumerated_Domain_Value: 94
Enumerated_Domain_Value_Definition: Rocky Mountain Alpine Dwarf Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This widespread ecological system occurs above upper timberline throughout the Rocky Mountain cordillera, including alpine areas of ranges in Utah and Nevada, and north into Canada. Elevations are above 3360 m in the Colorado Rockies but drop to less than 2100 m in northwestern Montana and in the mountains of Alberta. This system occurs in areas of level or concave glacial topography, with late-lying snow and subirrigation from surrounding slopes. Soils have become relatively stabilized in these sites, are moist but well-drained, strongly acidic, and often with substantial peat layers. Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost, and a short growing season. This ecological system is characterized by a semi-continuous layer of ericaceous dwarf-shrubs or dwarf willows which form a heath type ground cover less than 0.5 m in height. Dense tuffs of graminoids and scattered forbs occur. Dryas octopetala or Dryas integrifolia communities are not included here, except for one very moist association, because they occur on more windswept and drier sites than the heath communities. Within these communities. Cassiope mertensiana, Salix arctica, Salix reticulata, Salix vestita, or Phyllodoce empetriformis can be dominant shrubs. Vaccinium spp., Ledum glandulosum, Phyllodoce glanduliflora, and Kalmia microphylla may also be shrub associates. The herbaceous layer is a mixture of forbs and graminoids, especially sedges, including, Erigeron spp., Luetkea pectinata, Antennaria lanata, Oreostemma alpigenum

(= Aster alpigenus), Pedicularis spp., Castilleja spp., Deschampsia caespitosa, Caltha leptosepala, Erythronium spp., Juncus parryi, Luzula piperi, Carex spectabilis, Carex nigricans, and Polygonum bistortoides. Fellfields often intermingle with the alpine dwarf-shrubland.

Enumerated_Domain:
Enumerated_Domain_Value: 95
Enumerated_Domain_Value_Definition: Wyoming Basins Low Sagebrush Shrubland/WY Basins Dwarf Sagebrush Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This windswept ecological system is composed of dwarf sagebrush shrubland and shrub-steppe that forms matrix vegetation and large patches on the margins of high-elevation basins in central and southern Wyoming. Typical sites are gently rolling hills and long, gently sloping pediments and fans. These sites are very windy and have shallow, often rocky soils. The distinguishing feature of this system is a short-shrub stratum in which dwarf-shrubs (<30 cm tall) contribute at least two-thirds of the woody canopy. Four sagebrush taxa may dominate the shrub stratum: Artemisia tripartita ssp. rupicola, Artemisia nova, Artemisia arbuscula ssp. longiloba, and wind-dwarfed Artemisia tridentata ssp. wyomingensis. Two or more of these sagebrushes often codominate, but any of them may occur alone. Where graminoids are common and tall, the vegetation often has the appearance of grassland without shrubs; the shrubs are obvious only when the vegetation is viewed from up close. Where graminoids contribute less cover, the vegetation is a compact shrubland. The herbaceous component of the vegetation includes both rhizomatous and bunch-form graminoids, cushion plants, and other low-growing forbs. Bouteloua gracilis, a common species of Inter-Mountain Basins Big Sagebrush Steppe (CES304.778) in Wyoming, is absent.

Enumerated_Domain:
Enumerated_Domain_Value: 96
Enumerated_Domain_Value_Definition: Great Basin Xeric Mixed Sagebrush Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs in the Great Basin on dry flats and plains, alluvial fans, rolling hills, rocky hillslopes, saddles and ridges at elevations between 1000 and 2600 m. Sites are dry, often exposed to desiccating winds, with typically shallow, rocky, non-saline soils. Shrublands are dominated by *Artemisia nova* (mid and low elevations), *Artemisia arbuscula ssp. longicaulis*, or *Artemisia arbuscula ssp. longiloba* (higher elevation) and may be codominated by *Artemisia tridentata ssp. wyomingensis* or *Chrysothamnus viscidiflorus*. Other shrubs that may be present include *Atriplex confertifolia, Ephedra* spp., *Ericameria* spp., *Grayia spinosa, Lycium shockleyi, Picrothamnus desertorum, Sarcobatus vermiculatus*, and *Tetradymia* spp. The herbaceous layer is likely sparse and composed of perennial bunch grasses, such as *Achnatherum hymenoides, Achnatherum speciosum, Achnatherum thurberianum, Elymus elymoides*, or *Poa secunda*.

Enumerated_Domain:
Enumerated_Domain_Value: 97
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Big Sagebrush Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs throughout much of the western U.S., typically in broad basins between mountain ranges, plains and foothills between 1500 and 2300 m elevation. Soils are typically deep, well-drained and non-saline. These shrublands are dominated by *Artemisia tridentata ssp. tridentata* (not as common in Wyoming or Montana but possibly on stabilized part of Killpecker Dunes in Wyoming) and/or *Artemisia tridentata ssp. wyomingensis* (predominant in Wyoming and Montana). Scattered *Juniperus* spp., *Sarcobatus vermiculatus*, and *Atriplex* spp. may be present in some stands. *Ericameria nauseosa, Chrysothamnus viscidiflorus, Purshia tridentata* (not commonly in Montana or Wyoming), or *Symphoricarpos oreophilus* may codominate disturbed stands (e.g., in burned stands, these may become more predominant). Perennial herbaceous components typically contribute less than 25% vegetative cover. Common graminoid species can include *Achnatherum hymenoides, Bouteloua gracilis, Elymus lanceolatus, Festuca idahoensis* (not in Montana or Wyoming), *Hesperostipa comata, Leymus cinereus, Pleuraphis jamesii* (not present in northeastern portions of the range), *Pascopyrum smithii, Poa secunda*, or *Pseudoroegneria spicata* (not in Wyoming). Some semi-natural communities are included that often originate on abandoned agricultural land or on other disturbed sites. In these locations, *Bromus tectorum* or other annual bromes and invasive weeds can be abundant. Most *Artemisia tridentata ssp. wyomingensis* communities in Wyoming are placed in Inter-Mountain Basins Big Sagebrush Steppe (CES304.778); the shrubland system is more restricted in environmental setting than the steppe. Dunes in the Red Desert have areas of large basin big sage with very dense canopies. In Wyoming, this system is likely to only contain *Artemisia tridentata ssp. tridentata*.

Enumerated_Domain:
Enumerated_Domain_Value: 98
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Mixed Salt Desert Scrub
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This extensive ecological system includes open-canopied shrublands of typically saline basins, alluvial slopes and plains across the Intermountain western U.S. This type also extends in limited distribution into the southern Great Plains. Substrates are often saline and calcareous, medium- to fine-textured, alkaline soils, but include some coarser-textured soils. The vegetation is characterized by a typically open to moderately dense shrubland composed of one or more *Atriplex* species, such as *Atriplex confertifolia, Atriplex canescens, Atriplex polycarpa*, or *Atriplex spinifera*. *Grayia spinosa* tends to occur on coppice dunes that may have a silty component to them. Northern occurrences lack *Atriplex* species and are typically dominated by *Grayia spinosa, Krascheninnikovia*

lanata, and/or *Artemisia tridentata*. Other shrubs present to codominant may include *Artemisia tridentata ssp. wyomingensis, Chrysothamnus viscidiflorus, Ericameria nauseosa, Ephedra nevadensis, Grayia spinosa, Krascheninnikovia lanata, Lycium* spp., *Picrothamnus desertorum*, or *Tetradymia* spp. In Wyoming, occurrences are typically a mix of *Atriplex confertifolia, Grayia spinosa, Artemisia tridentata ssp. wyomingensis, Sarcobatus vermiculatus, Krascheninnikovia lanata*, and various *Ericameria* or *Chrysothamnus* species. Some places are a mix of *Atriplex confertifolia* and *Artemisia tridentata ssp. wyomingensis*. In the Great Basin, *Sarcobatus vermiculatus* is generally absent but, if present, does not codominate. The herbaceous layer varies from sparse to moderately dense and is dominated by perennial graminoids such as *Achnatherum hymenoides, Bouteloua gracilis, Elymus lanceolatus ssp. lanceolatus, Pascopyrum smithii, Pleuraphis jamesii, Pleuraphis rigida, Poa secunda*, or *Sporobolus airoides*. Various forbs are also present

Enumerated_Domain:
Enumerated_Domain_Value: 99
Enumerated_Domain_Value_Definition: North Pacific Avalanche Chute Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This tall shrubland system occurs throughout mountainous regions of the Pacific Northwest, from the southern Cascades and Coast Ranges north to south-central Alaska. This system occurs on sideslopes of mountains on glacial till or colluvium. These habitats range from moderately xeric to wet and occur on snow avalanche chutes at montane elevations. In the mountains of Washington, talus sites and snow avalanche chutes very often coincide spatially. On the west side of the Cascades, the major dominant species are *Acer circinatum, Alnus viridis ssp. sinuata, Rubus parviflorus*, and small trees, especially *Chamaecyparis nootkatensis*. Forbs, grasses, or other shrubs can also be locally dominant. *Prunus virginiana, Amelanchier alnifolia, Vaccinium membranaceum* or *Vaccinium scoparium*, and *Fragaria* spp. are common species on drier avalanche tracks on the east side of the Cascades (Ecosystems Working Group 1998). The main feature of this system is that it occurs on steep, frequently disturbed (snow avalanches) slopes. Avalanche chutes can be quite long, extending from the subalpine into the montane and foothill toeslopes.

Enumerated_Domain:
Enumerated_Domain_Value: 100
Enumerated_Domain_Value_Definition: North Pacific Montane Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system occurs as small to large patches scattered throughout the North Pacific region, but it is largely absent from the windward sides of the coastal mountains where fires are rare due to very wet climates. It is defined as long-lived seral shrublands that persist for several decades or more after major wildfires, or smaller patches of shrubland on dry sites that are marginal for tree growth and that have typically also experienced fire. This system occurs on ridgetops and upper to middle mountain slopes and is more

common on sunny southern aspects. It occurs from about 152 m (500 feet) elevation up to the lower limits of subalpine parkland. Vegetation is mostly deciduous broadleaf shrubs, sometimes mixed with shrub-statured trees or sparse evergreen needleleaf trees. It can also be dominated by evergreen shrubs, especially *Xerophyllum tenax* (usually considered a forb). Species composition is highly variable; some of most common species include *Acer circinatum, Arctostaphylos nevadensis, Acer glabrum, Vaccinium membranaceum, Ceanothus velutinus, Holodiscus discolor, Shepherdia canadensis, Sorbus* spp., and *Rubus parviflorus*. On the west side of the Cascades, *Gaultheria shallon* is an important dominant.

Enumerated_Domain:
Enumerated_Domain_Value: 101
Enumerated_Domain_Value_Definition: Northwestern Great Plains Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system ranges from South Dakota into southern Canada on moderately shallow to deep, fine to sandy loam soils. These sites are typically more mesic than most of the surrounding area. This system may be located along upper terraces of rivers and streams, gently inclined slopes near breaklands, and upland sandy loam areas throughout its range. This system is dominated by shrub species such as *Amelanchier alnifolia, Rhus trilobata, Symphoricarpos* spp., *Shepherdia argentea, Crataegus douglasii, Elaeagnus commutata, Dasiphora fruticosa ssp. floribunda*, and dwarf-shrubs such as *Juniperus horizontalis*. Midgrasses such as *Festuca* spp., *Koeleria macrantha*, and *Pseudoroegneria spicata* and species such as *Carex filifolia* can co-occur. This system differs from Northwestern Great Plains Mixedgrass Prairie (CES303.674) in that it contains greater than 10% cover in conjunction with topographic relief (breaks) of natural shrub species. Fire and grazing constitute the primary dynamics affecting this system; drought can also impact this system. This system may include areas of Northwestern Great Plains Mixedgrass Prairie (CES303.674) where fire suppression has allowed for a greater cover of shrub species. This system is similar to Northern Rocky Mountain Montane-Foothill Deciduous Shrubland (CES306.994) but occurs in the grassland matrix of the Great Plains, whereas the Rocky Mountain system occurs adjacent to the lower treeline of generally forested mountains and highlands. Floristically their shrub composition is similar, but associated grasses and forbs will differ somewhat given their respective adjacent vegetation types.

Enumerated_Domain:
Enumerated_Domain_Value: 102
Enumerated_Domain_Value_Definition: Rocky Mountain Lower Montane Foothill Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is found in the foothills, canyon slopes and lower mountains of the Rocky Mountains and on outcrops and canyon slopes in the western Great Plains. It ranges from southern New Mexico, extending north into Wyoming, and west into the

Intermountain West region. These shrublands occur between 1500 and 2900 m elevation and are usually associated with exposed sites, rocky substrates, and dry conditions, which limit tree growth. It is common where *Quercus gambelii* is absent, such as the northern Colorado Front Range and in drier foothills and prairie hills. This system is generally drier than Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818) but may include mesic montane shrublands where *Quercus gambelii* does not occur. *Cercocarpus montanus* dominates pure stands in parts of Wyoming and Colorado. Scattered trees or inclusions of grassland patches or steppe may be present, but the vegetation is typically dominated by a variety of shrubs, including *Amelanchier utahensis, Cercocarpus montanus, Purshia tridentata, Rhus trilobata, Ribes cereum, Symphoricarpos oreophilus*, or *Yucca glauca*. Grasses are represented as species of *Muhlenbergia, Bouteloua, Hesperostipa*, and *Pseudoroegneria spicata*. Fires play an important role in this system as the dominant shrubs usually have a severe die-back, although some plants will stump sprout. *Cercocarpus montanus* requires a disturbance such as fire to reproduce, either by seed sprout or root-crown sprouting. Fire suppression may have allowed an invasion of trees into some of these shrublands, but in many cases sites are too xeric for tree growth. In Wyoming, stands where *Cercocarpus montanus* is a component of mixed shrublands are placed in Northern Rocky Mountain Montane-Foothill Deciduous Shrubland (CES306.994).

Enumerated_Domain:
Enumerated_Domain_Value: 103
Enumerated_Domain_Value_Definition: California Montane Woodland and Chaparral
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system includes chaparral or open shrubby woodlands found among montane forests above 1500 m (4550 feet) elevation from the southern Cascades of Oregon to the Peninsular Ranges of California into Baja California, Mexico, where much annual precipitation occurs as snow. These are often locations with steep, exposed slopes with rocky and/or shallow soils, often glaciated. These are mosaics of woodlands with chaparral understories, shrub-dominated chaparral, or short-lived chaparral with conifer species invading if good seed source is available. Shrubs will often have higher densities than the trees which are more limited due to the rocky/thin soils. These can also be short-duration chaparrals in previously forested areas that have experienced crownfires. Trees tend to have a scattered open canopy or can be clustered, over a usually continuous dense shrub layer. Trees can include *Pinus jeffreyi, Abies concolor, Abies magnifica, Pinus monticola, Pinus lambertiana, Pinus coulteri, Pinus attenuata, Cupressus forbesii, Cupressus arizonica ssp. stephensonii*, and *Cupressus arizonica ssp. nevadensis (= Cupressus nevadensis)*. Typical sclerophyllous chaparral shrubs include *Arctostaphylos nevadensis, Arctostaphylos patula, Arctostaphylos glandulosa, Ceanothus cordulatus, Ceanothus diversifolius, Ceanothus pinetorum, Ceanothus velutinus*, and *Chrysolepis sempervirens (= Castanopsis sempervirens)*. Some stands can be dominated by winter deciduous shrubs, such as *Prunus emarginata, Prunus subcordata* and *Ceanothus sanguineus* (in Oregon), *Prunus virginiana, Ceanothus integerrimus, Holodiscus discolor (= Holodiscus microphyllus)*, and *Quercus garryana var. breweri*. Most chaparral species

are fire-adapted, resprouting vigorously after burning or producing fire-resistant seeds. Occurrences of this system likely shift across montane forested landscapes with catastrophic fire events.

Enumerated_Domain:
Enumerated_Domain_Value: 104
Enumerated_Domain_Value_Definition: California Xeric Serpentine Chaparral
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs throughout Mediterranean California (excluding far southern California) on thin, rocky, ultramafic (gabbro, peridotite, serpentinite) soils and in areas below winter snow accumulations that typically experience hot and dry summers. Not all ultramafic outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. This system is highly variable and spotty in distribution. Characteristic plant species include *Cupressus macnabiana, Quercus durata, Arctostaphylos viscida, Arctostaphylos pungens*, and *Arctostaphylos glauca*. Common associates include *Adenostoma fasciculatum, Ceanothus cuneatus, Fremontodendron californicum, Quercus sadleriana, Quercus vacciniifolia, Garrya* spp., *Umbellularia californica, Ceanothus pumilus, Frangula californica (= Rhamnus californica)*, and *Arctostaphylos nevadensis*. California endemics such as *Ceanothus jepsonii* also occur. *Pinus sabiniana* can occur at varying cover from trace to more abundant. Many locally endemic and often rare forbs can occur, such as *Streptanthus* spp., *Hesperolinon* spp., *Eriogonum* spp., *Madia* spp., *Mimulus* spp., *Allium* spp., and *Asclepias solanoana*. This chaparral type tends to have fewer trees than mesic chaparral.

Enumerated_Domain:
Enumerated_Domain_Value: 105
Enumerated_Domain_Value_Definition: Great Basin Semi-Desert Chaparral
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system includes chaparral on sideslopes transitioning from low-elevation desert landscapes up into pinyon-juniper woodlands of the western and central Great Basin. There are limited occurrences extending as far west as the inner Coast Ranges in central California. These are typically fairly open-canopy shrublands with open spaces either bare or supporting patchy grasses and forbs. Characteristic species may include *Arctostaphylos patula, Arctostaphylos pungens, Ceanothus greggii, Ceanothus velutinus, Cercocarpus montanus var. glaber, Cercocarpus intricatus, Eriogonum fasciculatum, Garrya flavescens, Quercus turbinella, Purshia stansburiana*, and *Rhus trilobata*. *Cercocarpus ledifolius* is generally absent. Typical fire regime in these systems varies with the amount of organic accumulation.

Enumerated_Domain:
Enumerated_Domain_Value: 106
Enumerated_Domain_Value_Definition: Northern and Central California Dry-Mesic Chaparral

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system includes chaparral typically located inland from maritime chaparral up to 1500 m (4550 feet) elevation in central and northern California through the northern end of the Central Valley and north into Oregon. This system includes extensive areas on coarse-grained soils with annual precipitation up to 75 cm (winter rain but not snow). Adjacent fine-textured soils support savanna under similar climatic regimes. These areas have supported extensive stand-replacing wildfires. This system is made up of a mixture of mostly obligate seeders. Characteristic species include *Adenostoma fasciculatum, Ceanothus cuneatus, Arctostaphylos viscida, Arctostaphylos manzanita, Arctostaphylos glauca, Arctostaphylos glandulosa, Arctostaphylos stanfordiana, Fremontodendron californicum, Malacothamnus fasciculatus, Dendromecon rigida*, and *Pickeringia montana*. Common shrubs in Oregon include *Arctostaphylos viscida, Cercocarpus montanus var. glaber*, and *Ceanothus cordulatus*. Fire regimes are intense, stand-replacing crownfires.

Enumerated_Domain:
Enumerated_Domain_Value: 107
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Montane-Foothill Deciduous Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This shrubland ecological system is found in the lower montane and foothill regions around the Columbia Basin, and north and east into the northern Rockies. These shrublands typically occur below treeline, within the matrix of surrounding low-elevation grasslands and sagebrush shrublands. They also occur in the ponderosa pine and Douglas-fir zones, but rarely up into the subalpine zone (on dry sites). The shrublands are usually found on steep slopes of canyons and in areas with some soil development, either loess deposits or volcanic clays; they occur on all aspects. Fire, flooding and erosion all impact these shrublands, but they typically will persist on sites for long periods. These communities develop near talus slopes as garlands, at the heads of dry drainages, and toeslopes in the moist shrub-steppe and steppe zones. *Physocarpus malvaceus, Prunus emarginata, Prunus virginiana, Rosa* spp., *Rhus glabra, Acer glabrum, Amelanchier alnifolia, Symphoricarpos albus, Symphoricarpos oreophilus*, and *Holodiscus discolor* are the most common dominant shrubs, occurring alone or any combination. *Rubus parviflorus* and *Ceanothus velutinus* are other important shrubs in this system, being more common in montane occurrences than in subalpine situations. Occurrences in central and eastern Wyoming can include *Artemisia tridentata ssp. vaseyana* and *Cercocarpus montanus*, but neither of these are dominant, and where they occur, the stands are truly mixes of shrubs, often with *Amelanchier alnifolia, Prunus virginiana*, and others being the predominant taxa. In moist areas, *Crataegus douglasii* can be common. *Shepherdia canadensis* and *Spiraea betulifolia* can be abundant in some cases but also occur in Northern Rocky Mountain Subalpine Deciduous Shrubland (CES306.961). *Festuca idahoensis, Festuca campestris, Calamagrostis rubescens, Carex geyeri, Koeleria macrantha, Pseudoroegneria spicata*, and *Poa secunda* are the most

important grasses. *Achnatherum thurberianum* and *Leymus cinereus* can be locally important. *Poa pratensis* and *Phleum pratense* are common introduced grasses. *Geum triflorum, Potentilla gracilis, Lomatium triternatum, Balsamorhiza sagittata*, and species of *Eriogonum, Phlox*, and *Erigeron* are important forbs.

Enumerated_Domain:
Enumerated_Domain_Value: 108
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Subalpine Deciduous Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This shrubland ecological system is found within the zone of continuous forest in the upper montane and lower subalpine zones of the northern Rocky Mountains. Soils tend to be moist to wet. Stands are typically initiated by fires and will persist on sites for long periods because of repeated burns and changes in the presence of volatile oils in the soil which impedes tree regeneration. *Menziesia ferruginea, Rhamnus alnifolia, Ribes lacustre, Rubus parviflorus, Alnus viridis, Rhododendron albiflorum, Sorbus scopulina, Sorbus sitchensis, Vaccinium myrtillus, Vaccinium scoparium*, and *Vaccinium membranaceum* are the most common dominant shrubs, occurring alone or in any combination. Other shrubs can include *Shepherdia canadensis* and *Ceanothus velutinus*, but these also commonly occur in Northern Rocky Mountain Montane-Foothill Deciduous Shrubland (CES306.994). *Rubus parviflorus* and *Ceanothus velutinus* are occasionally present, being more common in montane shrublands than in this subalpine system. Important forbs include *Xerophyllum tenax, Chamerion angustifolium*, and *Pteridium aquilinum*, reflecting the mesic nature of many of these shrublands.

Enumerated_Domain:
Enumerated_Domain_Value: 109
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Avalanche Chute Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs in the mountains throughout the northern Rockies, from Wyoming north and west into British Columbia and Alberta. It is composed of a diverse mix of deciduous shrubs or trees, and conifers found on steep, frequently disturbed slopes in the mountains. Occurrences are found on the lower portions and runout zones of avalanche tracks, and slopes are generally steep, ranging from 15-60%. Aspects vary, but are more common where unstable or heavy snowpack conditions frequently occur. Sites are often mesic to wet because avalanche paths are often in stream gullies, and snow deposition can be heavy in the run-out zones. The vegetation consists of moderately dense, woody canopy characterized by dwarfed and damaged conifers and small, deciduous trees/shrubs. Characteristic species include *Abies lasiocarpa, Acer glabrum, Alnus viridis ssp. sinuata* or *Alnus incana, Populus balsamifera ssp. trichocarpa, Populus tremuloides*, or *Cornus sericea*. Other common woody plants include *Paxistima myrsinites, Sorbus scopulina*, and *Sorbus sitchensis*. The ground cover is moderately

dense to dense forb-rich, with *Senecio triangularis, Castilleja* spp., *Athyrium filix-femina, Thalictrum occidentale, Urtica dioica, Erythronium grandiflorum, Myosotis asiatica (= Myosotis alpestris), Veratrum viride, Heracleum maximum (= Heracleum lanatum)*, and *Xerophyllum tenax*. Mosses and ferns are often present.

Enumerated_Domain:
Enumerated_Domain_Value: 110
Enumerated_Domain_Value_Definition: California Lower Montane Blue Oak-Foothill Pine Woodland and Savanna
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is primarily found in the valley margins and foothills of the Sierra Nevada and Coast Ranges of California from approximately 120-1200 m (360-3600 feet) elevation on rolling plains or dry slopes. Over a century of anthropogenic changes (especially cutting of oak) have altered the density and distribution of woody vegetation. A high-quality occurrence often consists of open park-like stands of *Pinus sabiniana*, with oaks and other various broadleaf tree and shrub species, including *Quercus douglasii, Quercus wislizeni, Quercus agrifolia* (primarily central and southern Coast Ranges), *Quercus lobata, Aesculus californica, Arctostaphylos* spp., *Cercis canadensis var. texensis (= Cercis occidentalis), Ceanothus cuneatus, Frangula californica (= Rhamnus californica), Ribes quercetorum, Juniperus californica*, and *Pinus coulteri* (central and southern Coast Ranges). *Pinus sabiniana* tends to drop out all together in the driest and more southerly sites, which are often dominated by *Quercus douglasii*. Northern extensions of this system include *Quercus garryana* as the dominant oak, where it becomes successional to Mediterranean California Lower Montane Black Oak-Conifer Forest and Woodland (CES206.923). *Pinus sabiniana* density also varies based on intensity or frequency of fire, being less abundant in areas of higher intensity or frequency fires, hence it is often more abundant on steep, rocky or more mesic north-facing slope exposures. Historically, understory vegetation included mixed chaparral to perennial bunchgrass. Currently, most occurrences have understories dominated by dense cover of annual species, both native and non-native. Variable canopy densities in existing occurrences are likely due to variation in soil moisture regime, natural patch dynamics of fire, and land use (fire suppression, livestock grazing, herbivory, etc.).

Enumerated_Domain:
Enumerated_Domain_Value: 111
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Juniper Savanna
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This widespread ecological system occupies dry foothills and sandsheets of western Colorado, northwestern New Mexico, northern Arizona, Utah, and west into the Great Basin of Nevada and southern Idaho. It is typically found at lower elevations ranging from 1500-2300 m. This system is generally found at lower elevations and more xeric sites than Great Basin Pinyon-Juniper Woodland (CES304.773) or Colorado Plateau Pinyon-Juniper Woodland (CES304.767). These occurrences are found on lower

mountain slopes, hills, plateaus, basins and flats often where juniper is expanding into semi-desert grasslands and steppe. The vegetation is typically open savanna, although there may be inclusions of more dense juniper woodlands. This savanna is typically dominated by *Juniperus osteosperma* trees with high cover of perennial bunch grasses and forbs, with *Bouteloua gracilis, Hesperostipa comata*, and *Pleuraphis jamesii* being most common. In the southern Colorado Plateau, *Juniperus monosperma* or juniper hybrids may dominate the tree layer. Pinyon trees are typically not present because sites are outside the ecological or geographic range of *Pinus edulis* and *Pinus monophylla*. It has been suggested that all *Juniperus osteosperma* stands in Wyoming be placed in Colorado Plateau Pinyon-Juniper Woodland (CES304.767). This savanna system does not occur in Wyoming.

Enumerated_Domain:
Enumerated_Domain_Value: 112
Enumerated_Domain_Value_Definition: Willamette Valley Upland Prairie and Savanna
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This grassland system is endemic to the Puget Trough and Willamette Valley. It formed a complex mosaic of varying patch sizes with wet prairies and riparian forests over much of the Willamette Valley during the pre-European settlement era. In parts of the Puget Trough, it occurred as large patches in more forested landscapes, usually associated with deep, coarse outwash deposits. Historically, it also occurred as large patches on glacially associated soils of variable texture in localized portions of the Georgia Basin in both Washington and British Columbia. It occurs on well-drained deep soils and was maintained historically by frequent anthropogenic burning. Landforms are usually flat, rolling, or gently sloping, and often part of extensive plains. Dominant vegetation is perennial bunch grasses, especially *Festuca roemeri (= Festuca idahoensis var. roemeri)* and, to a lesser degree, *Danthonia californica*, with abundant and diverse forbs. Scattered deciduous (*Quercus garryana*) and/or coniferous (*Pseudotsuga menziesii, Pinus ponderosa*) trees are rarely found now, but such savannas historically covered about one-third of the total acreage. In the absence of disturbance, many of them have succeeded to forest and others continue to do so.

Enumerated_Domain:
Enumerated_Domain_Value: 113
Enumerated_Domain_Value_Definition: Klamath-Siskiyou Xeromorphic Serpentine Savanna and Chaparral
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system occurs throughout the Klamath - Siskiyou region below 1500 m (4550 feet) on thin rocky soils below winter snow accumulations and typically experiences hot and dry summers. These savannas and shrublands are almost always found on ultramafic soils (gabbro, peridotite, serpentinite), especially on the Josephine Peridotite Formation in the western Klamaths, with very low Ca:Mg ratio. These systems are highly variable and spotty in distribution. This system represents the most xeromorphic of these

environments, generally supporting savannas or shrublands in areas with high rainfall amounts (over 130 cm/year) that would usually support closed-canopy forests. Landforms can include rocky ridges and ridgetops, south-facing slopes and river terraces, or gravelly valley bottomlands. These contain mosaics or patches of open-canopy tree-savannas with chaparral understories or shrub-dominated chaparral. Shrubs will often have higher densities than the trees which are more limited due to the rocky/thin soils and are often stunted in growth-form. These can also be short-duration chaparrals in previously forested areas that have experienced crownfires. When present, trees tend to have a scattered, open canopy or can be clustered, over a usually continuous, dense shrub layer, but sometimes with a grassy understory. *Pinus jeffreyi* or occasionally *Pinus attenuata* can form a scattered tree layer over bunch grasses. Dense shrub layers can also be present in some stands, or form their own patches without trees, especially on ridges. *Quercus vacciniifolia, Quercus sadleriana* (coastal and wetter climate but found on xeric sties), *Lithocarpus densiflorus var. echinoides, Quercus garryana var. breweri* (drier, inland), *Ceanothus cuneatus, Ceanothus pumilus, Arctostaphylos viscida, Arctostaphylos X cinerea, Arctostaphylos canescens, Arctostaphylos nevadensis, Frangula californica (= Rhamnus californica)*, and *Garrya buxifolia* represent some of the many chaparral shrubs that can be found in these habitats. Perennial grasses such as *Festuca roemeri, Achnatherum lemmonii, Melica*, and *Danthonia californica* may also be characteristic, although a diverse and often endemic forb component (including rare serpentine endemics) is usually present. This system tends to have lower diversity within stands than in the other serpentine woodland and shrubland systems. Locally occurring, stunted and open stands of *Pinus contorta* and *Pinus monticola* on serpentine at low elevation are included in this system. The grassy understory savannas tend to have understory burns, while shrub-dense stands will suffer intense, stand-replacing fires.

Enumerated_Domain:
Enumerated_Domain_Value: 114
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Foothill Conifer Wooded Steppe
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This inland Pacific Northwest ecological system occurs in the foothills of the northern Rocky Mountains in the Columbia Plateau region and west along the foothills of the Modoc Plateau and eastern Cascades into southern interior British Columbia. It also occurs east across Idaho into the eastern foothills of the Montana Rockies. The system may also occur on the lower treeline slopes of the Wyoming Rockies. These wooded steppes occur at the lower treeline/ecotone between grasslands or shrublands and forests and woodlands, typically on warm, dry, exposed sites too droughty to support a closed tree canopy. This is not a fire-maintained system. The "savanna" character results from a climate-edaphic interaction that results in widely scattered trees over shrubs or grasses, and even in the absence of fire, a "woodland" or "forest" structure will not be obtained. Elevations range from less than 500 m in British Columbia to 1600 m in the central Idaho mountains. Occurrences are found on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. This system can occur in association

with cliff and canyon systems. It generally occurs on glacial till, glacio-fluvial sand and gravel, dune, basaltic rubble, colluvium, to deep loess or volcanic ash-derived soils, with characteristic features of good aeration and drainage, coarse textures, circumneutral to slightly acidic pH, an abundance of mineral material, rockiness, and periods of drought during the growing season. These can also occur on areas of sand dunes, scablands, and pumice where the edaphic conditions limit tree abundance. *Pinus ponderosa* (vars. *ponderosa* and *scopulorum*) and *Pseudotsuga menziesii* are the predominant conifers (not always together); *Pinus flexilis* may be present or common in the tree canopy. In interior British Columbia, *Pseudotsuga menziesii* is the characteristic canopy dominant. In transition areas with big sagebrush steppe systems, *Purshia tridentata, Artemisia tridentata ssp. wyomingensis, Artemisia tridentata ssp. tridentata*, and *Artemisia tripartita* may be common in fire-protected sites such as rocky areas. Deciduous shrubs, such as *Physocarpus malvaceus, Symphoricarpos albus*, or *Spiraea betulifolia*, can be abundant in more northerly sites or more moist climates. Important grass species include *Pseudoroegneria spicata, Poa secunda, Hesperostipa* spp., *Achnatherum* spp., and *Elymus elymoides*.

Enumerated_Domain:
Enumerated_Domain_Value: 115
Enumerated_Domain_Value_Definition: Columbia Plateau Steppe and Grassland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
These grasslands are similar floristically to Inter-Mountain Basins Big Sagebrush Steppe (CES304.778) but are defined by a more frequent fire regime and the absence or low cover of shrubs over large areas, occasionally entire landforms. These are extensive grasslands, not grass-dominated patches within the sagebrush shrub-steppe ecological system. This system occurs throughout much of the Columbia Plateau and is found at slightly higher elevations farther south. Soils are variable, ranging from relatively deep, fine-textured often with coarse fragments, and non-saline often with a microphytic crust, to stony volcanic-derived clays to alluvial sands. This grassland is dominated by perennial bunch grasses and forbs (>25% cover), sometimes with a sparse (<10% cover) shrub layer; *Chrysothamnus viscidiflorus, Ericameria nauseosa, Tetradymia* spp., or *Artemisia* spp. may be present in disturbed stands. Associated graminoids include *Achnatherum hymenoides, Elymus elymoides, Elymus lanceolatus ssp. lanceolatus, Hesperostipa comata, Festuca idahoensis, Koeleria macrantha, Poa secunda*, and *Pseudoroegneria spicata*. Common forbs are *Phlox hoodii, Arenaria* spp., and *Astragalus* spp. Areas with deeper soils are rare because of conversion to other land uses. The rapid fire-return regime of this ecological system maintains a grassland by retarding shrub invasion, and landscape isolation and fragmentation limit seed dispersal of native shrub species. Fire frequency is presumed to be less than 20 years. Through isolation from a seed source, combined with repeated burning, these are "permanently" (more than 50 years) converted to grassland

Enumerated_Domain:
Enumerated_Domain_Value: 116

Enumerated_Domain_Value_Definition: Columbia Plateau Low Sagebrush Steppe
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This matrix ecological system is composed of sagebrush dwarf-shrub-steppe that occurs in a variety of shallow-soil habitats throughout eastern Oregon, northern Nevada and southern Idaho. *Artemisia arbuscula ssp. arbuscula* and close relatives (*Artemisia arbuscula ssp. longiloba* and occasionally *Artemisia nova*) form stands that typically occur on mountain ridges and flanks and broad terraces, ranging from 1000 to 3000 m in elevation. Substrates are shallow, fine-textured soils, poorly drained clays, shallow-soiled areas, almost always very stony, characterized by recent rhyolite or basalt. Other shrubs and dwarf-shrubs present may include *Purshia tridentata, Eriogonum* spp., and other species of *Artemisia*. Common graminoids include *Festuca idahoensis, Koeleria macrantha, Pseudoroegneria spicata*, and *Poa secunda*. Many forbs also occur and may dominate the herbaceous vegetation, especially at the higher elevations. Isolated individuals of *Juniperus occidentalis* (western juniper) and *Cercocarpus ledifolius* (mountain-mahogany) can often be found in this system.

Enumerated_Domain:
Enumerated_Domain_Value: 117
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Big Sagebrush Steppe
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This widespread matrix-forming ecological system occurs throughout much of the Columbia Plateau and northern Great Basin, east into the Wyoming Basins, central Montana, and north and east onto the western fringe of the Great Plains in Montana and South Dakota. It is found at slightly higher elevations farther south. In central Montana, this system differs slightly, with more summer rain than winter precipitation, more precipitation annually, and it occurs on glaciated landscapes. Soils are typically deep and non-saline, often with a microphytic crust. This shrub-steppe is dominated by perennial grasses and forbs (>25% cover) with *Artemisia tridentata ssp. tridentata* (this is not at all important in Wyoming occurrences), *Artemisia tridentata ssp. xericensis, Artemisia tridentata ssp. wyomingensis, Artemisia tripartita ssp. tripartita* (Snake River valley in Wyoming), *Artemisia cana ssp. cana*, and/or *Purshia tridentata* dominating or codominating the open to moderately dense (10-40% cover) shrub layer. *Atriplex confertifolia, Chrysothamnus viscidiflorus, Ericameria nauseosa, Sarcobatus vermiculatus, Tetradymia* spp., or *Artemisia frigida* may be common especially in disturbed stands. In Montana and Wyoming, stands are more mesic, with more biomass of grass, have less shrub diversity than stands farther west, and 50 to 90% of the occurrences are dominated by *Artemisia tridentata ssp. wyomingensis* with *Pascopyrum smithii*. In addition, *Bromus japonicus* and *Bromus tectorum* are indicators of disturbance, and *Bromus tectorum* is typically not as abundant as in the Intermountain West, possibly due to a colder climate. Associated graminoids can include *Achnatherum hymenoides, Calamagrostis montanensis, Elymus lanceolatus ssp. lanceolatus, Koeleria macrantha, Poa secunda, Pascopyrum smithii, Hesperostipa comata, Nassella viridula, Bouteloua gracilis*, and *Pseudoroegneria spicata*. Important rhizomatous species include

Carex filifolia and *Carex duriuscula*, which are very common and important in the eastern distribution of this system in both Wyoming and Montana. *Festuca idahoensis* is uncommon in this system, although it does occur in areas of higher elevations/precipitation; *Festuca campestris* is also uncommon. In Wyoming, both *Nassella viridula* and *Pseudoroegneria spicata* rarely occur, with the latter typically found in eastern Wyoming on ridgetops and rocky slopes outside of this system. In Montana, there is an absence of *Festuca* spp., except *Vulpia octoflora*. Common forbs are *Phlox hoodii, Arenaria* spp., *Opuntia* spp., *Sphaeralcea coccinea, Dalea purpurea, Liatris punctata*, and *Astragalus* spp. Areas with deeper soils more commonly support *Artemisia tridentata ssp. tridentata* but have largely been converted for other land uses. The natural fire regime of this ecological system likely maintains a patchy distribution of shrubs, so the general aspect of the vegetation is a grassland. Shrubs may increase following heavy grazing and/or with fire suppression, particularly in moist portions of the northern Columbia Plateau where it forms a landscape mosaic pattern with shallow-soil scabland shrublands. Where fire frequency has allowed for shifts to a native grassland condition, maintained without significant shrub invasion over a 50- to 70-year interval, the area would be considered Columbia Basin Foothill and Canyon Dry Grassland (CES304.993).

Enumerated_Domain:
Enumerated_Domain_Value: 118
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Montane Sagebrush Steppe
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system includes sagebrush communities occurring at foothills (in Wyoming) to montane and subalpine elevations across the western U.S. from 1000 m in eastern Oregon and Washington to over 3000 m in the southern Rockies. In Montana, it occurs on mountain "islands" in the north-central portion of the state and possibly along the Boulder River south of Absarokee and at higher elevations. In British Columbia, it occurs between 450 and 1650 m in the southern Fraser Plateau and the Thompson and Okanagan basins. Climate is cool, semi-arid to subhumid. This system primarily occurs on deep-soiled to stony flats, ridges, nearly flat ridgetops, and mountain slopes. In general, this system shows an affinity for mild topography, fine soils, some source of subsurface moisture or more mesic sites, zones of higher precipitation and areas of snow accumulation. Across its range of distribution, this is a compositionally diverse system. It is composed primarily of *Artemisia tridentata ssp. vaseyana, Artemisia cana ssp. viscidula*, and related taxa such as *Artemisia tridentata ssp. spiciformis (= Artemisia spiciformis)*. *Purshia tridentata* may codominate or even dominate some stands. *Artemisia arbuscula ssp. arbuscula*-dominated shrublands commonly occur within this system on rocky or windblown sites. Other common shrubs include *Symphoricarpos* spp., *Amelanchier* spp., *Ericameria nauseosa, Peraphyllum ramosissimum, Ribes cereum*, and *Chrysothamnus viscidiflorus*. *Artemisia tridentata ssp. wyomingensis* may be present to codominant if the stand is clearly montane as indicated by montane indicator species such as *Festuca idahoensis, Leucopoa kingii*, or *Danthonia intermedia*. Most stands have an

abundant perennial herbaceous layer (over 25% cover, in many cases over 50% cover), but this system also includes *Artemisia tridentata ssp. vaseyana* shrublands. Common graminoids include *Danthonia intermedia, Festuca arizonica, Festuca idahoensis, Hesperostipa comata, Poa fendleriana, Elymus trachycaulus, Bromus carinatus, Poa secunda, Leucopoa kingii, Deschampsia caespitosa, Calamagrostis rubescens*, and *Pseudoroegneria spicata*. Species of *Achnatherum* are common, including *Achnatherum nelsonii ssp. dorei, Achnatherum nelsonii ssp. nelsonii, Achnatherum hymenoides*, and others. In many areas, wildfires can maintain an open herbaceous-rich steppe condition, although at most sites, shrub cover can be unusually high for a steppe system (>40%), with the moisture providing equally high grass and forb cover.

Enumerated_Domain:
Enumerated_Domain_Value: 119
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Semi-Desert Shrub-Steppe
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs throughout the intermountain western U.S., typically at lower elevations on alluvial fans and flats with moderate to deep soils, and extends into south-central Montana between the Pryor and Beartooth ranges where a distinct rainshadow effect occurs. This semi-arid shrub-steppe is typically dominated by graminoids (>25% cover) with an open shrub to moderately dense woody layer with a typically strong graminoid layer. The most widespread (but not dominant) species is *Pseudoroegneria spicata*, which occurs from the Columbia Basin to the northern Rockies. Characteristic grasses include *Achnatherum hymenoides, Bouteloua gracilis, Distichlis spicata, Poa secunda, Poa fendleriana, Sporobolus airoides , Hesperostipa comata, Pleuraphis jamesii*, and *Leymus salinus*. The woody layer is often a mixture of shrubs and dwarf-shrubs, although it may be dominated by a single species. Characteristic species include *Atriplex canescens, Artemisia tridentata, Chrysothamnus greenei, Chrysothamnus viscidiflorus, Ephedra* spp., *Ericameria nauseosa, Gutierrezia sarothrae*, and *Krascheninnikovia lanata*. *Artemisia tridentata* or *Atriplex canescens* may be present but does not dominate. Annual grasses, especially the exotics *Bromus japonicus* and *Bromus tectorum*, may be present to abundant. Forbs are generally of low importance and are highly variable across the range but may be diverse in some occurrences. The general aspect of occurrences may be either open shrubland with patchy grasses or patchy open herbaceous layers. Disturbance may be important in maintaining the woody component. Microphytic crust is very important in some stands.

Enumerated_Domain:
Enumerated_Domain_Value: 120
Enumerated_Domain_Value_Definition: Northern California Coastal Scrub
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system includes a variety of mixed and single-species-dominated shrublands along a narrow coastal strip with maritime and summer fog influences, on

marine sediments, coastal bluffs, terraces, stabilized dunes, and hills below 500 m (1500 feet) elevation from southern Oregon south through central California. It is restricted to coastal plateaus and lower slopes of the Coast Ranges where precipitation ranges from 50-200 cm annually. These are dominated by evergreen, microphyllous-leaved or hemi-sclerophyllous shrub taxa; drought-deciduous species are unimportant or absent in this system. Dense shrublands typically include a well-developed woody and herbaceous understory. Characteristic species include *Baccharis pilularis, Lupinus arboreus, Ceanothus thyrsiflorus, Eriophyllum stoechadifolium, Diplacus aurantiacus (= Mimulus aurantiacus), Toxicodendron diversilobum, Rubus ursinus, Rubus parviflorus, Rubus spectabilis, Frangula californica (= Rhamnus californica), Holodiscus discolor, Gaultheria shallon, Heracleum maximum (= Heracleum lanatum)*, and *Polystichum munitum*. These areas have supported extensive stand-replacing wildfires. This system has direct seral relationships with California Northern Coastal Grassland (CES206.941) as, in the absence of fire and grazing, the grassland will usually succeed to this system. In the absence of fire in this system, conifers (*Abies grandis, Pseudotsuga menziesii*) can invade and become prominent.

Enumerated_Domain:
Enumerated_Domain_Value: 121
Enumerated_Domain_Value_Definition: California Mesic Serpentine Grassland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
These grasslands are of very limited distribution in California within the Coast Ranges, Sierra Nevada, and Transverse Ranges on deep soils with serpentine-rich parent material. Not all serpentinite outcrops support distinct vegetation; only those with very low Ca:Mg ratios impact biotic composition. In this system, native bunchgrass dominates, though typically in less dense cover than other perennial bunchgrass types. Characteristic species include *Calamagrostis ophitidis, Eschscholzia californica, Vulpia microstachys var. ciliata (= Festuca grayi), Poa secunda (= Poa scabrella), Hemizonia congesta ssp. luzulifolia (= Hemizonia luzulifolia), Nassella cernua*, and *Nassella pulchra*. Historic fire regimes in this system are not well known.

Enumerated_Domain:
Enumerated_Domain_Value: 122
Enumerated_Domain_Value_Definition: California Northern Coastal Grassland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is found in discontinuous patches below 300 m (1000 feet) elevation from San Francisco Bay north into Oregon on coastal terraces and ridgeline balds in the Coast Ranges and Klamath Mountains. Small patches have been documented as far south as Santa Barbara and San Luis Obispo counties. It has a similar distribution to coastal shrublands (Northern California Coastal Scrub (CES206.932)) in areas that receive more rainfall than other California grasslands of the interior or southern coastal California. In recent centuries, these were fire-dominated systems, and there is a known

history of Native American use of fire in these areas. While still present, annuals grasses and forbs are not as prevalent in these grasslands as elsewhere in California. With fire suppression, *Baccharis pilularis* and other shrub components of north coastal scrub often invade and can replace these grasslands with scrub-dominated systems. *Agrostis* spp., *Bromus carinatus, Calamagrostis nutkaensis, Danthonia californica, Festuca rubra, Festuca idahoensis, Deschampsia caespitosa, Koeleria macrantha, Trisetum canescens*, and perennial forbs such as *Iris douglasiana, Sisyrinchium bellum, Grindelia hirsutula*, and *Sanicula arctopoides* are characteristic.

Enumerated_Domain:
Enumerated_Domain_Value: 123
Enumerated_Domain_Value_Definition: Columbia Basin Foothill and Canyon Dry Grassland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
These grasslands are similar floristically to Columbia Basin Palouse Prairie (CES304.792) but are distinguished by landform, soil, and process characteristics. They occur in the canyons and valleys of the Columbia Basin, particularly along the Snake River canyon, the lower foothill slopes of the Blue Mountains, and along the main stem of the Columbia River in eastern Washington. Occurrences are found on steep open slopes, from 90 to 1525 m (300-5000 feet) elevation. Annual precipitation is low, ranging from 4 to 10 cm. Settings are primarily long, steep slopes of 100 m to well over 400 m, with soils derived from residuum and having patchy, thin, wind-blown surface deposits. Slope failures are a common process. Fire frequency is presumed to be less than 20 years. The vegetation is dominated by patchy graminoid cover, cacti, and some forbs. *Pseudoroegneria spicata, Festuca idahoensis*, and *Opuntia polyacantha* are common species. Deciduous shrubs *Symphoricarpos* spp., *Physocarpus malvaceus, Holodiscus discolor*, and *Ribes* spp. are infrequent native species that may increase with fire exclusion.

Enumerated_Domain:
Enumerated_Domain_Value: 124
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Semi-Desert Grassland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This widespread ecological system includes the driest grasslands throughout the intermountain western U.S. It occurs on xeric sites over an elevation range of approximately 1450 to 2320 m (4750-7610 feet) on a variety of landforms, including swales, playas, mesas, alluvial flats, and plains. This system may constitute the matrix over large areas of intermountain basins, and also may occur as large patches in mosaics with shrubland systems dominated by *Artemisia tridentata ssp. tridentata, Artemisia tridentata ssp. wyomingensis, Atriplex* spp., *Coleogyne* spp., *Ephedra* spp., *Gutierrezia sarothrae*, or *Krascheninnikovia lanata*. Grasslands in areas of higher precipitation, at higher elevation, typically belong to other systems. Substrates are often well-drained sandy or loam soils derived from sedimentary parent materials but are quite variable and

may include fine-textured soils derived from igneous and metamorphic rocks. The dominant perennial bunch grasses and shrubs within this system are all drought-resistant plants. Dominant or codominant species are *Achnatherum hymenoides, Aristida* spp., *Bouteloua gracilis, Hesperostipa comata, Muhlenbergia* spp., or *Pleuraphis jamesii*. Scattered shrubs and dwarf-shrubs often are present, especially *Artemisia tridentata ssp. tridentata, Artemisia tridentata ssp. wyomingensis, Atriplex* spp., *Coleogyne* spp., *Ephedra* spp., *Gutierrezia sarothrae*, and *Krascheninnikovia lanata*. Grasslands in the basins of south-central and southwestern Wyoming, dominated by *Pseudoroegneria spicata* and *Poa secunda* and containing cushion-form forbs and other species typical of dry basins, are included in this system.

Enumerated_Domain:
Enumerated_Domain_Value: 125
Enumerated_Domain_Value_Definition: Mediterranean California Alpine Dry Tundra
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
These dry meadows typically occur between 3200 and 4500 m (9700-13,600 feet) elevation in the northern Sierra Nevada, Klamath Mountains and Cascade Mountains. They are typically found on gentle to steep slopes, flat ridges and upper basins where the soil is thin and the water supply is constant and strongly regulated by snowpatch patterns. These sites are generally very well-drained and xeric once the snow melts. The system is commonly comprised of a mosaic of small-patch plant communities that are dominated by sedges, grasses and forbs. Characteristic species include *Phlox diffusa, Phlox covillei, Erigeron pygmaeus, Podistera nevadensis, Carex congdonii, Calamagrostis purpurascens, Eriogonum incanum, Raillardiopsis muirii (= Raillardella muirii), Castilleja nana, Erigeron compositus, Eriogonum ovalifolium, Eriogonum gracilipes*, etc. There is a rocky mesic version of this system with *Hulsea algida, Saxifraga tolmiei, Carex helleri, Ranunculus eschscholtzii, Polemonium eximium, Salix reticulata* (rarely), *Oxyria digyna, Sibbaldia procumbens*, etc. that could be found near snowmelt patches generally on sheltered, steep, rocky slopes. Alpine dry tundra typically intermingles with alpine bedrock and scree, ice field, fell-field, alpine dwarf-shrubland, and alpine/subalpine wet meadows.

Enumerated_Domain:
Enumerated_Domain_Value: 126
Enumerated_Domain_Value_Definition: Mediterranean California Subalpine Meadow
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs at subalpine elevations where finely textured soils, snow deposition, or windswept dry conditions limit tree establishment. It is typically found above 3000 m (9100 feet) elevation in California, Nevada and Oregon. The soils in these sites can be seasonally moist to saturated in the spring but, if so, will dry out later in the growing season. Characteristic plant species include *Achillea millefolium var. occidentalis (= Achillea lanulosa), Artemisia rothrockii, Oreostemma alpigenum (= Aster alpigenus), Calamagrostis breweri, Cistanthe umbellata (= Calyptridium*

umbellatum), Carex exserta, Eriogonum incanum, Horkeliella purpurascens (= Ivesia purpurascens), and *Trisetum spicatum*. Burrowing mammals can increase the forb diversity. Herbs can include *Carex subnigricans, Carex vernacula, Calamagrostis breweri, Antennaria media, Potentilla drummondii, Lewisia pygmaea, Erigeron algidus, Lupinus lepidus, Dodecatheon alpinum*, and *Solidago multiradiata*. Wet meadows of *Carex, Calamagrostis, Camassia, Eleocharis, Juncus, Veratrum*, etc. from montane to subalpine are treated in Temperate Pacific Subalpine-Montane Wet Meadow (CES200.998).

Enumerated_Domain:
Enumerated_Domain_Value: 127
Enumerated_Domain_Value_Definition: North Pacific Montane Grassland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system includes open dry meadows and grasslands on the west side of the Cascades Mountains and northern Sierra Nevada. They occur in montane elevations up to 3500 m (10,600 feet). Soils tend to be deeper and more well-drained than the surrounding forest soils. Soils can resemble prairie soils in that the A-horizon is dark brown, relatively high in organic matter, slightly acid, and usually well-drained. Dominant species include *Elymus* spp., *Festuca idahoensis*, and *Nassella cernua*. These large-patch grasslands are intermixed with matrix stands of red fir, lodgepole pine, and dry-mesic mixed conifer forests and woodlands.

Enumerated_Domain:
Enumerated_Domain_Value: 128
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Lower Montane, Foothill, and Valley Grassland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system of the northern Rocky Mountains is found at lower montane to foothill elevations in the mountains and large valleys of northeastern Wyoming and western Montana, west through Idaho into the Blue Mountains of Oregon, and north into the Okanagan and Fraser plateaus of British Columbia and the Canadian Rockies. They also occur to the east in the central Montana mountain "islands," foothills, as well as the Rocky Mountain Front and Big and Little Belt ranges. These grasslands are floristically similar to Inter-Mountain Basins Big Sagebrush Steppe (CES304.778), Columbia Basin Foothill and Canyon Dry Grassland (CES304.993), and Columbia Basin Palouse Prairie (CES304.792), but are defined by shorter summers, colder winters, and young soils derived from recent glacial and alluvial material. These northern lower montane and valley grasslands represent a shift in the precipitation regime from summer monsoons and cold snowy winters found in the southern Rockies to predominantly dry summers and winter precipitation. In the eastern portion of its range in Montana, winter precipitation is replaced by a huge spring peak in precipitation. They are found at elevations from 300 to 1650 m, ranging from small meadows to large open parks surrounded by conifers in the lower montane, to extensive foothill and valley grasslands below the lower treeline.

Many of these valleys may have been primarily sage-steppe with patches of grassland in the past, but because of land-use history post-settlement (herbicide, grazing, fire suppression, pasturing, etc.), they have been converted to grassland-dominated areas. Soils are relatively deep, fine-textured, often with coarse fragments, and non-saline, often with a microphytic crust. The most important species are cool-season perennial bunch grasses and forbs (>25% cover), sometimes with a sparse (<10% cover) shrub layer. Pseudoroegneria spicata, Festuca campestris, Festuca idahoensis, or Hesperostipa comata commonly dominate sites on all aspects of level to moderate slopes and on certain steep slopes with a variety of other grasses, such as Achnatherum hymenoides, Achnatherum richardsonii, Hesperostipa curtiseta, Koeleria macrantha, Leymus cinereus, Elymus trachycaulus, Bromus inermis ssp. pumpellianus (= Bromus pumpellianus), Achnatherum occidentale (= Stipa occidentalis), Pascopyrum smithii, and other graminoids such as Carex filifolia and Danthonia intermedia. Other grassland species include Opuntia fragilis, Artemisia frigida, Carex petasata, Antennaria spp., and Selaginella densa. Important exotic grasses include Phleum pratense, Bromus inermis, and Poa pratensis. Shrub species may be scattered, including Amelanchier alnifolia, Rosa spp., Symphoricarpos spp., Juniperus communis, Artemisia tridentata, and in Wyoming Artemisia tripartita ssp. rupicola. Common associated forbs include Geum triflorum, Galium boreale, Campanula rotundifolia, Antennaria microphylla, Geranium viscosissimum, and Potentilla gracilis. A soil crust of lichen covers almost all open soil between clumps of grasses; Cladonia and Peltigera are the most common lichens. Unvegetated mineral soil is commonly found between clumps of grass and the lichen cover. The fire regime of this ecological system maintains a grassland due to rapid fire return that retards shrub invasion or landscape isolation and fragmentation that limits seed dispersal of native shrub species. Fire frequency is presumed to be less than 20 years. These are extensive grasslands, not grass-dominated patches within the sagebrush shrub steppe ecological system. Festuca campestris is easily eliminated by grazing and does not occur in all areas of this system.

Enumerated_Domain:
Enumerated_Domain_Value: 129
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Subalpine-Upper Montane Grassland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This is an upper montane to subalpine, high-elevation, lush grassland system dominated by perennial grasses and forbs on dry sites, particularly south-facing slopes. It is most extensive in the Canadian Rockies portion of the Rocky Mountain cordillera, extending south into western Montana, eastern Oregon, eastern Washington and Idaho. Subalpine dry grasslands are small meadows to large open parks surrounded by conifer trees but lack tree cover within them. In general, soil textures are much finer, and soils are often deeper under grasslands than in the neighboring forests. Grasslands, although composed primarily of tussock-forming species, do exhibit a dense sod that makes root penetration difficult for tree species. Disturbance such as fire also plays a role in maintaining these open grassy areas. Typical dominant species include *Leymus innovatus (= Elymus*

innovatus), Koeleria macrantha, Festuca campestris, Festuca idahoensis, Festuca viridula, Achnatherum occidentale (= Stipa occidentalis), Achnatherum richardsonii (= Stipa richardsonii), Bromus inermis ssp. pumpellianus (= Bromus pumpellianus), Elymus trachycaulus, Phleum alpinum, Trisetum spicatum, and a variety of Carices, such as *Carex hoodii, Carex obtusata*, and *Carex scirpoidea*. Important forbs include *Lupinus argenteus var. laxiflorus, Potentilla diversifolia, Potentilla flabellifolia, Fragaria virginiana*, and *Chamerion angustifolium (= Epilobium angustifolium)*. This system is similar to Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland (CES306.040) but is found at higher elevations and is more often composed of species of *Festuca, Achnatherum*, and/or *Hesperostipa* with additional floristic components of more subalpine taxa. Occurrences of this system are often more forb-rich than Southern Rocky Mountain Montane-Subalpine Grassland (CES306.824).

Enumerated_Domain:
Enumerated_Domain_Value: 130
Enumerated_Domain_Value_Definition: Northwestern Great Plains Mixed Grass Prairie
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system extends from northern Nebraska into southern Canada and westward through the Dakotas to the Rocky Mountain Front in Montana and probably Wyoming, on both glaciated and non-glaciated substrates. Soil texture (which ultimately effects water available to plants) is the defining environmental descriptor; soils are primarily fine and medium-textured and do not include sands, sandy soils, or sandy loams. This system occurs on a wide variety of landforms (e.g., mesatops, stream terraces) and in proximity to a diversity of other systems. Most usually it is found in association with Western Great Plains Sand Prairie (CES303.670) which occupies the coarser-textured substrates. In various locales the topography where this system occurs is broken by many glacial pothole lakes, and this system may be proximate to Great Plains Prairie Pothole (CES303.661). On the eastern Montana plains, mixedgrass prairie is by far the predominant system. Here it occurs continuously for hundreds of square kilometers, interrupted only by riparian areas or sand prairies, which are associated with gentle rises, eroded ridges or mesas derived from sandstone. Historically, this system covered approximately 38 million ha in Nebraska, North and South Dakota, and Canada; now it covers approximately 270,000 square km in this region. The growing season and rainfall are intermediate to drier units to the southwest and mesic tallgrass regions to the east. Graminoids typically comprising the greatest canopy cover include Pascopyrum smithii, Nassella viridula, and Festuca spp. In Montana these include Festuca campestris and Festuca idahoensis. Other commonly dominant species in Montana are Bouteloua gracilis, Hesperostipa comata, and Carex filifolia, while Festuca campestris and Festuca idahoensis may be more abundant in the north and foothill/montane grassland transition areas. Remnants of Hesperostipa curtiseta-dominated vegetation are found in northernmost Montana and North Dakota associated with the most productive sites (largely plowed to cereal grains); this species, usually in association with Pascopyrum smithii, is much more abundant in Canada. Sites with a strong component of Nassella viridula indicate a more favorable moisture balance and perhaps a favorable grazing

regime as well because this is one of the most palatable of the mid-grasses. Hesperostipa comata is also an important component and becomes increasingly so as improper grazing regimes favor it at the expense of (usually) Pascopyrum smithii; progressively more destructive grazing can result in the loss of Pascopyrum smithii from the system followed by drastic reduction in Hesperostipa comata and ultimately the dominance of Bouteloua gracilis (or Poa secunda and other short graminoids) and/or a lawn of Selaginella densa. Koeleria macrantha, at least in Montana and southern Canada, is the most pervasive grass; if it has high cover, past intensive grazing is the presumed reason. Shrub species such as Symphoricarpos spp. and Artemisia frigida and Artemisia cana also occur. Fire and grazing constitute the primary dynamics affecting this system. Drought can also impact this system, in general favoring the shortgrass component at the expense of the mid-grasses. With intensive grazing, cool-season exotics such as Poa pratensis, Bromus inermis, and Bromus japonicus can increase in dominance; both of the rhizomatous grasses have been shown to markedly depress species diversity. Shrub species such as Juniperus virginiana can also increase in dominance with fire suppression. This system is one of the most disturbed grassland systems in Nebraska, North and South Dakota, and Canada.

Enumerated_Domain:
Enumerated_Domain_Value: 131
Enumerated_Domain_Value_Definition: Columbia Basin Palouse Prairie
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This once-extensive grassland system occurs in eastern Washington and Oregon, and west-central Idaho, though in very small patches there. In much of its range it is characterized by rolling topography composed of loess hills and plains over basalt plains. The climate of this region has warm-hot, dry summers and cool, wet winters. Annual precipitation is high, 38-76 cm (15-30 inches). The soils are typically deep, well-developed, and old. The cool-season bunch grasses that dominate the vegetation are adapted to this winter precipitation. Characteristic species are *Pseudoroegneria spicata* and *Festuca idahoensis* with *Hesperostipa comata, Achnatherum scribneri, Leymus condensatus, Leymus cinereus, Koeleria macrantha, Pascopyrum smithii*, or *Poa secunda*. Shrubs commonly found include *Amelanchier alnifolia, Rosa* spp., *Eriogonum* spp., *Symphoricarpos albus*, and *Crataegus douglasii*. Excessive grazing, past land use and invasion by introduced annual species have resulted in a massive conversion to agriculture or shrub-steppe and annual grasslands dominated by *Artemisia* spp. and *Bromus tectorum* or *Poa pratensis*. Remnant grasslands are now typically associated with steep and rocky sites or small and isolated sites within an agricultural landscape.

Enumerated_Domain:
Enumerated_Domain_Value: 132
Enumerated_Domain_Value_Definition: Rocky Mountain Alpine Fell Field
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org

This ecological system is found discontinuously at alpine elevations throughout the Rocky Mountains, west into the mountainous areas of the Great Basin, and north into the Canadian Rockies. Small areas are represented in the west side of the Okanagan Ecoregion in the eastern Cascades. These are wind-scoured fell-fields that are free of snow in the winter, such as ridgetops and exposed saddles, exposing the plants to severe environmental stress. Soils on these windy unproductive sites are shallow, stony, low in organic matter, and poorly developed; wind deflation often results in a gravelly pavement. Most fell-field plants are cushioned or matted, frequently succulent, flat to the ground in rosettes and often densely haired and thickly cutinized. Plant cover is 15-50%, while exposed rocks make up the rest. Fell-fields are usually within or adjacent to alpine tundra dry meadows. Common species include *Arenaria capillaris, Geum rossii, Kobresia myosuroides, Minuartia obtusiloba, Myosotis asiatica, Paronychia pulvinata, Phlox pulvinata, Sibbaldia procumbens, Silene acaulis, Trifolium dasyphyllum*, and *Trifolium parryi*.

Enumerated_Domain:
Enumerated_Domain_Value: 133
Enumerated_Domain_Value_Definition: Rocky Mountain Alpine Turf
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This widespread ecological system occurs above upper treeline throughout the Rocky Mountain cordillera, including alpine areas of ranges in Utah and Nevada, and isolated alpine sites in the northeastern Cascades. It is found on gentle to moderate slopes, flat ridges, valleys, and basins, where the soil has become relatively stabilized and the water supply is more or less constant. Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost, and a short growing season. This system is characterized by a dense cover of low-growing, perennial graminoids and forbs. Rhizomatous, sod-forming sedges are the dominant graminoids, and prostrate and mat-forming plants with thick rootstocks or taproots characterize the forbs. Dominant species include Artemisia arctica, Carex elynoides, Carex siccata, Carex scirpoidea, Carex nardina, Carex rupestris, Festuca brachyphylla, Festuca idahoensis, Geum rossii, Kobresia myosuroides, Phlox pulvinata, and Trifolium dasyphyllum. Many other graminoids, forbs, and prostrate shrubs can also be found, including Calamagrostis purpurascens, Deschampsia caespitosa, Dryas octopetala, Leucopoa kingii, Poa arctica, Saxifraga spp., Selaginella densa, Sibbaldia procumbens, Silene acaulis, Solidago spp., and Trifolium parryi. Although alpine dry tundra is the matrix of the alpine zone, it typically intermingles with alpine bedrock and scree, ice field, fell-field, alpine dwarf-shrubland, and alpine/subalpine wet meadow systems.

Enumerated_Domain:
Enumerated_Domain_Value: 134
Enumerated_Domain_Value_Definition: Rocky Mountain Subalpine-Montane Mesic Meadow
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org

This Rocky Mountain ecological system is restricted to sites from lower montane to subalpine where finely textured soils, snow deposition, or windswept dry conditions limit tree establishment. Many occurrences are small patch in spatial character, and are often found in mosaics with woodlands, more dense shrublands, or just below alpine communities. It is typically found above 2000 m in elevation in the southern part of its range and above 600 m in the northern part. These upland communities occur on gentle to moderate-gradient slopes and relatively moist habitats. The soils are typically seasonally moist to saturated in the spring, but if so will dry out later in the growing season. These sites are not as wet as those found in Rocky Mountain Alpine-Montane Wet Meadow (CES306.812). Vegetation is typically forb-rich, with forbs often contributing more to overall herbaceous cover than graminoids. Some stands are comprised of dense grasslands, these often being taxa with relatively broad and soft blades, but where the moist habitat promotes a rich forb component. Important taxa include *Erigeron* spp., Asteraceae spp., *Mertensia* spp., *Penstemon* spp., *Campanula* spp., *Lupinus* spp., *Solidago* spp., *Ligusticum* spp., *Thalictrum occidentale, Valeriana sitchensis, Rudbeckia occidentalis, Balsamorhiza sagittata*, and *Wyethia* spp. Important grasses include *Deschampsia caespitosa, Koeleria macrantha*, perennial *Bromus* spp., and a number of *Carex* species. *Dasiphora fruticosa ssp. floribunda* and *Symphoricarpos* spp. are occasional but not abundant. Burrowing mammals can increase the forb diversity.

Enumerated_Domain:
Enumerated_Domain_Value: 135
Enumerated_Domain_Value_Definition: Southern Rocky Mountian Montane-Subalpine Grassland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This Rocky Mountain ecological system typically occurs between 2200 and 3000 m elevation on flat to rolling plains and parks or on lower sideslopes that are dry, but it may extend up to 3350 m on warm aspects. Soils resemble prairie soils in that the A-horizon is dark brown, relatively high in organic matter, slightly acidic, and usually well-drained. An occurrence usually consists of a mosaic of two or three plant associations with one of the following dominant bunch grasses: Danthonia intermedia, Danthonia parryi, Festuca idahoensis, Festuca arizonica, Festuca thurberi, Muhlenbergia filiculmis, or Pseudoroegneria spicata. The subdominants include Muhlenbergia montana, Bouteloua gracilis, and Poa secunda. These large-patch grasslands are intermixed with matrix stands of spruce-fir, lodgepole pine, ponderosa pine, and aspen forests. In limited circumstances (e.g., South Park in Colorado), they form the "matrix" of high-elevation plateaus. Small-patch representations of this system do occur at high elevations of the Trans-Pecos where they present as occurrences of Festuca arizonica - Blepharoneuron tricholepis Herbaceous Vegetation (CEGL004508). These occurrences often occupy sites adjacent to Madrean Oriental Chaparral (CES302.031).

Enumerated_Domain:
Enumerated_Domain_Value: 136

Enumerated_Domain_Value_Definition: Western Great Plains Foothill and Piedmont Grassland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system typically occurs between 1600 and 2200 m in elevation. It is best characterized as a mixedgrass to tallgrass prairie on mostly moderate to gentle slopes, usually at the base of foothill slopes, e.g., the hogbacks of the Rocky Mountain Front Range where it typically occurs as a relatively narrow elevational band between montane woodlands and shrublands and the shortgrass steppe and mixedgrass prairie, but extends east on the Front Range piedmont alongside the Chalk Bluffs near the Colorado-Wyoming border, out into the Great Plains on the Palmer Divide, and on piedmont slopes below mesas and foothills in northeastern New Mexico. A combination of increased precipitation from orographic rain, temperature, and soils limits this system to the lower elevation zone with approximately 40 cm of precipitation/year. It is maintained by frequent fire and associated with well-drained clay soils. Usually occurrences of this system have multiple plant associations that may be dominated by *Andropogon gerardii, Schizachyrium scoparium, Muhlenbergia montana, Nassella viridula, Pascopyrum smithii, Sporobolus cryptandrus, Bouteloua gracilis, Hesperostipa comata*, or *Hesperostipa neomexicana*. In Wyoming, typical grasses found in this system include *Pseudoroegneria spicata, Schizachyrium scoparium, Hesperostipa neomexicana, Hesperostipa comata*, and species of *Poa*. Typical adjacent ecological systems include foothill shrublands, ponderosa pine savannas, juniper savannas, as well as shortgrass prairie.

Enumerated_Domain:
Enumerated_Domain_Value: 137
Enumerated_Domain_Value_Definition: Western Great Plains Sand Prairie
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
The sand prairies constitute a very unique system within the western Great Plains. These sand prairies are often considered part of the tallgrass or mixedgrass regions in the western Great Plains but can contain elements from Western Great Plains Shortgrass Prairie (CES303.672), Central Mixedgrass Prairie (CES303.659), and Northwestern Great Plains Mixedgrass Prairie (CES303.674). The largest expanse of sand prairies (approximately 5 million ha) can be found in the Sandhills of north-central Nebraska and southwestern South Dakota. These areas are relatively intact. The primary use of this system has been grazing (not cultivation), and areas such as the Nebraska Sandhills can experience less degeneration than other prairie systems. Although greater than 90% of the Sandhills region is privately owned, the known fragility of the soils and the cautions used by ranchers to avoid poor grazing practices have allowed for fewer significant changes in the vegetation of the Sandhills compared to other grassland systems. The unifying and controlling feature for this system is that coarse-textured soils predominate and the dominant grasses are well-adapted to this condition. Soils in the sand prairies can be relatively undeveloped and are highly permeable. Soil texture and drainage along with a species' rooting morphology, photosynthetic physiology, and mechanisms to avoid

transpiration loss are highly important in determining the composition of the sand prairies. In the northwestern portion of its range, stand size corresponds to the area of exposed caprock sandstone, and small patches predominate, but large patches are also found embedded in the encompassing Northwestern Great Plains Mixedgrass Prairie (CES303.674). Another important feature is their susceptibility to wind erosion. Blowouts and sand draws are some of the unique wind-driven disturbances in the sand prairies, particularly the Nebraska Sandhills. In most of eastern Montana, substrates supporting this system have weathered in place from sandstone caprock; thus the solum is relatively thin, and the wind-sculpted features present further east, particularly in Nebraska, do not develop. Graminoid species dominate the sand prairies, although relative dominance can change due to impacts of wind disturbance. *Andropogon hallii* and *Calamovilfa longifolia* are the most common species, but other grass and forb species such as *Hesperostipa comata, Carex inops ssp. heliophila*, and *Panicum virgatum* may be present. Apparently only *Calamovilfa longifolia* functions as a dominant throughout the range of the system. In the western extent, *Hesperostipa comata* becomes more dominant, and *Andropogon hallii* is less abundant but still present. Communities of *Artemisia cana ssp. cana* are included here in central and eastern Montana. Patches of *Quercus havardii* can also occur within this system in the southern Great Plains. Fire and grazing constitute the other major dynamic processes that can influence this system.

Enumerated_Domain:
Enumerated_Domain_Value: 138
Enumerated_Domain_Value_Definition: Western Great Plains Shortgrass Prairie
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system is found primarily in the western half of the Western Great Plains Division in the rainshadow of the Rocky Mountains and ranges from the Nebraska Panhandle south into Texas and New Mexico, although grazing-impacted examples may reach as far north as southern Canada where it grades into Northwestern Great Plains Mixedgrass Prairie (CES303.674). This system occurs primarily on flat to rolling uplands with loamy, ustic soils ranging from sandy to clayey. In much of its range, this system forms the matrix system with *Bouteloua gracilis* dominating this system. Associated graminoids may include *Aristida purpurea, Bouteloua curtipendula, Bouteloua hirsuta, Buchloe dactyloides, Hesperostipa comata, Koeleria macrantha (= Koeleria cristata), Pascopyrum smithii (= Agropyron smithii), Pleuraphis jamesii, Sporobolus airoides*, and *Sporobolus cryptandrus*. Although mid-height grass species may be present, especially on more mesic land positions and soils, they are secondary in importance to the sod-forming short grasses. Sandy soils have higher cover of *Hesperostipa comata, Sporobolus cryptandrus*, and *Yucca elata*. Scattered shrub and dwarf-dwarf species such as *Artemisia filifolia, Artemisia frigida, Artemisia tridentata, Atriplex canescens, Eriogonum effusum, Gutierrezia sarothrae*, and *Lycium pallidum* may also be present. Also, because this system spans a wide range, there can be some differences in the relative dominance of some species from north to south and from east to west. Large-scale processes such as climate, fire and grazing influence this system. High variation in amount and timing of annual precipitation impacts the relative cover of cool- and warm-

season herbaceous species.

In contrast to other prairie systems, fire is less important, especially in the western range of this system, because the often dry and xeric climate conditions can decrease the fuel load and thus the relative fire frequency within the system. However, historically, fires that did occur were often very expansive. Currently, fire suppression and more extensive grazing in the region have likely decreased the fire frequency even more, and it is unlikely that these processes could occur at a natural scale. A large part of the range for this system (especially in the east and near rivers) has been converted to agriculture. Areas of the central and western range have been impacted by the unsuccessful attempts to develop dryland cultivation during the Dust Bowl of the 1930s. The short grasses that dominate this system are extremely drought- and grazing-tolerant. These species evolved with drought and large herbivores and, because of their stature, are relatively resistant to overgrazing. This system in combination with the associated wetland systems represents one of the richest areas for mammals and birds. Endemic bird species to the shortgrass system may constitute one of the fastest declining bird populations.

Enumerated_Domain:
Enumerated_Domain_Value: 139
Enumerated_Domain_Value_Definition: North Pacific Alpine and Subalpine Dry Grassland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This high-elevation, grassland system is dominated by perennial grasses and forbs found on dry sites, particularly south-facing slopes, typically imbedded in or above subalpine forests and woodlands. Disturbance such as fire also plays a role in maintaining these open grassy areas, although drought and exposed site locations are primary characteristics limiting tree growth. It is most extensive in the eastern Cascades, although it also occurs in the Olympic Mountains. Alpine and subalpine dry grasslands are small openings to large open ridges above or drier than high-elevation conifer trees. In general, soil textures are much finer, and soils are often deeper under grasslands than in the neighboring forests. These grasslands, although composed primarily of tussock-forming species, do exhibit a dense sod that makes root penetration difficult for tree species. Typical dominant species include *Festuca idahoensis, Festuca viridula*, and *Festuca roemeri* (the latter species occurring only in the Olympic Mountains). This system is similar to Northern Rocky Mountain Subalpine-Upper Montane Grassland (CES306.806), differing in its including dry alpine habitats, more North Pacific floristic elements, greater snowpack, and higher precipitation.

Enumerated_Domain:
Enumerated_Domain_Value: 140
Enumerated_Domain_Value_Definition: North Pacific Hypermaritime Shrub and Herbaceous Headland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org

This system consists of herbaceous- and shrub-dominated areas directly adjacent to the outer Pacific Coast from central Oregon north to Vancouver Island. These are very windy sites where wind and salt spray combine to limit tree growth. The climate is very wet, relatively warm in winter, and cool and foggy. In Oregon, fires apparently set by Native Americans also contributed to the open character of many of these sites. The relative prevalence of grasslands versus shrublands increases to the south. Steep slopes on coastal bluffs, headlands, or small islands are typical, though sometimes this system occurs on relatively level tops of headlands or islands. Soils can be shallow to bedrock or of glacial or marine sediment origin. Vegetation is dominated by perennial bunch grasses or shrubs. Dominant species include *Vaccinium ovatum, Gaultheria shallon, Rubus spectabilis, Calamagrostis nutkaensis*, and *Festuca rubra*. Scattered stunted trees, especially *Picea sitchensis*, are often present.

Enumerated_Domain:
Enumerated_Domain_Value: 141
Enumerated_Domain_Value_Definition: North Pacific Herbaceous Bald and Bluff
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system consists of mostly herbaceous-dominated areas located primarily on shallow soils from eastern Vancouver Island and the Georgia Basin south to at least the southern end of the Willamette Valley and adjacent slopes of the Coast Ranges and western Cascades, excluding areas adjacent to the outer coastline (hypermaritime climate). They are largely, if not completely, absent from the windward side of Vancouver Island, the Olympic Peninsula, and the Coast Ranges of Washington and Oregon. Due to shallow soils, steep slopes, sunny aspect, and/or upper slope position, these sites are dry and marginal for tree establishment and growth except in favorable microsites. Rock outcrops are a typical small-scale feature within balds and are considered part of this system. Sites with many favorable microsites can have a "savanna" type structure with a sparse tree layer of *Pseudotsuga menziesii* or, less commonly, *Quercus garryana*. The climate is relatively dry to wet (20 to perhaps 100 inches annual precipitation), always with a distinct dry summer season when these sites usually become droughty enough to limit tree growth and establishment. Seeps are a frequent feature in many balds and result in vernally moist to wet areas within the balds that dry out by summer. Vegetation differences are associated with relative differences in soil moisture. Most sites have little snowfall, but sites in the *Abies amabilis* zone (montane *Tsuga heterophylla* in British Columbia) can have significant winter snowpacks. Snowpacks would be expected to melt off sooner on these sunny aspect sites than surrounding areas. Fog and salt spray probably have some influence (but less than in the hypermaritime) on exposed slopes or bluffs adjacent to saltwater shorelines in the Georgia Basin, where soils on steep coastal bluffs sometime deviate from the norm and are deep glacial deposits. Slightly to moderately altered serpentine soils occur rarely. Fires, both lightning-ignited and those ignited by Native Americans, undoubtedly at least occasionally burn all these sites. Lower elevation sites in the Georgia Basin, Puget Trough, and Willamette Valley probably were burned somewhat more frequently and in some cases intentionally. Because of this fire history, the extent of this system has declined locally through tree

invasion and growth, as areas formerly maintained herbaceous by burning have filled in with trees.

Grasslands are the most prevalent vegetation cover, though forblands are also common especially in the mountains. Dwarf-shrublands occur commonly, especially in mountains or foothills, as very small patches for the most part, usually in a matrix of herbaceous vegetation, most often near edges. Dominant or codominant native grasses include *Festuca roemeri, Danthonia californica, Achnatherum lemmonii, Festuca rubra* (near saltwater), and *Koeleria macrantha*. Forb diversity can be high. Some typical codominant forbs include *Camassia quamash, Camassia leichtlinii, Triteleia hyacinthina, Mimulus guttatus* (seeps), *Plectritis congesta, Lomatium martindalei, Allium cernuum*, and *Phlox diffusa* (can be considered a dwarf-shrub). Important dwarf-shrubs are *Arctostaphylos uva-ursi, Arctostaphylos nevadensis*, and *Juniperus communis*. Small patches and strips dominated by the shrub *Arctostaphylos columbiana* are a common feature nested within herbaceous balds. Significant portions of some balds, especially on rock outcrops, are dominated by bryophytes (mosses) and to a lesser degree lichens.

Enumerated_Domain:
Enumerated_Domain_Value: 142
Enumerated_Domain_Value_Definition: Ruderal Upland - Old Field
Enumerated_Domain_Value_Definition_Source:NLCD 1992
This land cover class is used to describe areas that were historically used for agricultural purposes but have subsequently been abandon and are returning to dominance by natural or semi-natural vegetation

Enumerated_Domain:
Enumerated_Domain_Value: 143
Enumerated_Domain_Value_Definition: Ruderal Wetland
Enumerated_Domain_Value_Definition_Source:NLCD 1992
This land cover class is used to describe areas that were historically dominated by wetland vegetation but have been transformed either by natural or human influenced processes to dominance by upland vegetation

Enumerated_Domain:
Enumerated_Domain_Value: 144
Enumerated_Domain_Value_Definition: Introduced Upland Vegetation - Treed
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program
Areas dominated by non-native tree species

Enumerated_Domain:
Enumerated_Domain_Value: 145
Enumerated_Domain_Value_Definition: Introduced Upland Vegetation - Shrub
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program
Areas dominated by non-native shrub species

Enumerated_Domain:
Enumerated_Domain_Value: 146
Enumerated_Domain_Value_Definition: Introduced Upland Vegetation - Annual and Biennial Forbland
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program
Areas dominated by non-native annual and biennial forb species

Enumerated_Domain:
Enumerated_Domain_Value: 147
Enumerated_Domain_Value_Definition: Introduced Upland Vegetation - Annual Grassland
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program
Areas dominated by non-native annual grassland species

Enumerated_Domain:
Enumerated_Domain_Value: 148
Enumerated_Domain_Value_Definition: Introduced Upland Vegetation - Perennial Grassland
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program
Areas dominated by non-native perennial grassland species

Enumerated_Domain:
Enumerated_Domain_Value: 149
Enumerated_Domain_Value_Definition: Introduced Riparian Vegetation
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program
www.NatureServe.org
Areas dominated by non-native riparian species

Enumerated_Domain:
Enumerated_Domain_Value: 150
Enumerated_Domain_Value_Definition: Mining Operations
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program
Areas of known mining activity

Enumerated_Domain:
Enumerated_Domain_Value: 151
Enumerated_Domain_Value_Definition: Recently burned forest
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program
Areas where recent fire activity is visible on the image that have regenerated to tree dominated vegetation

Enumerated_Domain:
Enumerated_Domain_Value: 152
Enumerated_Domain_Value_Definition: Recently burned grassland
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program

Areas where recent fire activity is visible on the image that have regenerated to grass dominated vegetation

Enumerated_Domain:
Enumerated_Domain_Value: 153
Enumerated_Domain_Value_Definition: Recently burned shrubland
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program
Areas where recent fire activity is visible on the image that have regenerated to shrub dominated vegetation

Enumerated_Domain:
Enumerated_Domain_Value: 154
Enumerated_Domain_Value_Definition: Agriculture
Enumerated_Domain_Value_Definition_Source:Historic class, not used in final land cover drafts
Should be recoded to cultivated cropland in final draft

Enumerated_Domain:
Enumerated_Domain_Value: 155
Enumerated_Domain_Value_Definition: Harvested forest-tree regeneration
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program
Areas of visible timber harvest that have regenerated to tree dominated vegetation

Enumerated_Domain:
Enumerated_Domain_Value: 156
Enumerated_Domain_Value_Definition: Harvested forest-shrub regeneration
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program
Areas of visible timber harvest that have regenerated to shrub dominanted vegetation

Enumerated_Domain:
Enumerated_Domain_Value: 157
Enumerated_Domain_Value_Definition: Harvested forest-grass regeneration
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program
Areas of visible timber harvest that have regenerated to grass dominated vegetation

Enumerated_Domain:
Enumerated_Domain_Value: 158
Enumerated_Domain_Value_Definition: Harvested forest-herbaceous regeneration
Enumerated_Domain_Value_Definition_Source:National Gap Analysis Program
Areas of visible timber harvest that have regenerated to herbaceous dominated vegetation

Enumerated_Domain:
Enumerated_Domain_Value: 159
Enumerated_Domain_Value_Definition: Inter-Mountain Basins Greasewood Flat

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs throughout much of the western U.S. in Intermountain basins and extends onto the western Great Plains and into central Montana. It typically occurs near drainages on stream terraces and flats or may form rings around more sparsely vegetated playas. Sites typically have saline soils, a shallow water table and flood intermittently, but remain dry for most growing seasons. The water table remains high enough to maintain vegetation, despite salt accumulations. This system usually occurs as a mosaic of multiple communities, with open to moderately dense shrublands dominated or codominated by *Sarcobatus vermiculatus*. Other shrubs that may be present to codominant in some occurrences include *Atriplex canescens, Atriplex confertifolia, Atriplex gardneri, Artemisia tridentata ssp. wyomingensis, Artemisia tridentata ssp. tridentata, Artemisia cana ssp. cana*, or *Krascheninnikovia lanata*. Occurrences are often surrounded by mixed salt desert scrub or big sagebrush shrublands. The herbaceous layer, if present, is usually dominated by graminoids. There may be inclusions of *Sporobolus airoides, Pascopyrum smithii, Distichlis spicata* (where water remains ponded the longest), *Calamovilfa longifolia, Poa pratensis, Puccinellia nuttalliana*, or *Eleocharis palustris* herbaceous types.

Enumerated_Domain:
Enumerated_Domain_Value: 160
Enumerated_Domain_Value_Definition: North Pacific Lowland Riparian Forest and Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
Lowland riparian systems occur throughout the Pacific Northwest. They are the low-elevation, alluvial floodplains that are confined by valleys and inlets and are more abundant in the central and southern portions of the Pacific Northwest Coast. These forests and tall shrublands are linear in character, occurring on floodplains or lower terraces of rivers and streams. Major broadleaf dominant species are *Acer macrophyllum, Alnus rubra, Populus balsamifera ssp. trichocarpa, Salix sitchensis, Salix lucida ssp. lasiandra, Cornus sericea*, and *Fraxinus latifolia*. Conifers tend to increase with succession in the absence of major disturbance. Conifer-dominated types are relatively uncommon and not well-described; *Abies grandis, Picea sitchensis*, and *Thuja plicata* are important. Riverine flooding and the succession that occurs after major flooding events are the major natural processes that drive this system. Very early-successional stages can be sparsely vegetated or dominated by herbaceous vegetation.

Enumerated_Domain:
Enumerated_Domain_Value: 161
Enumerated_Domain_Value_Definition: North Pacific Montane Riparian Woodland and Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org

This system occurs throughout mountainous areas of the Pacific Northwest coast, both on the mainland and on larger islands. It occurs on steep streams and narrow floodplains above foothills but below the alpine environments, e.g., above 1500 m (4550 feet) elevation in the Klamath Mountains and western Cascades of Oregon, up as high as 3300 m (10,000 feet) in the southern Cascades, and above 610 m (2000 feet) in northern Washington. Surrounding habitats include subalpine parklands and montane forests. In Washington they are defined as occurring primarily above the *Tsuga heterophylla* zone, i.e., beginning at or near the lower boundary of the *Abies amabilis* zone. Dominant species include *Pinus contorta var. murrayana, Populus balsamifera ssp. trichocarpa, Abies concolor, Abies magnifica, Populus tremuloides, Alnus incana ssp. tenuifolia (= Alnus tenuifolia), Alnus viridis ssp. crispa (= Alnus crispa), Alnus viridis ssp. sinuata (= Alnus sinuata), Alnus rubra, Rubus spectabilis, Ribes bracteosum, Oplopanax horridus, Acer circinatum*, and several *Salix* species. In Western Washington, major species are *Alnus viridis ssp. sinuata, Acer circinatum, Salix, Oplopanax horridus, Alnus rubra, Petasites frigidus, Rubus spectabilis*, and *Ribes bracteosum*. These are disturbance-driven systems that require flooding, scour and deposition for germination and maintenance. They occur on streambanks where the vegetation is significantly different than surrounding forests, usually because of its shrubby or deciduous character.

Enumerated_Domain:
Enumerated_Domain_Value: 162
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Conifer Swamp
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs in the northern Rocky Mountains from northwestern Wyoming north into the Canadian Rockies and west into eastern Oregon and Washington. It is dominated by conifers on poorly drained soils that are saturated year-round or may have seasonal flooding in the spring. These are primarily on flat to gently sloping lowlands, but also occur up to near the lower limits of continuous forest (below the subalpine parkland). It can occur on steeper slopes where soils are shallow over unfractured bedrock. This system is indicative of poorly drained, mucky areas, and areas are often a mosaic of moving water and stagnant water. Soils can be woody peat, muck or mineral but tend toward mineral. Stands generally occupy sites on benches, toeslopes or valley bottoms along mountain streams. Associations present include wetland phases of *Thuja plicata, Tsuga heterophylla*, and *Picea engelmannii* forests. The wetland types are generally distinguishable from other upland forests and woodlands by shallow water tables and mesic or hydric undergrowth vegetation; some of the most typical species include *Athyrium filix-femina, Dryopteris* spp., *Lysichiton americanus, Equisetum arvense, Senecio triangularis, Mitella breweri, Mitella pentandra, Streptopus amplexifolius, Calamagrostis canadensis*, or *Carex disperma*.

Enumerated_Domain:
Enumerated_Domain_Value: 163
Enumerated_Domain_Value_Definition: Western Great Plains Floodplain

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is found in the floodplains of medium and large rivers of the western Great Plains. It occurs on the lower reaches of the North and South Platte, Platte, Arkansas, and Canadian rivers. Alluvial soils and periodic, intermediate flooding (every 5-25 years) typify this system. These are the perennial big rivers of the region with hydrologic dynamics largely driven by snowmelt in the mountains, instead of local precipitation events. Dominant communities within this system range from floodplain forests to wet meadows to gravel/sand flats; however, they are linked by underlying soils and the flooding regime. Dominant species include *Populus deltoides* and *Salix* spp. Grass cover underneath the trees is an important part of this system and is a mix of tallgrass species, including *Panicum virgatum* and *Andropogon gerardii*. *Tamarix* spp. and less desirable grasses and forbs can invade degraded areas within the floodplains, especially in the western portion of the province. These areas are often subjected to heavy grazing and/or agriculture and can be heavily degraded. Another factor is that groundwater depletion and lack of fire have created additional species changes. In most cases, the majority of the wet meadow and prairie communities may be extremely degraded or extirpated from the system.

Enumerated_Domain:
Enumerated_Domain_Value: 164
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system of the northern Rocky Mountains and the east slopes of the Cascades consists of deciduous, coniferous, and mixed conifer-deciduous forests that occur on streambanks and river floodplains of the lower montane and foothill zones. Riparian forest stands are maintained by annual flooding and hydric soils throughout the growing season. Riparian forests are often accompanied by riparian shrublands or open areas dominated by wet meadows. *Populus balsamifera* is the key indicator species. Several other tree species can be mixed in the canopy, including *Populus tremuloides, Betula papyrifera, Betula occidentalis, Picea mariana*, and *Picea glauca*. *Abies grandis, Thuja plicata*, and *Tsuga heterophylla* are commonly dominant canopy species in western Montana and northern Idaho occurrences, in lower montane riparian zones. Shrub understory components include *Cornus sericea, Acer glabrum, Alnus incana, Betula papyrifera, Oplopanax horridus*, and *Symphoricarpos albus*. Ferns and forbs of mesic sites are commonly present in many occurrences, including such species as *Athyrium filix-femina, Gymnocarpium dryopteris*, and *Senecio triangularis*.

Enumerated_Domain:
Enumerated_Domain_Value: 165
Enumerated_Domain_Value_Definition: Rocky Mountain Lower Montane Riparian Woodland and Shrubland

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is found throughout the Rocky Mountain and Colorado Plateau regions within a broad elevational range from approximately 900 to 2800 m. This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. It is dependent on a natural hydrologic regime, especially annual to episodic flooding. Occurrences are found within the flood zone of rivers, on islands, sand or cobble bars, and immediate streambanks. It can form large, wide occurrences on mid-channel islands in larger rivers or narrow bands on small, rocky canyon tributaries and well-drained benches. It is also typically found in backwater channels and other perennially wet but less scoured sites, such as floodplains swales and irrigation ditches. In some locations, occurrences extend into moderately high intermountain basins where the adjacent vegetation is sage steppe. Dominant trees may include Acer negundo, Populus angustifolia, Populus deltoides, Populus fremontii, Pseudotsuga menziesii, Picea pungens, Salix amygdaloides, or Juniperus scopulorum. Dominant shrubs include Acer glabrum, Alnus incana, Betula occidentalis, Cornus sericea, Crataegus rivularis, Forestiera pubescens, Prunus virginiana, Rhus trilobata, Salix monticola, Salix drummondiana, Salix exigua, Salix irrorata, Salix lucida, Shepherdia argentea, or Symphoricarpos spp. Exotic trees of Elaeagnus angustifolia and Tamarix spp. are common in some stands. Generally, the upland vegetation surrounding this riparian system is different and ranges from grasslands to forests. In the Wyoming Basins, the high-elevation Populus angustifolia-dominated rivers are included here, including along the North Platte, Sweetwater, and Laramie rivers. In these situations, Populus angustifolia is extending down into the sage steppe zone of the basins.

Enumerated_Domain:
Enumerated_Domain_Value: 166
Enumerated_Domain_Value_Definition: Northwestern Great Plains Floodplaine
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is found in the floodplains of medium and large rivers of the northwestern Great Plains, ranging from the Dakotas Mixedgrass Prairie west through the Northern Great Plains Steppe and north into Canada. This system occurs in the upper Missouri River Basin and includes parts of the Niobrara, White, Cheyenne, Little Missouri, Yellowstone, Powder, Bighorn, Milk, and Musselshell rivers. Alluvial soils and periodic, intermediate flooding (every 5-25 years) typify this system. These are the perennial big rivers of the region with hydrologic dynamics largely driven by snowmelt in the mountains, rather than local precipitation events. Dominate communities within this system range from floodplain forests to wet meadows to gravel/sand flats, however, they are linked by underlying soils and flooding regime. Dominant species are Populus balsamifera ssp. trichocarpa or Populus deltoides and Salix spp. Fraxinus pennsylvanica, Salix amygdaloides, and Ulmus americana are common in some stands. If present, common shrub species include Amorpha fruticosa, Cornus drummondii, Cornus sericea, Symphoricarpos occidentalis, Salix exigua, Salix interior, and Salix planifolia. Grass cover underneath the trees is an important part of this system and is a mix of cool-season

graminoid species, including Carex pellita (= Carex lanuginosa), Elymus lanceolatus, Pascopyrum smithii, and Schoenoplectus spp., with warm-season species such as Panicum virgatum, Schizachyrium scoparium, and Spartina pectinata. This system is often subjected to heavy grazing and/or agriculture and can be heavily degraded. In Montana, most occurrences are now degraded to the point where the cottonwood overstory is the only remaining natural component; undergrowth is dominated by Bromus inermis, or a complex of pasture grasses. Another factor is that groundwater depletion and lack of fire have created additional species changes. In most cases, the majority of the wet meadow and prairie communities may be extremely degraded or extirpated from the system.

Enumerated_Domain:
Enumerated_Domain_Value: 167
Enumerated_Domain_Value_Definition: Northern Rocky Mountain Wooded Vernal Pool
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
These wooded vernal pools are small shallow circumneutral freshwater wetlands of glacial origin that partially or totally dry up as the growing season progresses. They are documented to occur in northern Idaho and western Montana. These vernal ponds and wetlands usually fill with water over the fall, winter and early spring, but then at least partially dry up towards the end of the growing season. Depending on annual patterns of temperature and precipitation, the drying of the pond may be complete or partial by the fall. These sites are usually shallow and less than 1 m in depth, but can be as much as 2 m deep. The pool substrate is a poorly drained, often clayey layer with shallow organic sediments. The freshwater ponds have pH ranges from 6.2 to 7.8 with most measurements between 6.5 and 7.5, i.e., relatively neutral. The ponds in Montana were thought to be isolated, but it has been shown that in high water years the ponds spill over, and there is an exchange of surface water between ponds. The pools have a ring of trees surrounding the ponds that provide shade and influence their hydrology. A variety of tree species dominant the upper canopy, including *Abies grandis, Abies lasiocarpa, Larix occidentalis, Picea engelmannii, Pinus contorta, Pseudotsuga menziesii*, and the broadleaf trees *Populus balsamifera ssp. trichocarpa (= Populus trichocarpa)* (black cottonwood), *Fraxinus latifolia*, and, to a lesser extent, *Populus tremuloides* (quaking aspen) and *Betula papyrifera* (paper birch). Common shrubs include *Alnus incana, Cornus sericea (= Cornus stolonifera), Rhamnus alnifolia*, and *Salix* spp. *Alopecurus aequalis, Callitriche heterophylla, Carex vesicaria* (inflated sedge), *Eleocharis palustris*, and *Phalaris arundinacea* (reed canarygrass) are common herbaceous plant associates.

Enumerated_Domain:
Enumerated_Domain_Value: 168
Enumerated_Domain_Value_Definition: North Pacific Bog and Fen
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This wetland system occurs in peatlands along the Pacific coast from southeastern Alaska to northern California, in and west of the coastal mountain summits but including the

Puget Sound lowlands. Elevations are mostly under 457 m (1500 feet), and annual precipitation ranges from 890-3050 mm (35-120 inches). These wetlands are relatively abundant in Alaska and British Columbia but diminish rapidly in size and number farther south. They occur in river valleys, around lakes and marshes, or on slopes. In Alaska, they occur within ponded basins or low-gradient (<3%) slopes with an elevated water table on glacial drift, moraines, distal glacial outwash plains, and uplifted tidal marshes. Organic soils are characterized by an abundance of sodium cations from oceanic precipitation. Poor fens and bogs are often intermixed except in a few calcareous areas in Alaska and British Columbia where rich fen vegetation may dominate. *Sphagnum* characterizes poor fens and bogs (pH <5.5), and the two are lumped here, while "brown mosses" and sedges characterize rich fens (pH >5.5). Mire profiles in Alaska and British Columbia may be flat, raised (domed), or sloping, but most occurrences in Washington and Oregon are flat with only localized hummock development. Vegetation is usually a mix of conifer-dominated swamp, shrub swamp, and open sphagnum or sedge mire, often with small lakes and ponds interspersed. Vegetation includes many species common to boreal continental bogs and fens, such as *Ledum groenlandicum, Vaccinium uliginosum, Myrica gale, Andromeda polifolia, Vaccinium oxycoccos, Equisetum fluviatile, Comarum palustre*, and *Drosera rotundifolia*. However, it is also distinguished from boreal continental bogs and fens by the presence of Pacific coastal species, including *Chamaecyparis nootkatensis, Pinus contorta var. contorta, Picea sitchensis, Tsuga heterophylla, Ledum glandulosum, Thuja plicata, Gaultheria shallon, Spiraea douglasii, Carex aquatilis var. dives, Carex lyngbyei, Carex obnupta, Carex pluriflora, Darlingtonia californica, Sphagnum pacificum, Sphagnum henryense*, and *Sphagnum mendocinum*.

Enumerated_Domain:
Enumerated_Domain_Value: 169
Enumerated_Domain_Value_Definition: Great Basin Foothill and Lower Montane Riparian Woodland and Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system occurs in mountain ranges of the Great Basin and along the eastern slope of the Sierra Nevada within a broad elevation range from about 1220 m (4000 feet) to over 2135 m (7000 feet). This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. The variety of plant associations connected to this system reflects elevation, stream gradient, floodplain width, and flooding events. Dominant trees may include *Abies concolor, Alnus incana, Betula occidentalis, Populus angustifolia, Populus balsamifera ssp. trichocarpa, Populus fremontii, Salix laevigata, Salix gooddingii*, and *Pseudotsuga menziesii*. Dominant shrubs include *Artemisia cana, Cornus sericea, Salix exigua, Salix lasiolepis, Salix lemmonii*, or *Salix lutea*. Herbaceous layers are often dominated by species of *Carex* and *Juncus*, and perennial grasses and mesic forbs such *Deschampsia caespitosa, Elymus trachycaulus, Glyceria striata, Iris missouriensis, Maianthemum stellatum*, or *Thalictrum fendleri*. Introduced forage species such as *Agrostis stolonifera, Poa pratensis, Phleum pratense*, and the weedy annual *Bromus tectorum* are often present in disturbed stands. These are

disturbance-driven systems that require flooding, scour and deposition for germination and maintenance. Livestock grazing is a major influence in altering structure, composition, and function of the community.

Enumerated_Domain:
Enumerated_Domain_Value: 170
Enumerated_Domain_Value_Definition: Columbia Basin Foothill Riparian Woodland and Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This is a low-elevation riparian system found on the periphery of the mountains surrounding the Columbia River Basin, along major tributaries and the main stem of the Columbia at relatively low elevations. This is the riparian system associated with all streams at and below lower treeline, including permanent, intermittent and ephemeral streams with woody riparian vegetation. These forests and woodlands require flooding and some gravels for reestablishment. They are found in low-elevation canyons and draws, on floodplains, or in steep-sided canyons, or narrow V-shaped valleys with rocky substrates. Sites are subject to temporary flooding during spring runoff. Underlying gravels may keep the water table just below the ground surface and are favored substrates for cottonwood. Large bottomlands may have large occurrences, but most have been cut over or cleared for agriculture. Rafted ice and logs in freshets may cause considerable damage to tree boles. Beavers crop younger cottonwood and willows and frequently dam side channels occurring in these stands. In steep-sided canyons, streams typically have perennial flow on mid to high gradients. Important and diagnostic trees include *Populus balsamifera ssp. trichocarpa, Alnus rhombifolia*, *Populus tremuloides, Celtis laevigata var. reticulata, Betula occidentalis*, or *Pinus ponderosa*. Important shrubs include *Crataegus douglasii, Philadelphus lewisii, Cornus sericea, Salix lucida ssp. lasiandra, Salix eriocephala, Rosa nutkana, Rosa woodsii, Amelanchier alnifolia, Prunus virginiana*, and *Symphoricarpos albus*. Grazing is a major influence in altering structure, composition, and function of the community.

Enumerated_Domain:
Enumerated_Domain_Value: 171
Enumerated_Domain_Value_Definition: Rocky Mountain Subalpine-Montane Riparian Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This riparian woodland system is comprised of seasonally flooded forests and woodlands found at montane to subalpine elevations of the Rocky Mountain cordillera, from southern New Mexico north into Montana, and west into the Intermountain region and the Colorado Plateau. It occurs throughout the interior of British Columbia and the eastern slopes of the Cascade Mountains. This system contains the conifer and aspen woodlands that line montane streams. These are communities tolerant of periodic flooding and high water tables. Snowmelt moisture in this system may create shallow water tables or seeps for a portion of the growing season. Stands typically occur at

elevations between 1500 and 3300 m (4920-10,830 feet), farther north elevation ranges between 900 and 2000 m. This is confined to specific riparian environments occurring on floodplains or terraces of rivers and streams, in V-shaped, narrow valleys and canyons (where there is cold-air drainage). Less frequently, occurrences are found in moderate-wide valley bottoms on large floodplains along broad, meandering rivers, and on pond or lake margins. Dominant tree species vary across the latitudinal range, although it usually includes *Abies lasiocarpa* and/or *Picea engelmannii*; other important species include *Pseudotsuga menziesii, Picea pungens, Picea engelmannii X glauca, Populus tremuloides*, and *Juniperus scopulorum*. Other trees possibly present but not usually dominant include *Alnus incana, Abies concolor, Abies grandis, Pinus contorta, Populus angustifolia, Populus balsamifera ssp. trichocarpa*, and *Juniperus osteosperma*.

Enumerated_Domain:
Enumerated_Domain_Value: 172
Enumerated_Domain_Value_Definition: North Pacific Shrub Swamp
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
Swamps vegetated by shrublands occur throughout the Pacific Northwest coast, from Cook Inlet and Prince William Sound, Alaska, to the southern coast of Oregon. These are deciduous broadleaf tall shrublands that are located in depressions, around lakes or ponds, or river terraces where water tables fluctuate seasonally (mostly seasonally flooded regime), in areas that receive nutrient-rich waters. These are nutrient-rich systems with muck or mineral soils. Various species of *Salix, Spiraea douglasii, Malus fusca, Cornus sericea, Alnus incana ssp. tenuifolia (= Alnus tenuifolia), Alnus viridis ssp. crispa (= Alnus crispa)*, and *Alnus viridis ssp. sinuata (= Alnus sinuata)* are the major dominants. They may occur in mosaics with marshes or forested swamps, being on average more wet than forested swamps and more dry than marshes. However, it is also frequent for them to dominate entire wetland systems. Hardwood-dominated stands (especially *Fraxinus latifolia*) may be considered a shrub swamp when they are not surrounded by conifer forests. Typical landscape for the *Fraxinus latifolia* stands were very often formerly dominated by prairies and now by agriculture.

Enumerated_Domain:
Enumerated_Domain_Value: 173
Enumerated_Domain_Value_Definition: Rocky Mountain Subalpine-Montane Riparian Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system is found throughout the Rocky Mountain cordillera from New Mexico north into Montana, and also occurs in mountainous areas of the Intermountain region and Colorado Plateau. These are montane to subalpine riparian shrublands occurring as narrow bands of shrubs lining streambanks and alluvial terraces in narrow to wide, low-gradient valley bottoms and floodplains with sinuous stream channels. Generally it is found at higher elevations, but can be found anywhere from 1700-3475 m. Occurrences can also be found around seeps, fens, and isolated springs on hillslopes away from valley

bottoms. Many of the plant associations found within this system are associated with beaver activity. This system often occurs as a mosaic of multiple communities that are shrub- and herb-dominated and includes above-treeline, willow-dominated, snowmelt-fed basins that feed into streams. The dominant shrubs reflect the large elevational gradient and include *Alnus incana, Betula nana, Betula occidentalis, Cornus sericea, Salix bebbiana, Salix boothii, Salix brachycarpa, Salix drummondiana, Salix eriocephala, Salix geyeriana, Salix monticola, Salix planifolia*, and *Salix wolfii*. Generally the upland vegetation surrounding these riparian systems are of either conifer or aspen forests.

Enumerated_Domain:
Enumerated_Domain_Value: 174
Enumerated_Domain_Value_Definition: North Pacific Hardwood-Conifer Swamp
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This wetland system occurs from southern coastal Alaska to coastal Washington and Oregon, west of the coastal mountain summits (not interior). It is quite abundant in southeastern Alaska, less so farther south. Forested swamps are mostly small-patch size, occurring sporadically in glacial depressions, in river valleys, around the edges of lakes and marshes, or on slopes with seeps that form subirrigated soils. These are primarily on flat to gently sloping lowlands up to 457 m (1500 feet) elevation but also occur up to near the lower limits of continuous forest (below the subalpine parkland). It can occur on steeper slopes where soils are shallow over unfractured bedrock. This system is indicative of poorly drained, mucky areas, and areas are often a mosaic of moving water and stagnant water. Soils can be woody peat, muck, or mineral. It can be dominated by any one or a number of conifer and hardwood species (*Tsuga heterophylla, Picea sitchensis, Tsuga mertensiana, Chamaecyparis nootkatensis, Pinus contorta var. contorta, Alnus rubra, Fraxinus latifolia, Betula papyrifera*) that are capable of growing on saturated or seasonally flooded soils. Overstory is often less than 50% cover, but shrub understory can have high cover. In the southern end of the range of this type, e.g., the Willamette Valley, tends to have more hardwood-dominated stands (especially *Fraxinus latifolia*) and very little in the way of conifer-dominated stands. While the typical landscape context for the type is extensive upland forests, for the *Fraxinus latifolia* stands, landscapes were very often formerly dominated by prairies and now by agriculture. Many conifer-dominated stands have been converted to dominance by *Alnus rubra* due to timber harvest.

Enumerated_Domain:
Enumerated_Domain_Value: 175
Enumerated_Domain_Value_Definition: Great Plain Prairie Pothole
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
The prairie pothole system is found primarily in the glaciated northern Great Plains of the United States and Canada, and is dominated by depressional wetlands formed by glaciers scraping the landscape during the Pleistocene era. This system is typified by several classes of wetlands distinguished by changes in topography, soils and hydrology. Many of the basins within this system are closed basins and receive irregular inputs of water

from their surroundings (groundwater and precipitation), and export water as groundwater. Hydrology of the potholes is complex. Precipitation and runoff from snowmelt are often the principal water sources, with groundwater inflow secondary. Evapotranspiration is the major water loss, with seepage loss secondary. Most of the wetlands and lakes contain water that is alkaline (pH >7.4). The concentration of dissolved solids result in water that ranges from fresh to extremely saline. The flora and vegetation of this system are a function of the topography, water regime, and salinity. In addition, because of periodic droughts and wet periods, many wetlands within this system may undergo vegetation cycles. This system includes elements of emergent marshes and wet, sedge meadows that develop into a pattern of concentric rings. This system is responsible for a significant percentage of the annual production of many economically important waterfowl in North America and houses more than 50% of North American's migratory waterfowl, with several species reliant on this system for breeding and feeding. Much of the original extent of this system has been converted to agriculture, and only approximately 40-50% of the system remains undrained.

Enumerated_Domain:
Enumerated_Domain_Value: 176
Enumerated_Domain_Value_Definition: Rocky Mountain Alpine-Montane Wet Meadow
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
These are high-elevation communities found throughout the Rocky Mountains and Intermountain regions, dominated by herbaceous species found on wetter sites with very low-velocity surface and subsurface flows. They range in elevation from montane to alpine (1000-3600 m). These types occur as large meadows in montane or subalpine valleys, as narrow strips bordering ponds, lakes, and streams, and along toeslope seeps. They are typically found on flat areas or gentle slopes, but may also occur on sub-irrigated sites with slopes up to 10%. In alpine regions, sites typically are small depressions located below late-melting snow patches or on snowbeds. Soils of this system may be mineral or organic. In either case, soils show typical hydric soil characteristics, including high organic content and/or low chroma and redoximorphic features. This system often occurs as a mosaic of several plant associations, often dominated by graminoids, including *Calamagrostis stricta, Caltha leptosepala, Cardamine cordifolia, Carex illota, Carex microptera, Carex nigricans, Carex scopulorum, Carex utriculata, Carex vernacula, Deschampsia caespitosa, Eleocharis quinqueflora, Juncus drummondii, Phippsia algida, Rorippa alpina, Senecio triangularis, Trifolium parryi*, and *Trollius laxus*. Often alpine dwarf-shrublands, especially those dominated by *Salix*, are immediately adjacent to the wet meadows. Wet meadows are tightly associated with snowmelt and typically not subjected to high disturbance events such as flooding.

Enumerated_Domain:
Enumerated_Domain_Value: 177
Enumerated_Domain_Value_Definition: Western Great Plains Open Freshwater Depression Wetland

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This Great Plains emergent marsh ecological system is composed of lowland depressions; it also occurs along lake borders that have more open basins and a permanent water source through most of the year, except during exceptional drought years. These areas are distinct from Western Great Plains Closed Depression Wetland (CES303.666) by having a large watershed and/or significant connection to the groundwater table. A variety of species are part of this system, including emergent species of *Typha, Carex, Eleocharis, Juncus, Spartina*, and *Schoenoplectus*, as well as floating genera such as *Potamogeton, Sagittaria, Stuckenia*, or *Ceratophyllum*. The system includes submergent and emergent marshes and associated wet meadows and wet prairies. These types can also drift into stream margins that are more permanently wet and linked directly to the basin via groundwater flow from/into the pond or lake. Some of the specific communities will also be found in the floodplain system and should not be considered a separate system in that case. These types should also not be considered a separate system if they are occurring in lowland areas of the prairie matrix only because of an exceptional wet year.

Enumerated_Domain:
Enumerated_Domain_Value: 178
Enumerated_Domain_Value_Definition: Temperate Pacific Freshwater Aquatic Bed
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
Freshwater aquatic beds are found throughout the humid temperate regions of the Pacific Coast of North America. They are small patch in size, confined to lakes, ponds, and slow-moving portions of rivers and streams. In large bodies of water, they are usually restricted to the littoral region where penetration of light is the limiting factor for growth. A variety of rooted or floating aquatic herbaceous species may dominate, including *Azolla* spp., *Nuphar lutea, Polygonum* spp., *Potamogeton* spp., *Ranunculus* spp., and *Wolffia* spp. Submerged vegetation, such as *Myriophyllum* spp., *Ceratophyllum* spp., and *Elodea* spp., is often present. These communities occur in water too deep for emergent vegetation.

Enumerated_Domain:
Enumerated_Domain_Value: 179
Enumerated_Domain_Value_Definition: North Pacific Intertidal Freshwater Wetland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system occurs throughout the coastal margin and intertidal zone of the Pacific Northwest Coast, from Cook Inlet, Alaska, south to the central coast of Oregon. Intertidal freshwater wetlands occur as narrow strips to more extensive patches along tidally influenced portions of rivers. There has been little vegetation data collection of this type in this region; a few studies indicate dominant species include *Picea sitchensis, Alnus rubra, Carex lyngbyei, Cornus sericea, Myriophyllum hippuroides, Typha angustifolia, Athyrium filix-femina*, and *Carex lyngbyei*. This system is driven by daily tidal flooding of freshwater and associated soil saturation. Vegetation structure and composition are varied and depend on substrate characteristics and the tidal flooding regime of particular

sites. Where small areas of mudflat occur in tidally influenced freshwater areas, they are included in this intertidal freshwater wetland and not in Temperate Pacific Freshwater Mudflat (CES200.878).

Enumerated_Domain:
Enumerated_Domain_Value: 180
Enumerated_Domain_Value_Definition: Willamette Valley Wet Prairie
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system is largely restricted to the Willamette Valley of Oregon and adjacent Washington. It is nearly extirpated from the Puget Trough of Washington. These are high-nutrient wetlands that are temporarily to seasonally flooded. They are dominated primarily by graminoids, especially *Deschampsia caespitosa, Camassia quamash, Carex densa*, and *Carex unilateralis*, and to a lesser degree by forbs (e.g., *Isoetes nuttallii*) or shrubs (e.g., *Rosa nutkana*). Wet prairies historically covered large areas of the Willamette Valley where they were maintained by a combination of wetland soil hydrology and frequent burning. They have been reduced to tiny fragments of their former extent.

Enumerated_Domain:
Enumerated_Domain_Value: 181
Enumerated_Domain_Value_Definition: North American Arid West Emergent Marsh
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This widespread ecological system occurs throughout much of the arid and semi-arid regions of western North America, typically surrounded by savanna, shrub steppe, steppe, or desert vegetation. Natural marshes may occur in depressions in the landscape (ponds, kettle ponds), as fringes around lakes, and along slow-flowing streams and rivers (such riparian marshes are also referred to as sloughs). Marshes are frequently or continually inundated, with water depths up to 2 m. Water levels may be stable, or may fluctuate 1 m or more over the course of the growing season. Water chemistry may include some alkaline or semi-alkaline situations, but the alkalinity is highly variable even within the same complex of wetlands. Marshes have distinctive soils that are typically mineral, but can also accumulate organic material. Soils have characteristics that result from long periods of anaerobic conditions in the soils (e.g., gleyed soils, high organic content, redoximorphic features). The vegetation is characterized by herbaceous plants that are adapted to saturated soil conditions. Common emergent and floating vegetation includes species of *Scirpus* and/or *Schoenoplectus, Typha, Juncus, Potamogeton, Polygonum, Nuphar*, and *Phalaris*. This system may also include areas of relatively deep water with floating-leaved plants (*Lemna, Potamogeton*, and *Brasenia*) and submergent and floating plants (*Myriophyllum, Ceratophyllum*, and *Elodea*).

Enumerated_Domain:
Enumerated_Domain_Value: 182
Enumerated_Domain_Value_Definition: North Pacific Maritime Eelgrass Bed

Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
Eelgrass beds are found throughout the coastal areas of the North Pacific Coast, from southern Oregon (Coos Bay) north into the Gulf of Alaska, Cook Inlet, and Bristol Bay coasts. Intertidal zones are found with clear water in bays, inlets and lagoons, typically dominated by macrophytic algae and marine aquatic angiosperms along the temperate Pacific coast. Subtidal portions are never exposed while intertidal areas support species that can tolerate exposure to the air. Common substrates include marine silts, but may also include exposed bedrock and cobble, where many algal species become attached with holdfasts. Subtidal/lower intertidal in clear water. Substrate is usually marine silts, but may be cobble. Beds are dominated by *Zostera marina*.

Enumerated_Domain:
Enumerated_Domain_Value: 183
Enumerated_Domain_Value_Definition: Columbia Plateau Vernal Pool
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system includes shallow ephemeral water bodies found in very small (3 square meters to 1 acre) to large depressions (1500 square meters to a square mile, average size of vernal pools are 1600 square meters, while average size on non-alkaline playa lakes are 5-10 acres) throughout the exposed volcanic scablands of the Columbia Plateau in Washington, Oregon, and northern Nevada. Most of these pools and lakes are located on massive basalt flows exposed by Pleistocene floods; southward they also occur on andesite or rhyodacite caprock. Inundation is highly irregular, sometimes not occurring for several years. Depressions usually (but not always) fill with water during winter and spring. They are generally dry again within 9 months, though in exceptional times they can remain inundated for two years in a row. Water is from rainfall and snowmelt in relatively small closed basins, on average probably no more than 5-15 times the area of the ponds themselves. Because these pools and playas are perched above the general surrounding landscape, they are not generally subject to runoff from major stream systems. They typically have silty clay soils, sometimes with sandy margins. Pools are often found within a mounded or biscuit-swale topography with *Artemisia* shrub-steppe or rarely *Pinus ponderosa* savanna. In the northern Columbia Plateau, characteristic species are predominantly annual and diverse. Floristically akin to California vernal pool flora (one-third), however, many of the most abundant species are not reported in Californian pools. Characteristic species include *Callitriche marginata, Camissonia tanacetifolia, Elatine* spp., *Epilobium densiflorum (= Boisduvalia densiflora), Eryngium vaseyi, Juncus uncialis, Myosurus X clavicaulis, Plagiobothrys* spp., *Polygonum polygaloides ssp. confertiflorum, Polygonum polygaloides ssp. polygaloides, Psilocarphus brevissimus, Psilocarphus elatior, Psilocarphus oregonus*, and *Trifolium cyathiferum*. *Artemisia ludoviciana ssp. ludoviciana* can occur on better developed soils. In northern Nevada, most of the species by biomass are perennials and include *Polygonum, Rumex, Juncus balticus, Eleocharis, Carex douglasii, Muhlenbergia richardsonis*, and *Polyctenium* species, in addition to *Camissonia tanacetifolia* and

Psilocarphus brevissimus. Endemic plant species *Navarretia leucocephala ssp. diffusa* and *Polyctenium williamsiae* may occur.

Enumerated_Domain:
Enumerated_Domain_Value: 184
Enumerated_Domain_Value_Definition: Rocky Mountain Subalpine-Montane Fen
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system occurs infrequently throughout the Rocky Mountains from Colorado north into Canada. It is confined to specific environments defined by groundwater discharge, soil chemistry, and peat accumulation of at least 40 cm. This system includes extreme rich fens and iron fens, both being quite rare. Fens form at low points in the landscape or near slopes where groundwater intercepts the soil surface. Groundwater inflows maintain a fairly constant water level year-round, with water at or near the surface most of the time. Constant high water levels lead to accumulation of organic material. In addition to peat accumulation and perennially saturated soils, the extreme rich and iron fens have distinct soil and water chemistry, with high levels of one or more minerals such as calcium, magnesium, or iron. These fens usually occur as a mosaic of several plant associations dominated by *Carex aquatilis, Carex limosa, Carex lasiocarpa, Betula nana, Kobresia myosuroides, Kobresia simpliciuscula*, and *Trichophorum pumilum (= Scirpus pumilus)*. *Sphagnum* spp. (peatmoss) is indicative of iron fens. The surrounding landscape may be ringed with other wetland systems, e.g., riparian shrublands, or a variety of upland systems from grasslands to forests.

Enumerated_Domain:
Enumerated_Domain_Value: 185
Enumerated_Domain_Value_Definition: Mediterranean California Subalpine-Montane Fen
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system is found in montane to subalpine elevations confined to specific environments defined by groundwater discharge, soil chemistry, and peat accumulation. This system includes extreme rich fens which are quite rare. Fens form at low points in the landscape or near slopes where groundwater intercepts the soil surface. Groundwater inflows maintain a fairly constant water level year-round, with water at or near the surface most of the time. Constant high water levels lead to accumulation of organic material. In addition to peat accumulation and perennially saturated soils, the extreme rich fens have distinct soil and water chemistry, with high levels of one or more minerals such as calcium and/or magnesium. They usually occur as a mosaic of several plant associations dominated by species of *Carex, Betula, Kobresia*, or *Schoenoplectus*. The surrounding landscape may be ringed with other wetland systems, e.g., riparian shrublands, or a variety of upland systems from grasslands to forests.

Enumerated_Domain:
Enumerated_Domain_Value: 186

Enumerated_Domain_Value_Definition: Northern California Claypan Vernal Pool
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
These systems are shallow ephemeral water bodies found in depressions (up to several hectares in size) among grasslands and open woodlands throughout the northern Central Valley of California. Northern claypan vernal pools include a clay hardpan that retains water inputs throughout some portion of the spring, but typically the depression dries down entirely into early summer months. They tend to be circumneutral to alkaline and slightly saline wetlands with characteristic plant species including *Downingia bella, Downingia insignis, Cressa truxillensis, Plagiobothrys leptocladus (= Allocarya leptoclada), Pogogyne douglasii, Eryngium aristulatum, Veronica peregrina, Lasthenia ferrisiae, Lasthenia glaberrima*, and *Spergularia salina (= Spergularia marina)*. Due to draw-down characteristics, vernal pools typically form concentric rings of similar forb-rich vegetation. Given their relative isolation in upland-dominated landscapes, many endemic plant species are common in California vernal pools.

Enumerated_Domain:
Enumerated_Domain_Value: 187
Enumerated_Domain_Value_Definition: Western Great Plain Closed Depressional Wetland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
These are primarily upland depressional basins. This hydric system is typified by the presence of an impermeable layer such as a dense clay, hydric soil and is usually recharged by rainwater and nearby runoff. They are rarely linked to outside groundwater sources and do not have an extensive watershed.

Enumerated_Domain:
Enumerated_Domain_Value: 188
Enumerated_Domain_Value_Definition: Mediterranean California Serpentine Fen
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is found uncommonly throughout coastal lowlands and high mountains of the Klamath Mountains and surrounding landscapes where serpentine soils are common in cool and moist environments. This system includes unique assemblages of wetlands species restricted to serpentine and ultramafic substrates. These sites remain moist or wet throughout the year and may have substantial *Sphagnum* accumulation. Some may be bogs in the sense of nutrients and moisture primarily coming from rainfall, or more commonly they are seeps or fens maintained by groundwater discharge. Soils are acidic and often derived from ultramafic parent materials. The acidic (6.5-6.7 pH) and nutrient-poor substrates produce severe nitrogen deficiency which favors insectivorous plants. Characteristic plant species include *Darlingtonia californica, Drosera rotundifolia, Eleocharis quinqueflora, Eriophorum crinigerum, Carex californica*, and *Deschampsia caespitosa*. Around the edges of these fens *Chamaecyparis lawsoniana* can occur and form part of the fen. Burning is essential to maintain healthy stands.

Darlingtonia fens are important habitat for rare species that respond positively to burning. Burning at least eliminates some of the tree invaders (*Pinus jeffreyi, Pseudotsuga menziesii, Chamaecyparis lawsoniana*) and maintains a high water table, essential for the fen-dependent plants.

Enumerated_Domain:
Enumerated_Domain_Value: 189
Enumerated_Domain_Value_Definition: Western Great PlainSaline Depression Wetland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is very similar to Western Great Plains Open Freshwater Depression Wetland (CES303.675) and Western Great Plains Closed Depression Wetland (CES303.666). However, strongly saline soils cause both the shallow lakes and depressions and the surrounding areas to be more brackish. Salt encrustations can occur on the surface in some examples of this system, and the soils are severely affected and have poor structure. Species that typify this system are salt-tolerant and halophytic species such as Distichlis spicata, Sporobolus airoides, and Hordeum jubatum. Other commonly occurring taxa include Puccinellia nuttalliana, Salicornia rubra, Schoenoplectus maritimus, Schoenoplectus americanus, Suaeda calceoliformis, Spartina spp., Triglochin maritima, and shrubs such as Sarcobatus vermiculatus and Krascheninnikovia lanata. During exceptionally wet years, an increase in precipitation can dilute the salt concentration in the soils of some examples of this system which may allow for less salt-tolerant species to occur. Communities found within this system may also occur in floodplains (i.e., more open depressions) but probably should not be considered a separate system unless they transition to areas outside the immediate floodplain.

Enumerated_Domain:
Enumerated_Domain_Value: 190
Enumerated_Domain_Value_Definition: Temperate Pacific Freshwater Emergent Marsh
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
Freshwater marshes are found at all elevations below timberline throughout the temperate Pacific Coast and mountains of western North America. In the Pacific Northwest, they are mostly small patch, confined to limited areas in suitable floodplain or basin topography. They are mostly semipermanently flooded, but some marshes have seasonal hydrologic flooding. Water is at or above the surface for most of the growing season. Soils are muck or mineral, and water is high-nutrient. By definition, freshwater marshes are dominated by emergent herbaceous species, mostly graminoids (*Carex, Scirpus* and/or *Schoenoplectus, Eleocharis, Juncus, Typha latifolia*) but also some forbs. Occurrences of this system typically are found in a mosaic with other wetland systems. It is often found along the borders of ponds, lakes or reservoirs that have more open basins and a permanent water source throughout all or most of the year. Some of the specific communities will also be found in the floodplain systems where more extensive bottomlands remain. Common emergent and floating vegetation includes species of

Scirpus and/or *Schoenoplectus, Typha, Eleocharis, Sparganium, Sagittaria, Bidens, Cicuta, Rorippa, Mimulus*, and *Phalaris*. In relatively deep water, there may be occurrences of the freshwater aquatic bed system, where there are floating-leaved genera such as *Lemna, Potamogeton, Polygonum, Nuphar, Hydrocotyle*, and *Brasenia*. A consistent source of freshwater is essential to the function of these systems.

Enumerated_Domain:
Enumerated_Domain_Value: 191
Enumerated_Domain_Value_Definition: Temperate Pacific Subalpine-Montane Wet Meadow
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
Montane and subalpine wet meadows occur in open wet depressions, basins and flats among montane and subalpine forests from California's Transverse and Peninsular ranges north to the Alaskan coastal forests at varying elevations depending on latitude. Sites are usually seasonally wet, often drying by late summer, and many occur in a tension zone between perennial wetlands and uplands, where water tables fluctuate in response to long-term climatic cycles. They may have surface water for part of the year, but depths rarely exceed a few centimeters. Soils are mostly mineral and may show typical hydric soil characteristics, and shallow organic soils may occur as inclusions. This system often occurs as a mosaic of several plant associations with varying dominant herbaceous species that may include *Camassia quamash, Carex bolanderi, Carex utriculata, Carex exsiccata, Dodecatheon jeffreyi, Glyceria striata (= Glyceria elata), Carex nigricans, Calamagrostis canadensis, Juncus nevadensis, Caltha leptosepala ssp. howellii, Veratrum californicum*, and *Scirpus* and/or *Schoenoplectus* spp. Trees occur peripherally or on elevated microsites and include *Picea engelmannii, Abies lasiocarpa, Abies amabilis, Tsuga mertensiana*, and *Chamaecyparis nootkatensis*. Common shrubs may include *Salix* spp., *Vaccinium uliginosum, Betula nana*, and *Vaccinium macrocarpon*. Wet meadows are tightly associated with snowmelt and typically are not subjected to high disturbance events such as flooding.

Enumerated_Domain:
Enumerated_Domain_Value: 192
Enumerated_Domain_Value_Definition: Temperate Pacific Tidal Salt and Brackish Marsh
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
Intertidal salt and brackish marshes are found throughout the Pacific Coast, from south-central Alaska to the central California coast. They are primarily associated with estuaries or coastal lagoons. Salt marshes are limited to bays and behind sand spits or other locations protected from wave action. Typically these areas form with a mixture of inputs from freshwater sources into coastal saltwater, so they commonly co-occur with brackish marshes. This is a small-patch system, confined to specific environments defined by ranges of salinity, tidal inundation regime, and soil texture. Patches usually occur as zonal mosaics of multiple communities. They vary in location and abundance with daily

and seasonal dynamics of freshwater input from inland balanced against evaporation and tidal flooding of saltwater. Summer-dry periods result in decreased freshwater inputs from inland. Hypersaline environments within salt marshes occur in "salt pans" where tidal water collects and evaporates. Characteristic plant species include *Distichlis spicata, Monanthochloe littoralis, Limonium californicum, Jaumea carnosa, Salicornia* spp., *Suaeda* spp., *Batis maritima*, and *Triglochin* spp. Low marshes are located in areas that flood every day and are dominated by a variety of low-growing forbs and low to medium-height graminoids, especially *Salicornia virginica, Distichlis spicata, Schoenoplectus maritimus (= Scirpus maritimus), Schoenoplectus americanus (= Scirpus americanus), Carex lyngbyei*, and *Triglochin maritima*. High marshes are located in areas that flood infrequently and are dominated by medium-tall graminoids and low forbs, especially *Deschampsia caespitosa, Argentina egedii, Juncus balticus*, and *Symphyotrichum subspicatum (= Aster subspicatus)*. Transition zone (slightly brackish) marshes are often dominated by *Typha* spp. or *Schoenoplectus acutus*. *Atriplex prostrata (= Atriplex triangularis), Juncus mexicanus, Phragmites* spp., *Cordylanthus* spp., and *Lilaeopsis masonii* are important species in California. The invasive weed *Lepidium latifolium* is a problem in many of these marshes. Rare plant species include *Cordylanthus maritimus ssp. maritimus*.

Enumerated_Domain:
Enumerated_Domain_Value: 193
Enumerated_Domain_Value_Definition: Inter-Mountain Basin Alkaline Closed Depression
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs on sites that are seasonally to semipermanently flooded, usually retaining water into the growing season and drying completely only in drought years. Many are associated with hot and cold springs, located in basins with internal drainage. Soils are alkaline to saline clays with hardpans. Seasonal drying exposes mudflats colonized by annual wetland vegetation. Salt encrustations can occur on the surface in some examples of this system, and the soils are severely affected and have poor structure. Species that typify this system are salt-tolerant and halophytic species such as Distichlis spicata, Puccinellia lemmonii, Poa secunda, Muhlenbergia spp., Leymus triticoides (= Elymus triticoides), Schoenoplectus maritimus, Schoenoplectus americanus, Triglochin maritima, and Salicornia spp. During exceptionally wet years, an increase in precipitation can dilute the salt concentration in the soils of some examples of this system which may allow for less salt-tolerant species to occur. Communities found within this system may also occur in floodplains (i.e., more open depressions), but probably should not be considered a separate system unless they transition to areas outside the immediate floodplain. Types often occur along the margins of perennial lakes, in alkaline closed basins, with extremely low-gradient shorelines. This system is very similar to Western Great Plains Closed Depression Wetland (CES303.666).

Enumerated_Domain:
Enumerated_Domain_Value: 194

Enumerated_Domain_Value_Definition: Columbia Plateau Silver Sagebrush Seasonally Flooded Shrub-Steppe
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system includes sagebrush communities occurring at lowland and montane elevations in the Columbia Plateau-northern Great Basin region, east almost to the Great Plains. These are generally depressional wetlands or non-alkaline playas, occurring as small- or occasionally large-patch communities, in a sagebrush or montane forest matrix. Climate is generally semi-arid, although it can be cool in montane areas. This system occurs in poorly drained depressional wetlands, the largest characterized as playas, the smaller as vernal pools, or along seasonal stream channels in valley bottoms or mountain meadows. *Artemisia cana ssp. bolanderi* or *Artemisia cana ssp. viscidula* are dominant, with *Artemisia tridentata ssp. tridentata, Artemisia tridentata ssp. wyomingensis*, or *Artemisia tridentata ssp. vaseyana* occasionally codominant; *Dasiphora fruticosa ssp. floribunda* can also be codominant. Understory graminoids and forbs are characteristic, with *Poa secunda (= Poa nevadensis), Poa cusickii, Festuca idahoensis, Muhlenbergia filiformis, Muhlenbergia richardsonis*, and *Leymus cinereus* dominant at the drier sites; *Eleocharis palustris, Deschampsia caespitosa*, and *Carex* species dominate at wetter or higher-elevation sites.

Enumerated_Domain:
Enumerated_Domain_Value: 195
Enumerated_Domain_Value_Definition: Mediterranean California Serpentine Foothill and Lower Montane Riparian Woodland and Seep
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is found mostly in the central and inner northern Coast Ranges of California and Sierra Nevada foothills. It includes springs, seeps, and perennial and intermittent streams in serpentine substrates (true serpentinite but also other related substrates). Characteristic species include Salix breweri, Cupressus sargentii, Frangula californica ssp. tomentella (= Rhamnus tomentella), Umbellularia californica, Cirsium fontinale, Stachys albens, Solidago spp., Packera clevelandii (= Senecio clevelandii), Mimulus glaucescens, Mimulus guttatus, Aquilegia eximia, and Carex serratodens. Riparian portions of this system are disturbance-driven and require limited flooding, scour and deposition for germination and maintenance.

Enumerated_Domain:
Enumerated_Domain_Value: 196
Enumerated_Domain_Value_Definition: Northwestern Great Plains Riparian
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system is found in the riparian areas of medium and small rivers and streams throughout the northwestern Great Plains. It is likely most common in the Northern Great Plains Steppe. This system occurs in the Upper Missouri and tributaries starting at the Niobrara, White, Cheyenne, Belle Fourche, Moreau, Grand, Heart, Little Missouri,

Yellowstone, Powder, Tongue, Bighorn, Wind, Milk, Musselshell, Marias, and Teton rivers; and in Canada, the Southern Saskatchewan, Red Deer and Old Man rivers to where they extend into Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821) or Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland (CES306.804). These are found on alluvial soils in highly variable landscape settings, from deep cut ravines to wide, braided streambeds. Hydrologically, these tend to be more flashy with less developed floodplain than on larger rivers, and typically dry down completely for some portion of the year. Dominant vegetation shares much with generally drier portions of larger floodplain systems downstream, but overall abundance of vegetation is generally lower. Communities within this system range from riparian forests and shrublands to gravel/sand flats. Dominant species include *Populus deltoides, Populus balsamifera ssp. trichocarpa, Salix* spp., *Artemisia cana ssp. cana*, and *Pascopyrum smithii*. These areas are often subjected to heavy grazing and/or agriculture and can be heavily degraded. Another factor is that groundwater depletion and lack of fire have created additional species changes.

Enumerated_Domain:
Enumerated_Domain_Value: 197
*Enumerated_Domain_Value_Definition:*Value is not used in final draft
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This value is not used in final draft

Enumerated_Domain:
Enumerated_Domain_Value: 198
Enumerated_Domain_Value_Definition: Western Great Plains Riparian Woodland and Shrubland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system is found in the riparian areas of medium and small rivers and streams throughout the western Great Plains. It is likely most common in the Shortgrass Prairie and Northern Great Plains Steppe but extends west as far as the Rio Grande in New Mexico and into the Wyoming Basins in the north. Major rivers include the North and South Platte, portions of the Arkansas, Cimarron, Canadian and upper Pecos rivers and tributaries to where they extend into Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland (CES306.821). It is found on alluvial soils in highly variable landscape settings, from deep cut ravines to wide, braided streambeds. Hydrologically, these sites tend to be more flashy with less developed floodplains than on larger rivers that are classified as floodplain systems, and may dry down completely for some portion of the year. Water sources for this riparian system are largely snowmelt near the Rocky Mountains, but it will respond to summer rains. This system includes numerous smaller prairie rivers and streams that are often groundwater-fed, such as the Arikaree River, a tributary of the Republican River. Dominant vegetation shares much with generally drier portions of larger floodplain systems downstream, but overall abundance of vegetation is generally lower. Communities within this system range from

riparian forests and shrublands to gravel/sand flats. Dominant species include Populus deltoides, Salix spp., Artemisia cana ssp. cana, Pascopyrum smithii, Panicum virgatum, Panicum obtusum, Sporobolus cryptandrus, and Schizachyrium scoparium. On the North Platte in southeastern Wyoming, Fraxinus pennsylvanica may be present to dominant. These areas are often subjected to heavy grazing and/or agriculture and can be heavily degraded. Tamarix spp., Elaeagnus angustifolia, and less desirable grasses and forbs can invade degraded examples up through central Colorado. Groundwater depletion and lack of fire have resulted in additional species changes.

Enumerated_Domain:
Enumerated_Domain_Value: 199
Enumerated_Domain_Value_Definition: Mediterranean California Foothill and Lower Montane Riparian Woodland
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This system is found throughout Mediterranean California within a broad elevation range from near sea level up to 300 m (900 feet) in the Coast Ranges and inland to 1500 m (4545 feet). This system often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. The variety of plant associations connected to this system reflects elevation, stream gradient, floodplain width, and flooding events. Dominant trees may include *Alnus rhombifolia, Acer negundo, Alnus rubra* (in Coast Ranges), *Populus fremontii, Salix laevigata, Salix gooddingii, Pseudotsuga menziesii, Platanus racemosa, Quercus agrifolia*, and *Acer macrophyllum* (in central and south coast). Dominant shrubs include *Salix exigua* and *Salix lasiolepis*. Exotic trees *Ailanthus altissima, Eucalyptus* spp., and herbs such as *Arundo donax* occur. These are disturbance-driven systems that require flooding, scour and deposition for germination and maintenance.

Enumerated_Domain:
Enumerated_Domain_Value: 200
Enumerated_Domain_Value_Definition: Rocky Mountain Bigtooth Maple Ravine
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs in cool ravines, on toeslopes and slump benches associated with riparian areas in the northern and central Wasatch Range and Tavaputs Plateau extending into southern Idaho, as well as in scattered localities in southwestern Utah, central Arizona and New Mexico and the Trans-Pecos of Texas. Substrates are typically rocky colluvial or alluvial soils with favorable soil moisture. These woodlands are dominated by *Acer grandidentatum* but may include mixed stands codominated by *Quercus gambelii* or with scattered conifers. Some stands may include *Acer negundo* or *Populus tremuloides* as minor components. It also occurs on steeper, north-facing slopes at higher elevations, often adjacent to Rocky Mountain Gambel Oak-Mixed Montane Shrubland (CES306.818) or Rocky Mountain Aspen Forest and Woodland (CES306.813).

Enumerated_Domain:
Enumerated_Domain_Value: 201
Enumerated_Domain_Value_Definition: Rocky Mountain Gambel Oak-Mixed Montane
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
This ecological system occurs in the mountains, plateaus and foothills of the southern Rocky Mountains and Colorado Plateau, including the Uinta and Wasatch ranges and the Mogollon Rim. These shrublands are most commonly found along dry foothills, lower mountain slopes, and at the edge of the western Great Plains from approximately 2000 to 2900 m in elevation, and are often situated above pinyon-juniper woodlands. Substrates are variable and include soil types ranging from calcareous, heavy, fine-grained loams to sandy loams, gravelly loams, clay loams, deep alluvial sand, or coarse gravel. The vegetation is typically dominated by *Quercus gambelii* alone or codominant with *Amelanchier alnifolia, Amelanchier utahensis, Artemisia tridentata, Cercocarpus montanus, Prunus virginiana, Purshia stansburiana, Purshia tridentata, Robinia neomexicana, Symphoricarpos oreophilus*, or *Symphoricarpos rotundifolius*. There may be inclusions of other mesic montane shrublands with *Quercus gambelii* absent or as a relatively minor component. This ecological system intergrades with the lower montane-foothills shrubland system and shares many of the same site characteristics. Density and cover of *Quercus gambelii* and *Amelanchier* spp. often increase after fire.

Enumerated_Domain:
Enumerated_Domain_Value: 202
Enumerated_Domain_Value_Definition: Mediterranean California Alkali Marsh
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
These highly variable systems occur in scattered locations throughout the California Central Valley and along California's south coast extending into Baja Norte, all at elevations below 300 m (1000 feet). They are found in old lake beds or in floodplains of major river systems where seasonal water inputs are limited, and often include some groundwater seepage. High rates of evaporation lead to alkaline water and soil conditions, with layers of salt encrusted soils often accumulating near seeps. These are highly variable in plant composition, but often include *Distichlis spicata, Juncus balticus, Anemopsis californica, Schoenoplectus americanus (= Scirpus americanus), Atriplex* spp., *Triglochin maritima*, and *Cirsium* spp. Endemic plant species include *Puccinellia howellii*.

Enumerated_Domain:
Enumerated_Domain_Value: 203
Enumerated_Domain_Value_Definition: Rocky Mountain Alpine Tundra/Fell-field/Dwarf-shrub Map Unit
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
Rocky Mountain Alpine Turf/Fell-field/Dwarf-shrub Map Unit This map unit combines three alpine Ecological Systems in Map Zones where it was not considered feasible to

separate them into separate classes. These three Ecological Systems are the' Rocky Mountain Alpine Turf', 'Rocky Mountain Alpine Fell-Field' and the 'Rocky Mountain Alpine Dwarf-Shrubland'.

Rocky Mountain Alpine Turf
This widespread ecological system occurs above upper treeline throughout the Rocky Mountain cordillera, including alpine areas of ranges in Utah and Nevada, and isolated alpine sites in the northeastern Cascades. It is found on gentle to moderate slopes, flat ridges, valleys, and basins, where the soil has become relatively stabilized and the water supply is more or less constant. Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost, and a short growing season. This system is characterized by a dense cover of low-growing, perennial graminoids and forbs. Rhizomatous, sod-forming sedges are the dominant graminoids, and prostrate and mat-forming plants with thick rootstocks or taproots characterize the forbs. Dominant species include Artemisia arctica, Carex elynoides, Carex siccata, Carex scirpoidea, Carex nardina, Carex rupestris, Festuca brachyphylla, Festuca idahoensis, Geum rossii, Kobresia myosuroides, Phlox pulvinata, and Trifolium dasyphyllum. Many other graminoids, forbs, and prostrate shrubs can also be found, including Calamagrostis purpurascens, Deschampsia caespitosa, Dryas octopetala, Leucopoa kingii, Poa arctica, Saxifraga spp., Selaginella densa, Sibbaldia procumbens, Silene acaulis, Solidago spp., and Trifolium parryi. Although alpine dry tundra is the matrix of the alpine zone, it typically intermingles with alpine bedrock and scree, ice field, fell-field, alpine dwarf-shrubland, and alpine/subalpine wet meadow systems.

Rocky Mountain Alpine Fell-Field
This ecological system is found discontinuously at alpine elevations throughout the Rocky Mountains, west into the mountainous areas of the Great Basin, and north into the Canadian Rockies. Small areas are represented in the west side of the Okanagan Ecoregion in the eastern Cascades. These are wind-scoured fell-fields that are free of snow in the winter, such as ridgetops and exposed saddles, exposing the plants to severe environmental stress. Soils on these windy unproductive sites are shallow, stony, low in organic matter, and poorly developed; wind deflation often results in a gravelly pavement. Most fell-field plants are cushioned or matted, frequently succulent, flat to the ground in rosettes and often densely haired and thickly cutinized. Plant cover is 15-50%, while exposed rocks make up the rest. Fell-fields are usually within or adjacent to alpine tundra dry meadows. Common species include Arenaria capillaris, Geum rossii, Kobresia myosuroides, Minuartia obtusiloba, Myosotis asiatica, Paronychia pulvinata, Phlox pulvinata, Sibbaldia procumbens, Silene acaulis, Trifolium dasyphyllum, and Trifolium parryi.

Rocky Mountain Alpine Dwarf-Shrubland
This widespread ecological system occurs above upper timberline throughout the Rocky Mountain cordillera, including alpine areas of ranges in Utah and Nevada, and north into Canada. Elevations are above 3360 m in the Colorado Rockies but drop to less than 2100 m in northwestern Montana and in the mountains of Alberta. This system occurs in areas

of level or concave glacial topography, with late-lying snow and subirrigation from surrounding slopes. Soils have become relatively stabilized in these sites, are moist but well-drained, strongly acidic, and often with substantial peat layers. Vegetation in these areas is controlled by snow retention, wind desiccation, permafrost, and a short growing season. This ecological system is characterized by a semi-continuous layer of ericaceous dwarf-shrubs or dwarf willows which form a heath type ground cover less than 0.5 m in height. Dense tuffs of graminoids and scattered forbs occur. Dryas octopetala or Dryas integrifolia communities are not included here, except for one very moist association, because they occur on more windswept and drier sites than the heath communities. Within these communities. Cassiope mertensiana, Salix arctica, Salix reticulata, Salix vestita, or Phyllodoce empetriformis can be dominant shrubs. Vaccinium spp., Ledum glandulosum, Phyllodoce glanduliflora, and Kalmia microphylla may also be shrub associates. The herbaceous layer is a mixture of forbs and graminoids, especially sedges, including, Erigeron spp., Luetkea pectinata, Antennaria lanata, Oreostemma alpigenum (= Aster alpigenus), Pedicularis spp., Castilleja spp., Deschampsia caespitosa, Caltha leptosepala, Erythronium spp., Juncus parryi, Luzula piperi, Carex spectabilis, Carex nigricans, and Polygonum bistortoides. Fellfields often intermingle with the alpine dwarf-shrubland.

Enumerated_Domain:
Enumerated_Domain_Value: 204
Enumerated_Domain_Value_Definition: Temperate Pacific Freshwater Mudflat
Enumerated_Domain_Value_Definition_Source:NatureServe-Ecological Systems www.NatureServe.org
Freshwater mudflats are found scattered throughout the temperate regions of the Pacific Coast of North America. In the Pacific Northwest, they occur primarily in seasonally flooded shallow lakebeds on floodplains, especially along the lower Columbia River. During any one year, they may be absent because of year-to-year variation in river water levels. Mudflats must be exposed before the vegetation develops from the seedbank. They are dominated mainly by low-stature annual plants. They range in physiognomy from sparsely vegetated mud to extensive sods of herbaceous vegetation. The predominant species include *Eleocharis obtusa, Lilaeopsis occidentalis, Crassula aquatica, Limosella aquatica, Gnaphalium palustre, Eragrostis hypnoides*, and *Ludwigia palustris*.

Enumerated_Domain:
Enumerated_Domain_Value: 205
Enumerated_Domain_Value_Definition: Non-specific Disturbed
Enumerated_Domain_Value_Definition_Source:National Gap Program
Used in areas with obvious human modification but where specific land use was not known
Attribute:

Attribute_Label: Count
Attribute_Definition: Number of pixels (30 x 30 meter) per class

Attribute:

Attribute_Label: ESLF
Attribute_Definition: Codes used to identify land use type or ecological system in NLCD or LandFire datasets

Attribute:

Attribute_Label: Description
Attribute_Definition: Name of Ecological System

Overview_Description:
Entity_and_Attribute_Overview:
Over the past decade, the partners engaged in regional land cover mapping have gained much practical experience in mapping at thematic and spatial resolutions relevant to resource management. For example, since the mid-1990's, the stated intention of the Gap Analysis Program for land cover mapping has been to use a priori, standard vegetation classification in land cover mapping, and to depict vegetation matching the scale and concept of the vegetation Alliance, as described in the National Vegetation Classification System (US-NVC)(FGDC 1997; Grossman et al. 1998). The vegetation Alliance is a physiognomically uniform group of US-NVC Associations sharing one or more dominant or diagnostic species, which as a rule are found in the uppermost strata of the vegetation (see Mueller-Dombois and Ellenberg 1974). NatureServe - along with the network of Natural Heritage Programs - have worked with others since 1985 on the systematic development, documentation, and description of vegetation types across the United States. Products from this on-going effort include a hierarchical vegetation classification standard (FGDC 1997) and the description of vegetation Alliances for the United States (e.g. Drake and Faber-Langendoen 1997, Reid et al. 1999). GAP efforts to map vegetation on a statewide scale had considerable difficulty achieving desired levels of mapping accuracy for map units reflecting all US-NVC Alliances. This is due to the reality that not all Alliances occur in sufficiently large and distinctive patches easily mapped with satellite imagery. For example, many wetlands and upland areas of herbaceous vegetation may include several Alliances co-mingled within a one-hectare area. New approaches are required that will 1) allow more broadly defined standard map units to be utilized to achieve desired map accuracy, 2) maintain a direct link to the US-NVC hierarchy, and 3) not preclude the ability of future analysts to meet the stated "Alliance-scale" goal with future technical refinements.

One alternative is to generate more accurate map units driven by a NatureServe classification of more broadly defined units called terrestrial ecological systems. Ecological system units are groups of US-NVC Associations from two or more Alliances that tend to occur together on a given landscape due to similar ecological dynamics (e.g., fire, riverine flooding), underlying environmental features (e.g., deep soils, serpentine bedrock), and/or environmental gradients (elevation). For example, along the Colorado Front Range, Rocky Mountain Foothill Riparian Forest and Shrubland systems include several low-elevation willow and cottonwood-dominated plant Alliances/Associations that all require periodic flooding. Ecological Systems provide additional "mid-scaled" units as a basis for analyzing existing vegetation patterns, habitat usage by animals and plants, and systems-level comparisons across multiple jurisdictions. They also provide useful, systematically defined, groupings of US-NVC Alliances and Associations, forming the basis of map units where Alliance and/or Association level mapping is impractical (Menard and Lauver 2000; Comer and Schulz 2004). NatureServe has developed a classification of terrestrial ecological systems for the coterminous United States (Comer et al. 2003; Josse et al. 2003). A database with description and distribution information is available from the NatureServe website at: <http://www.natureserve.org/getData/ecologyData.jsp#US>.

Distribution_Information:
Distributor:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Anne Davidson
Contact_Organization: USGS GAP
Contact_Position: Senior GIS/Remote Sensing Specialist
Resource_Description: Downloadable Data
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Transfer_Size: 0.000
Fees: none
Ordering_Instructions: <http://www.gap.uidaho.edu/Northwest/data.htm>
Turnaround: ftp

Metadata_Reference_Information:
Metadata_Date: 20081218
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization:
REQUIRED: Anne Davidson
Contact_Person: REQUIRED: Anne Davidson
Contact_Address:
Address_Type:
530 S. Asburry St. Suite 1
City: Moscow

State_or_Province: Idaho
Postal_Code: 83843
Contact_Voice_Telephone:
:208-885-3720
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time
Metadata_Extensions:
Online_Linkage: <http://www.esri.com/metadata/esriprof80.html>
Profile_Name: ESRI Metadata Profile

Appendix C: Comparison between OTA Vegetation Classification and GAP Ecological Systems, USGS Mapping Zone 18

Appendix C.1. The Gap Ecological Systems vegetation classes that occur on the same areas classified as big sagebrush (*Artemesia tridentata*) by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Inter-Mountain Basins Big Sagebrush Shrubland	55.79
Introduced Upland Vegetation - Annual Grassland	24.26
Columbia Plateau Steppe and Grassland	6.30
Inter-Mountain Basins Semi-Desert Shrub-Steppe	5.58
Inter-Mountain Basins Big Sagebrush Steppe	2.28
Inter-Mountain Basins Semi-Desert Grassland	1.89
Cultivated Cropland	1.68
Developed, Open Space	0.77
Inter-Mountain Basins Mixed Salt Desert Scrub	0.55
Inter-Mountain Basins Greasewood Flat	0.47
Columbia Basin Foothill and Canyon Dry Grassland	0.17
Recently burned grassland	0.11
Developed, Low Intensity	0.07
Inter-Mountain Basins Cliff and Canyon	0.03
Developed, Medium Intensity	0.02
Pasture/Hay	0.02
Columbia Basin Foothill Riparian Woodland and Shrubland	0.01
Introduced Upland Vegetation - Annual and Biennial Forbland	0.01
Columbia Plateau Ash and Tuff Badland	0.00
Developed, High Intensity	0.00
Columbia Plateau Western Juniper Woodland and Savanna	0.00
Rocky Mountain Aspen Forest and Woodland	0.00
Grand Total	100

Appendix C.2. The Gap Ecological Systems vegetation classes that occur on the same areas classified as shadscale (*Atriplex confertifolia*) by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Inter-Mountain Basins Mixed Salt Desert Scrub	46.36
Introduced Upland Vegetation - Annual Grassland	18.06
Inter-Mountain Basins Big Sagebrush Shrubland	15.57
Inter-Mountain Basins Semi-Desert Shrub-Steppe	11.79
Columbia Plateau Steppe and Grassland	4.62
Inter-Mountain Basins Greasewood Flat	1.69
Cultivated Cropland	0.45
Developed, Open Space	0.45
Columbia Plateau Ash and Tuff Badland	0.30
Inter-Mountain Basins Semi-Desert Grassland	0.26
Pasture/Hay	0.26
Developed, Low Intensity	0.07
Introduced Upland Vegetation - Annual and Biennial Forbland	0.05
Developed, Medium Intensity	0.02
Columbia Basin Foothill and Canyon Dry Grassland	0.01
Inter-Mountain Basins Big Sagebrush Steppe	0.01
Columbia Basin Foothill Riparian Woodland and Shrubland	0.01
Recently burned grassland	0.00
Columbia Plateau Western Juniper Woodland and Savanna	0.00
Open Water	0.00
Developed, High Intensity	0.00
Inter-Mountain Basins Cliff and Canyon	0.00
Grand Total	100.00

Appendix C.3. The Gap Ecological Systems vegetation classes that occur on the same areas classified as cheatgrass (*Bromus tectorum*) by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Introduced Upland Vegetation - Annual Grassland	59.02
Inter-Mountain Basins Big Sagebrush Shrubland	20.58
Columbia Plateau Steppe and Grassland	10.34
Inter-Mountain Basins Semi-Desert Shrub-Steppe	4.03
Inter-Mountain Basins Semi-Desert Grassland	2.97
Inter-Mountain Basins Mixed Salt Desert Scrub	1.33
Developed, Open Space	0.54
Cultivated Cropland	0.49
Inter-Mountain Basins Big Sagebrush Steppe	0.37
Inter-Mountain Basins Greasewood Flat	0.23
Pasture/Hay	0.03
Developed, Low Intensity	0.03
Columbia Basin Foothill and Canyon Dry Grassland	0.02
Developed, Medium Intensity	0.01
Columbia Basin Foothill Riparian Woodland and Shrubland	0.01
Recently burned grassland	0.00
Columbia Plateau Ash and Tuff Badland	0.00
Introduced Upland Vegetation - Annual and Biennial Forbland	0.00
Inter-Mountain Basins Cliff and Canyon	0.00
Unconsolidated Shore	0.00
Columbia Plateau Western Juniper Woodland and Savanna	0.00
Grand Total	100.00

Appendix C.4. The Gap Ecological Systems vegetation classes that occur on the same areas classified as winterfat (*Ceratoides lanata*) by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Inter-Mountain Basins Mixed Salt Desert Scrub	31.98
Inter-Mountain Basins Big Sagebrush Shrubland	19.88
Introduced Upland Vegetation - Annual Grassland	16.46
Inter-Mountain Basins Semi-Desert Shrub-Steppe	14.23
Columbia Plateau Steppe and Grassland	11.29
Columbia Plateau Ash and Tuff Badland	3.16
Inter-Mountain Basins Greasewood Flat	1.45
Developed, Open Space	0.64
Inter-Mountain Basins Semi-Desert Grassland	0.27
Inter-Mountain Basins Big Sagebrush Steppe	0.26
Developed, Low Intensity	0.13
Introduced Upland Vegetation - Annual and Biennial Forbland	0.09
Developed, Medium Intensity	0.05
Columbia Basin Foothill and Canyon Dry Grassland	0.03
Cultivated Cropland	0.03
Pasture/Hay	0.03
Inter-Mountain Basins Cliff and Canyon	0.00
Columbia Basin Foothill Riparian Woodland and Shrubland	0.00
Developed, High Intensity	0.00
Unconsolidated Shore	0.00
Columbia Plateau Western Juniper Woodland and Savanna	0.00
Open Water	0.00
Grand Total	100.00

Appendix C.5. The Gap Ecological Systems vegetation classes that occur on the same areas classified as rabbitbrush (*Chrysothamnus visidiflores*) by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Introduced Upland Vegetation - Annual Grassland	40.73
Inter-Mountain Basins Big Sagebrush Shrubland	24.42
Inter-Mountain Basins Semi-Desert Shrub-Steppe	22.68
Columbia Plateau Steppe and Grassland	5.20
Inter-Mountain Basins Semi-Desert Grassland	4.20
Inter-Mountain Basins Big Sagebrush Steppe	0.90
Developed, Open Space	0.62
Cultivated Cropland	0.48
Recently burned grassland	0.48
Columbia Basin Foothill Riparian Woodland and Shrubland	0.11
Inter-Mountain Basins Mixed Salt Desert Scrub	0.07
Developed, Low Intensity	0.04
Pasture/Hay	0.04
Inter-Mountain Basins Greasewood Flat	0.02
Columbia Basin Foothill and Canyon Dry Grassland	0.01
Developed, Medium Intensity	0.00
Introduced Upland Vegetation - Annual and Biennial Forbland	0.00
Unconsolidated Shore	0.00
Developed, High Intensity	0.00
Inter-Mountain Basins Cliff and Canyon	0.00
Columbia Plateau Western Juniper Woodland and Savanna	0.00
Grand Total	100.00

Appendix C.6. The Gap Ecological Systems vegetation classes that occur on the same areas classified as Sandberg's bluegrass (*Poa sandbergii*) by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Introduced Upland Vegetation - Annual Grassland	56.08
Columbia Plateau Steppe and Grassland	20.58
Inter-Mountain Basins Big Sagebrush Shrubland	10.28
Inter-Mountain Basins Semi-Desert Shrub-Steppe	4.73
Inter-Mountain Basins Semi-Desert Grassland	4.48
Inter-Mountain Basins Mixed Salt Desert Scrub	3.45
Developed, Open Space	0.18
Columbia Plateau Ash and Tuff Badland	0.06
Cultivated Cropland	0.05
Inter-Mountain Basins Greasewood Flat	0.03
Recently burned grassland	0.03
Inter-Mountain Basins Big Sagebrush Steppe	0.03
Developed, Low Intensity	0.01
Developed, Medium Intensity	0.01
Introduced Upland Vegetation - Annual and Biennial Forbland	0.00
Open Water	0.00
Pasture/Hay	0.00
Inter-Mountain Basins Cliff and Canyon	0.00
Columbia Basin Foothill Riparian Woodland and Shrubland	0.00
Grand Total	100.00

Appendix C.7. The Gap Ecological Systems vegetation classes that occur on the same areas classified as exotic annuals – exotic invader by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Introduced Upland Vegetation - Annual Grassland	54.37
Columbia Plateau Steppe and Grassland	12.91
Inter-Mountain Basins Big Sagebrush Shrubland	10.25
Inter-Mountain Basins Mixed Salt Desert Scrub	8.16
Inter-Mountain Basins Semi-Desert Shrub-Steppe	6.73
Recently burned grassland	3.21
Inter-Mountain Basins Semi-Desert Grassland	1.97
Columbia Plateau Ash and Tuff Badland	0.96
Developed, Open Space	0.46
Inter-Mountain Basins Greasewood Flat	0.29
Cultivated Cropland	0.28
Developed, Low Intensity	0.22
Inter-Mountain Basins Big Sagebrush Steppe	0.10
Introduced Upland Vegetation - Annual and Biennial Forbland	0.07
Columbia Basin Foothill Riparian Woodland and Shrubland	0.02
Developed, Medium Intensity	0.01
Pasture/Hay	0.00
Columbia Basin Foothill and Canyon Dry Grassland	0.00
Inter-Mountain Basins Cliff and Canyon	0.00
Developed, High Intensity	0.00
Grand Total	100.00

Appendix C.8. The Gap Ecological Systems vegetation classes that occur on the same areas classified as miscellaneous water by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Inter-Mountain Basins Big Sagebrush Shrubland	18.99
Columbia Basin Foothill and Canyon Dry Grassland	15.75
Cultivated Cropland	9.15
Inter-Mountain Basins Big Sagebrush Steppe	6.91
Developed, Low Intensity	6.72
Pasture/Hay	5.95
Inter-Mountain Basins Greasewood Flat	5.66
Introduced Upland Vegetation - Annual Grassland	4.90
Columbia Basin Foothill Riparian Woodland and Shrubland	4.61
Open Water	4.30
Developed, Medium Intensity	3.90
Inter-Mountain Basins Cliff and Canyon	3.68
Developed, Open Space	3.52
Inter-Mountain Basins Mixed Salt Desert Scrub	2.47
Developed, High Intensity	1.35
Columbia Plateau Steppe and Grassland	0.92
Inter-Mountain Basins Semi-Desert Shrub-Steppe	0.41
North American Arid West Emergent Marsh	0.29
Columbia Plateau Western Juniper Woodland and Savanna	0.29
Introduced Upland Vegetation - Annual and Biennial Forbland	0.11
Rocky Mountain Lower Montane Foothill Shrubland	0.06
Columbia Plateau Ash and Tuff Badland	0.03
Inter-Mountain Basins Semi-Desert Grassland	0.02
Unconsolidated Shore	0.02
Rocky Mountain Aspen Forest and Woodland	0.00
Recently burned grassland	0.00
Grand Total	100.00

Appendix C.9. The Gap Ecological Systems vegetation classes that occur on the same areas classified as primary agriculture (active during the analysis) by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Cultivated Cropland	46.18
Pasture/Hay	37.10
Developed, Open Space	5.49
Introduced Upland Vegetation - Annual Grassland	4.39
Inter-Mountain Basins Big Sagebrush Shrubland	2.37
Inter-Mountain Basins Greasewood Flat	1.04
Developed, Low Intensity	0.80
Columbia Basin Foothill Riparian Woodland and Shrubland	0.73
Columbia Plateau Steppe and Grassland	0.49
Inter-Mountain Basins Big Sagebrush Steppe	0.37
Inter-Mountain Basins Semi-Desert Shrub-Steppe	0.27
Inter-Mountain Basins Mixed Salt Desert Scrub	0.21
Developed, Medium Intensity	0.16
Open Water	0.11
Columbia Basin Foothill and Canyon Dry Grassland	0.08
Columbia Plateau Ash and Tuff Badland	0.06
Columbia Plateau Western Juniper Woodland and Savanna	0.03
Developed, High Intensity	0.03
Introduced Upland Vegetation - Annual and Biennial Forbland	0.03
Inter-Mountain Basins Semi-Desert Grassland	0.02
Unconsolidated Shore	0.01
North American Arid West Emergent Marsh	0.01
Recently burned grassland	0.01
Rocky Mountain Aspen Forest and Woodland	0.00
Inter-Mountain Basins Cliff and Canyon	0.00
Inter-Mountain Basins Montane Sagebrush Steppe	0.00
Grand Total	100.00

Appendix C.10. The Gap Ecological Systems vegetation classes that occur on the same areas classified as secondary agriculture (inactive but previously farmed) by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Cultivated Cropland	37.98
Pasture/Hay	21.95
Introduced Upland Vegetation - Annual Grassland	20.28
Inter-Mountain Basins Big Sagebrush Shrubland	9.55
Developed, Open Space	4.23
Columbia Plateau Steppe and Grassland	1.08
Columbia Basin Foothill and Canyon Dry Grassland	1.01
Inter-Mountain Basins Big Sagebrush Steppe	0.93
Inter-Mountain Basins Greasewood Flat	0.69
Inter-Mountain Basins Mixed Salt Desert Scrub	0.60
Developed, Low Intensity	0.54
Columbia Basin Foothill Riparian Woodland and Shrubland	0.42
Inter-Mountain Basins Semi-Desert Shrub-Steppe	0.27
Inter-Mountain Basins Cliff and Canyon	0.12
Recently burned grassland	0.10
Developed, Medium Intensity	0.06
Inter-Mountain Basins Semi-Desert Grassland	0.05
Introduced Upland Vegetation - Annual and Biennial Forbland	0.04
Open Water	0.03
Unconsolidated Shore	0.03
Columbia Plateau Western Juniper Woodland and Savanna	0.02
Developed, High Intensity	0.01
Columbia Plateau Ash and Tuff Badland	0.01
Rocky Mountain Aspen Forest and Woodland	0.01
North American Arid West Emergent Marsh	0.00
Rocky Mountain Lower Montane Foothill Shrubland	0.00
Grand Total	100.00

Appendix C.11. The Gap Ecological Systems vegetation classes that occur on the same areas classified as Snake River proper by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Open Water	88.71
Columbia Basin Foothill Riparian Woodland and Shrubland	3.94
Columbia Basin Foothill and Canyon Dry Grassland	2.27
Columbia Plateau Steppe and Grassland	1.97
Inter-Mountain Basins Big Sagebrush Shrubland	0.91
Pasture/Hay	0.68
North American Arid West Emergent Marsh	0.35
Cultivated Cropland	0.33
Inter-Mountain Basins Big Sagebrush Steppe	0.27
Inter-Mountain Basins Greasewood Flat	0.22
Developed, Open Space	0.14
Columbia Plateau Western Juniper Woodland and Savanna	0.09
Introduced Upland Vegetation - Annual Grassland	0.09
Inter-Mountain Basins Cliff and Canyon	0.02
Developed, Low Intensity	0.00
Inter-Mountain Basins Montane Sagebrush Steppe	0.00
Grand Total	100.00

Appendix C.12. The Gap Ecological Systems vegetation classes that occur on the same areas classified as cindered areas (volcanic) by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Inter-Mountain Basins Big Sagebrush Shrubland	31.27
Introduced Upland Vegetation - Annual Grassland	28.32
Inter-Mountain Basins Mixed Salt Desert Scrub	11.45
Developed, Open Space	5.44
Developed, Low Intensity	5.21
Inter-Mountain Basins Greasewood Flat	3.87
Developed, Medium Intensity	3.82
Developed, High Intensity	2.48
Columbia Basin Foothill and Canyon Dry Grassland	2.33
Columbia Plateau Steppe and Grassland	2.32
Inter-Mountain Basins Cliff and Canyon	1.06
Cultivated Cropland	0.77
Inter-Mountain Basins Semi-Desert Shrub-Steppe	0.47
Inter-Mountain Basins Big Sagebrush Steppe	0.34
Columbia Plateau Ash and Tuff Badland	0.30
Introduced Upland Vegetation - Annual and Biennial Forbland	0.21
Inter-Mountain Basins Semi-Desert Grassland	0.17
Recently burned grassland	0.07
Open Water	0.04
Columbia Basin Foothill Riparian Woodland and Shrubland	0.04
Pasture/Hay	0.01
Columbia Plateau Western Juniper Woodland and Savanna	0.00
Grand Total	100.00

Appendix C.13. The Gap Ecological Systems vegetation classes that occur on the same areas classified as bare ground areas by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Introduced Upland Vegetation - Annual Grassland	59.02
Inter-Mountain Basins Big Sagebrush Shrubland	20.58
Columbia Plateau Steppe and Grassland	10.34
Inter-Mountain Basins Semi-Desert Shrub-Steppe	4.03
Inter-Mountain Basins Semi-Desert Grassland	2.97
Inter-Mountain Basins Mixed Salt Desert Scrub	1.33
Developed, Open Space	0.54
Cultivated Cropland	0.49
Inter-Mountain Basins Big Sagebrush Steppe	0.37
Inter-Mountain Basins Greasewood Flat	0.23
Pasture/Hay	0.03
Developed, Low Intensity	0.03
Columbia Basin Foothill and Canyon Dry Grassland	0.02
Developed, Medium Intensity	0.01
Columbia Basin Foothill Riparian Woodland and Shrubland	0.01
Recently burned grassland	0.00
Columbia Plateau Ash and Tuff Badland	0.00
Introduced Upland Vegetation - Annual and Biennial Forbland	0.00
Inter-Mountain Basins Cliff and Canyon	0.00
Unconsolidated Shore	0.00
Columbia Plateau Western Juniper Woodland and Savanna	0.00
Grand Total	100.00

Appendix C.14. The Gap Ecological Systems vegetation classes that occur on the same areas classified as playa areas (ephemeral ponds) by the OTA vegetation classification.

GAP Ecological Systems Habitat Classes	Percentage
Columbia Plateau Ash and Tuff Badland	30.89
Inter-Mountain Basins Big Sagebrush Shrubland	20.72
Developed, Low Intensity	16.23
Developed, Medium Intensity	10.78
Introduced Upland Vegetation - Annual Grassland	8.56
Developed, High Intensity	7.66
Developed, Open Space	1.18
Inter-Mountain Basins Mixed Salt Desert Scrub	1.18
Cultivated Cropland	0.85
Columbia Plateau Steppe and Grassland	0.60
Pasture/Hay	0.60
Columbia Basin Foothill and Canyon Dry Grassland	0.33
Inter-Mountain Basins Semi-Desert Shrub-Steppe	0.28
Inter-Mountain Basins Big Sagebrush Steppe	0.07
Introduced Upland Vegetation - Annual and Biennial Forbland	0.04
Inter-Mountain Basins Cliff and Canyon	0.03
Grand Total	100.00