

# EDAPHIC FACTORS THAT CHARACTERIZE THE DISTRIBUTION OF *LEPIDIUM* *PAPILLIFERUM*

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*LEPIDIUMPAPILLIFERUM***

FINAL REPORT

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This report resulted from a Cooperative Challenge Cost Share Project between

Bureau of Land Management  
Boise Field Office  
3948 S. Development Avenue  
Boise, Idaho 83705

and

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*Cover drawing courtesy of the Idaho Army National Guard*

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### Summary:

*Lepidium papilliferum*, known as slick spot peppergrass, grows on visually distinct microsites within remnant communities of relatively undisturbed and moderately disturbed Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). This species is a Federal Category 2 candidate for listing as Threatened or Endangered. Its known range is southwestern Idaho where rapid habitat alteration is occurring. Typical *Lepidium* microsites are variously described as "slick spots", "playettes", and "natric sites", implying a soil-chemistry explanation for the typical sparsity of vegetation and the low water permeability sometimes observed. This study examines soil factors that affect the distribution of *Lepidium*-microsites. It describes the soil morphology and chemistry of *Lepidium*-slick spots and nearby shrub interspaces of three *Lepidium* populations that occur on distinct landscape units of the Lower Snake River Plain. Slick spots are best distinguished by a near-surface distribution of soluble sodium salts, thin vesicular surface crusts and shallow well-developed argillic horizons. High salinity and high sodium concentrations relative to soluble calcium and magnesium occur within 40 cm of the soil surface and the argillic horizons probably qualify as natric soil horizons. Searches for new *Lepidium* populations and habitat might best be focussed on remnant Pleistocene land surfaces where current soil surveys document occurrences of saline and natric soil series among the general matrix of non-saline Aridisols.

## Introduction

*Lepidium papilliferum* is a small annual mustard endemic to loess-capped soils of the lower Snake River Plain and foothill ridges adjacent to the plain in southern Idaho (Moseley, 1994). It is found in remnants of relatively undisturbed to moderately disturbed communities of Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). Typically, the habitat with vigorous *Lepidium* populations has not been recently burned, is not heavily grazed, has an understory of native bunchgrasses, and a well developed microbotic soil crust. *Lepidium papilliferum* is a federal category 2 (C2) candidate for listing as Threatened or Endangered and it is included on the Idaho Bureau of Land Management (BLM) list of special status plant species.

*Lepidium papilliferum*, commonly known as slick spot peppergrass, grows on visually distinct microsities within the sagebrush community. The typical peppergrass microsities are open areas up to 4 m in cross-section. They are variously described as "slick spots", "mini playas", or as "natric sites", implying a soil-chemistry explanation for the typical sparsity of vegetation and the low water permeability sometimes observed. Meyer and Quinney (1993) concluded that these microsities are slight landscape depressions that collect water from adjacent areas. They surmised that for *Lepidium* populations growing on the basalt plains of the lower Snake River, a tolerance for short-term "flooding" allows the species to occupy depressional microsities, whereas other intolerant plant species do not.

Not all slick spot microsities bear the peppergrass, however, and not all interspaces between the sagebrush canopies are like slick spots. The landscape microtopography is a mosaic of small coppices formed under and around shrubs and perennial grasses, interspersed with gently sloping to nearly flat interspace areas. The surface and soil characteristics of interspaces vary, depending on proximity to shrub coppices and to the size and slope of the interspace (Eckert 1986). Most interspaces found in the *Lepidium* habitat are relatively small (1 to 2 m in cross-section) and are formed in the extremely gentle swales between the shrub coppices. In contrast with slick spots, the shrub interspace surfaces are uneven and hummocky, do not appear to be compacted, and are sparsely covered by perennial grasses and weedy annuals. *Lepidium papilliferum* rarely grows on these areas.

The BLM administers most of the public land containing *Lepidium* habitat. This habitat is being altered at an alarming rate by urban sprawl, agricultural activities and rangeland fires (Moseley, 1994). Annual grasses are replacing the burned shrub communities, changing the vegetative features of the landscape (Whisenant, 1990). *Bromus tectorum* (cheatgrass) and *Lepidium perfoliatum* (clasping pepperweed), both exotic annuals, are invading slick spots in otherwise intact shrub communities. To address the ecological problems that these circumstances create, biologists must know the critical characteristics that make a *Lepidium* microsite, the variability of those characteristics, and how to identify *Lepidium* microsities even when the species is not present or the whole vegetative community is changed.

This study, conducted in 1991, compares soil morphology and non-visual soil properties of *Lepidium*-bearing slick spots with those of shrub interspaces without *Lepidium*. The purpose is to identify what soil properties, if any, define the landscape-level distribution of *Lepidium* and to identify whether these properties are correlated with visual site-cues.

## Study Area

This study examines three geographically distinct *Lepidium* populations, identified as Simco

Road, Tenmile Ridge and Kuna Butte (Figure 1). They are documented by the Idaho Conservation Data Center as occurrences #015, #024, and #032, respectively, and are A-ranked populations, meaning that plant numbers are relatively high and that the surrounding shrub-steppe community is of high quality (Moseley, 1994).

These populations occur at elevations from 2,900 to 3,300 ft (884 to 1,000 m) on distinct geologic units of the western Snake River Plain. The Kuna Butte population is on low, gently sloping (2 to 5%) basalt ridges. The soils formed on late-Pleistocene surfaces of loess or silty alluvium over basalt (Collette, 1980; Othberg, 1994). Lava boulders, smaller lava rocks and gravels are scattered across the terrain. The Tenmile Ridge population occurs on steeper nose and sideslopes of the oldest, early Pleistocene alluvial terrace of the Boise River. The Tenmile gravel formation is typically capped by 1 to 2 m of loess and generally has a well developed silica-cemented hardpan called a duripan (Othberg, 1994), although the loess cap appears to be significantly thinner on the dissected ridge where the *Lepidium* population occurs. The Simco Road population occurs to the southeast of Boise and the Boise River basin. It is on a gently sloping, dissected alluvial fan formed with igneous materials from foothills on the northern edge of the Snake River Plain (Noe, 1991). Soils with well-developed clayey horizons have formed on the thinly loess-capped Pleistocene deposits.

These landscapes are comprised of ridges, sideslopes and natural drainage lines. The *Lepidium* microsites were typically found on ridgetops and on various hillslope positions with up to 10% slope, but not along drainages or on unstable slopes.

## Methods

The study is based on a nested sampling design. Slick spot soils (bearing *Lepidium*) and sagebrush interspace soils (not bearing *Lepidium*) are characterized at 6 representative sampling sites within each of the populations (3 slick spots and 3 sagebrush interspaces for each of 3 populations). The sampling sites were selected randomly on representative landscape positions after stratifying each population area into ridgetops, sideslopes and bottoms. All *Lepidium*-bearing slick spots within each population had been identified prior to site selection.

To characterize the within-site soil variability, three randomly located auger holes were bored on each site. This was easily accomplished in the larger slick spots, but because the sagebrush interspaces are typically smaller in area, the within-site interspace variability was estimated from single auger holes on three adjacent interspaces. This sampling design produced soil descriptions and samples for nine profiles on three slick spot sites and nine profiles on three interspace sites at each of the three populations, producing a total of 54 profile observations.

For each auger hole, the prominent soil layers (horizons) were described to one-meter depth or to an impeding gravel or pan layer above that. Depth from the surface, thickness between upper and lower boundaries, color, texture, soil structure and porosity, presence of roots and moisture were recorded. Soil was also collected for laboratory characterization of four distinct

**Figure 1: The Distribution of Extant, Historic (not relocated), and Extirpated Populations of *Lepidium papilliferum* and the General Geomorphology of the Western Snake River Plain**

Aluvial Lake and River Terraces, Bonneville Flood Deposits, Aluvial Fans

Higher Aluvial Terraces in Foothills

Basalt Ridges and Plains, Interspersed with Dissected Aluvial Deposits

Dissected Piedmont

Low Stream Terraces and Floodplains

Open Water

★ Extirpated Populations

◆ Historical Populations

▲ Extant Populations

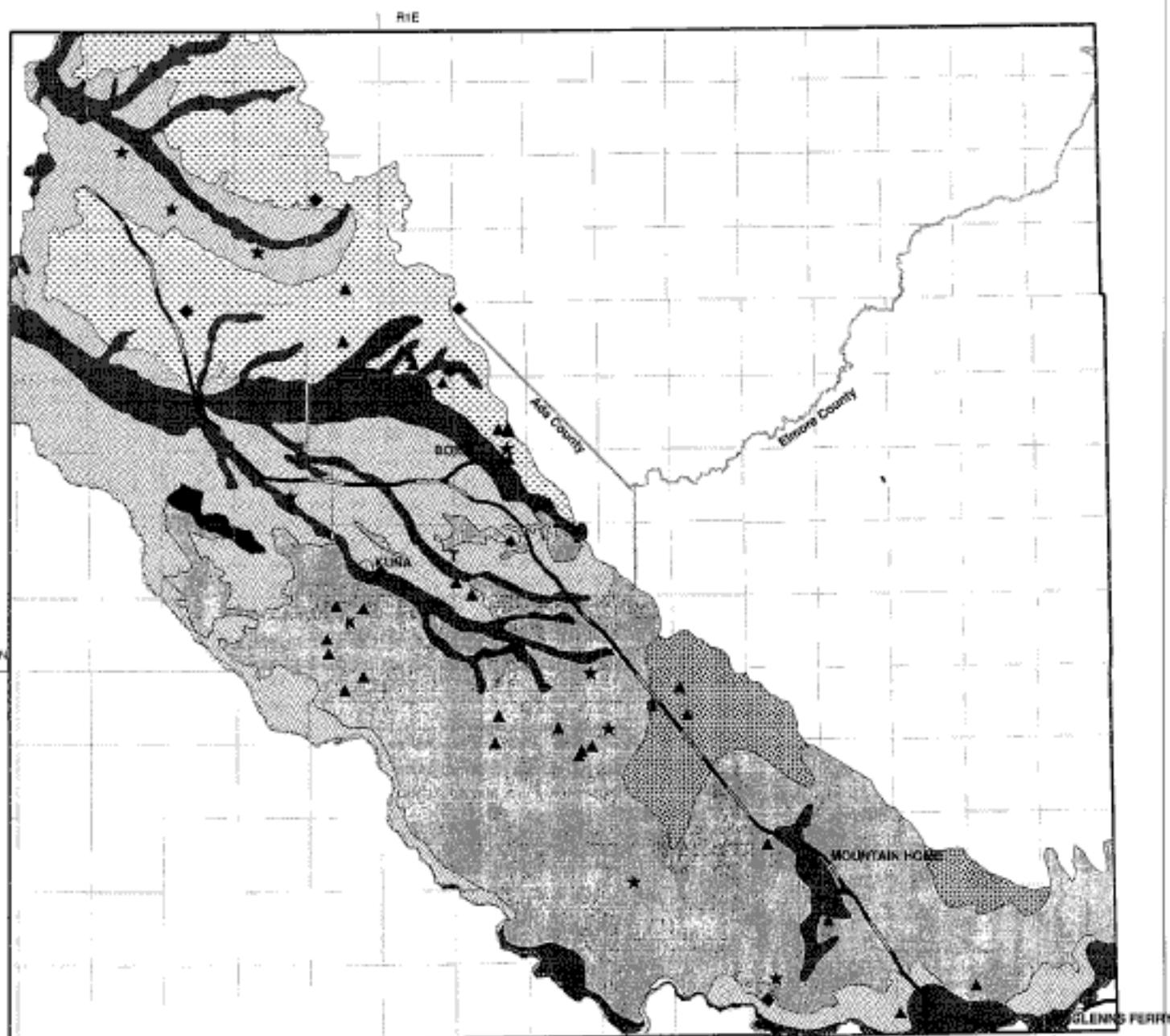
K Kuna Butte

T Termile Ridge

S Simco Road



Location



Scale 1:750,000

parts of the profiles: (i) the surface crust, (ii) the boundary between the crust and upper clay-accumulation layer, (iii) within the first or second distinct clay-accumulation layer, and (iv) the parent material or lower extent of the clay accumulation layer above an impeding pan or gravel layer. Bulk density samples were excavated beside each auger hole at depths from 0 to 4 cm and from 4 to 8 cm.

Standard laboratory soil analyses were performed on the air-dried, sieved fractions of soil <2 mm in diameter, including: Walkley-Black organic matter (Nelson and Sommers, 1982), pH (1:1 soil to water suspension, McClean, 1982), and particle size (hydrometer method, Gee and Bauder, 1986). Soil solution extracts were obtained by centrifugation of water-saturated soil pastes (Rhodes, 1982). Electrical conductivity, cations ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ), and anions ( $\text{Cl}^-$ ,  $\text{SO}_4^-$ ) were measured in the extract solutions using a Waters Ion Chromatograph.

## Results and Discussion

### Visual Site Cues

At all locations, there is a common set of visual cues that distinguish the *Lepidium*-bearing slick spots from the more common shrub interspaces (Table 1). It is the smooth panlike surface of slick spots that first draws attention. Typically, the slick spot surface follows the general slope of a prevailing landform with a slight levelling or break on steeper slopes. On mostly level surfaces, slick spots are very shallow but rarely closed depressions. They sometimes include smaller areas where remnants of thin soil-algal crusts indicate occasional surface ponding. This is most true for the Simco Road location. Slick spot surfaces are also highly reflective and light-colored. Surface gravels and generally higher gravimetric stone contents (Table 2) suggest that the microsites are historic erosion surfaces. The slick spot surface is crustlike and aptly described as a surface layer of uncemented fine earth which breaks free from the underlying soil as massive, platy fragments (Nettleton and Peterson, 1983). Vesicular pores (bubblelike air spaces up to 2 mm diameter) are prominent and common crust features. The moderately dense loam/silt loam of the crust dries to a soft or slightly hard consistence. In contrast, the surface of the typical shrub interspace is not even, but hummocky, formed of soft low mounds with up to 5 cm of relief. The mounds form over polygonal peds (10 to 30 cm across) that are defined by vertical cracks through the surface, an indication of the shrink-swell properties of smectite clays in the upper "clay" horizon.

### Generalized Soil Profiles for *Lepidium*-Slick Spots and Shrub Interspaces

Soil depths vary widely among the locations sampled, but in general, soil development has occurred to depths within 1 m of the surface. The shallowest soils occurred on Tenmile Ridge where either rounded river cobbles or a white hardpan restricted profile descriptions to an average depth of about 37 cm (s.d. 8, n=18). At Kuna Butte, carbonate-coated basalt gravels restricted the descriptions to an average depth of 57 cm (s.d. 23, n=18). At Simco Road, the average sampling depth of 80 cm (s.d. 13, n=18) was restricted by either granitic gravels or a hardpan.

There is very distinct horizonation in all slick spot and most shrub interspace profiles (Figure 2). The surface horizons of both site types are light-colored (pale brown when dry), unaggregated loams or silt loams, and generally less than 20 cm thick. All are described as E horizons (Soil Survey Staff, 1992) because of evidence of clay removal to the horizons below

Table 1: Visual surface characteristics of *Lepidium papilliferum*-slick spot sites and shrub interspace sites.

Feature	Surface Characteristics of Slick spot Sites	Surface Characteristics of Shrub Interspaces
Site Shape/Size	<p>Irregular shapes, ellipsoid to linear, often lobed: long axes varying from 2.7 to 10 m and short axes varying from 0.4 to 2.2 m.</p> <p>Slick spot boundaries are defined by the vegetated edge of shrub coppices, including the narrow transition zone between presence and absence of perennial vegetation, overstory cover and litter accumulation.</p>	<p>Relatively small areas of 1 m cross-section to larger and irregular with maximum axes 8 m X 3 m.</p> <p>Interspaces are defined by the edges of the shrub canopies and dunelike coppices that form beneath shrubs.</p>
Micro-topography	<p>Nearly flat, thinly crusted mineral surface; significant gravel cover, sometimes embedded, and occasional cobbles.</p> <p>Vertical cracks often breaking surface into polygonal peds.</p> <p>Shallow, generally open, depressions, sometimes containing small areas that temporarily pond water.</p>	<p>Generally hummocky, choppy microtopography (vertical relief from 1 to 5 cm), defined by vertical cracks that form large polygonal peds 10 to 30 cm across. Some sites include relatively smooth flat surfaces.</p> <p>There are few to no surface gravels or cobbles.</p>
Vegetation	<p><i>Lepidium</i> grew on all sites sampled.</p> <p>No perennial shrubs or grasses. The slick spots occasionally surround sagebrush coppices.</p> <p>Weedy invasions of <i>Bromus tectorum</i> (rooted in cracks), <i>Lepidium perfoliatum</i> (rooting in crust) and <i>Ranunculus testiculatus</i> (rooting in crust) are common.</p> <p>Algal-silt crusts occurred in small depressional areas where temporary water ponding had occurred.</p> <p>A variety of moss and lichen species covered from &lt; 10% to 90% of the mineral surfaces.</p>	<p>Vascular plant cover is generally low. Perennial bunchgrasses grow on some hummocks. Weedy invasions of <i>Bromus tectorum</i> (rooted in cracks), <i>Lepidium perfoliatum</i> (rooting in hummocks) and <i>Ranunculus testiculatus</i> (rooting in hummocks) are sometimes common.</p> <p>Mosses and lichens, cover as much as 100% of mineral surfaces.</p>

Table 2: Average gravimetric content (g/100 g) of coarse fragments, > 2 mm diameter, in surface soil crust (standard deviation in parentheses).

Population	Slick spot	Shrub Interspace
Tenmile	15 (10)	2 (1)
Kuna	6 (7)	2 (1)
Simco	12 (7)	4 (3)

(Figure 3), and because of the lack of significant accumulations of humified organic matter (Figure 4). The crust matrix on both site types varies from being weakly to strongly cohesive, but unaggregated, and has fine bubblelike air spaces, called vesicular pores (0.5 to 2 mm diameter). Vesicular crusts are common in silty surface soils of the Great Basin, most notably in

shrub interspaces where organic matter contents are lowest (Wood et al., 1978). Such soils have low infiltration rates (Blackburn 1975), provide poor seedbeds for native grasses (Wood et al., 1978) and are susceptible to sediment removal by overland flow (Blackburn 1975), particularly during diurnal freeze-thaw periods when surface water contents are high (Blackburn et al., 1990). Surface bulk density is moderately high on both slick spot and shrub interspace types (average 1.4 Mg/m<sup>3</sup>), reflecting the poorly aggregated, massive structure of the crust material, and the relatively dense clay layers very near to the surface of some slick spot profiles.

Very fine, fibrous roots and root pores (0.1 to 0.5 mm diameter) occur in shrub interspace and *Lepidium*-slick spot crust samples adjacent to bunchgrasses or annual plants, but are otherwise uncommon in surface soils. Cheatgrass (*Bromus tectorum*) often roots in the vertical cracks that extend through the crusts although *Lepidium papilliferum* and the annual weeds, *L. perfoliatum* and *Ranunculus testiculatus*, also root directly into the crust matrix.

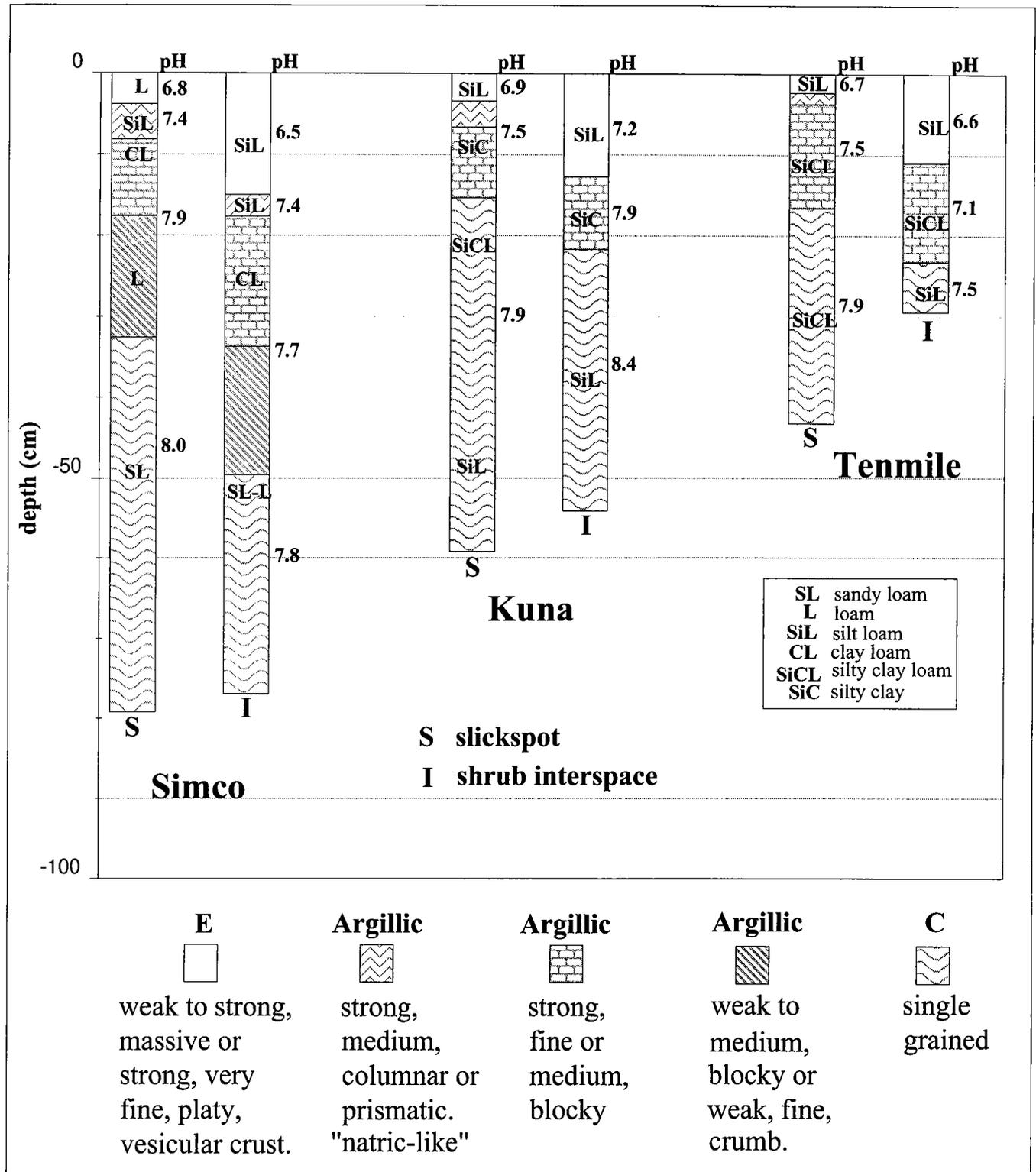
There is an abrupt change in soil texture and structure below the E horizons of most site profiles (Figure 2). The soil clay content increases abruptly (Figure 3), forming strongly structured, fine-textured horizons. Soil horizons developed by illuvial concentration of silicate clay minerals (Soil Survey Staff, 1992) are called argillic horizons. The *Lepidium*-slick spot and shrub interspace profiles typically have one or more strongly structured argillic horizons that are distinguished by differences in ped structure, texture and color. Below these horizons, clay content decreases gradually with depth (Figure 3), and at some lower depth, the soil material is an unaltered silt loam or sandy loam referred to as the C horizon. Free carbonate begins to accumulate in the lower argillic horizon and, in most cases, the white precipitate coats the gravels or rocks at the lowest extent of the profiles.

Fine fibrous roots and coarser woody roots typically occur in the subsoils of both *Lepidium*-slick spots and shrub interspaces. The highest concentrations of roots occur in the upper argillic horizons and are more likely to occur in the C horizon of shrub interspaces than of slick spots. Some roots appear to grow laterally along the E/Bt boundary into the slick spots, suggesting that shrubs might use water and nutrients from these apparently inhospitable soils and that the crust/argillic interface provides an avenue for shrub root growth.

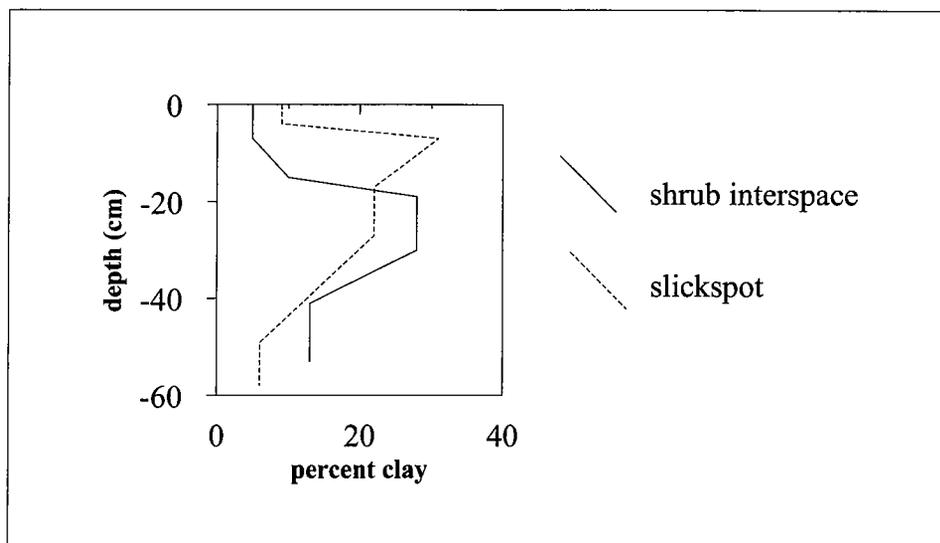
#### **Comparison of *Lepidium*-Slick Spot and Shrub Interspace Profiles**

*Lepidium* slick spot profiles are distinguished from shrub interspace profiles by a thin vesicular crust, an always abrupt boundary between the surface crust (E horizon) and the upper argillic horizon, and by a columnar or prismatic ped structure in the upper argillic. The average thickness of *Lepidium*-slick spot crusts is 3.4 cm (s.d. 2.4, n=27) which is significantly less than for shrub interspaces, 13.1 cm (s.d. 4.6, n=27). The surface crust thickness tends to be more variable in the shrub interspaces which range from obviously thick-crusts and hummocky to slightly compacted on animal trails (Table 3).

**Figure 2:** Average soil profiles for *Lepidium papilliferum*-slick spots and shrub interspace sites for the Simco Road, Kuna Butte, Tenmile Ridge *Lepidium* populations, displaying soil textures and average pH levels of sampled horizons.



**Figure 3:** Average depth profiles of soil clay content for *Lepidium papilliferum*-slick spot sites and shrub interspace sites at Simco Road.



**Figure 4:** Average depth profiles of soil organic matter content for *Lepidium papilliferum*-slick spot sites and shrub interspace sites at Simco Road, Kuna Butte, and Tenmile Ridge.

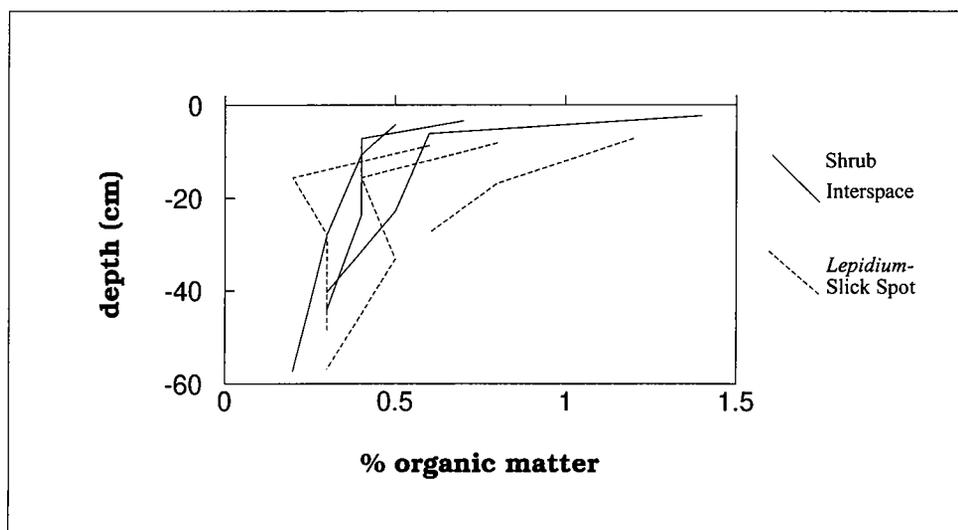


Table 3: Average depths and thicknesses (standard deviations in parentheses) of the argillic horizons for each population and site type.

Population	Depth to Argillic	Thickness of Argillic Layers	Depth to Surface of C Horizon
	<b>Shrub Interspaces</b> cm		
Tenmile	12 (5)	13 (6)	20 (4)
Kuna	13 (4)	22 (15)	23 (6)
Simco	15 (5)	33 (10)	48 (13)
	<b>Slick spots</b> cm		
Tenmile	3(1)	14 (3)	16(3)
Kuna	5 (3)	13 (3)	16 (1)
Simco	4 (2)	29 (13)	37 (16)

The abrupt crust-argillic boundary is always a feature of slick spot profiles, but may or may not occur in the soil profiles of shrub interspaces. At Simco Road, the clay content of *Lepidium* - slick spot profiles increases sharply by an average of 22% at the crust-argillic horizon boundary (Figure 3). Similarly abrupt increases in soil fines were identified by hand-textures of slick spot soils at the other locations. Clay pick-up on shrub interspace sites, however, is variable and at Tenmile Ridge there was neither an abrupt nor a large increase in clay accumulation in the shrub interspace profiles. At Simco Road, the argillic horizon of shrub interspaces was at least as abrupt and as well developed as for slick spot sites.

On all slick spots, the ped structure in the upper argillic horizon (Bt1) is columnar (long axes 2 - 5 cm) and sometimes domed on top (prismatic). By Soil Taxonomy rules, such structure is required for an argillic horizon for it to qualify as "natric", should the exchangeable sodium percentage also qualify as "sodic" (Nettleton and Peterson, 1983). The "natric-like" horizon of *Lepidium*-slick spot soils is thin, typically less than 5 cm in thickness. Below it, the structure is blocky and often comprised of fine crumbly, blocky peds described as "coffee grounds". "Natric-like" horizons also occurred in the shrub interspace profiles at Simco Road but not at the other locations (Figure 2).

#### Soil Profile Chemistry for *Lepidium*-Slick Spots and Shrub Interspaces

The pH levels of soil/water suspensions (Figure 2) reflect a downward movement of soluble salts through both slick spot and shrub interspace profiles. Crust and upper argillic horizons have slightly acid to near neutral surface pH levels. These increase with depth to alkaline levels of pH 8.0 to 8.5, reflecting the presence of calcium carbonate dissolution.

Electrical conductivity (EC) is another means of observing soluble salt eluviation and accumulation in soils. A soil is classified as saline if the electrical conductivity (EC) of the solution extracted from the saturated soil paste has a value >4 mmho/cm (Sposito, 1989). This

particular level correlates with reductions in crop growth and yield by osmotically stressed plants. For example, the relatively salt-tolerant crested wheatgrass (*Agropyron cristatum*), perennial ryegrass (*Lolium perenne*), and beardless wild rye (*Elymus triticoides*) experience yield reductions in the order of 10 to 25% when grown in soils with EC ranges of 4 to 11 mmho/cm (Bohn and others, 1979). Soil salinity levels measured by EC are also useful in describing the distributions of distinctive plant communities that grow naturally on salt-affected soils. North Dakota pan soils with EC-levels that range from 2.8 mmho/cm at the surface to 13 mmho/cm at 110 cm depth support a community of *Agropyron spicatum*, *A. trachycaulum*, *Poa sandbergii*, *Atriplex nuttallii*, *Chenopodium glaucum*, *Polygonum aviculare*, *Ceratoides lanata*, and *Opuntia* spp.. Most of the same species persist in adjacent transitional soils but are absent from the surrounding non-saline soil (Hopkins and others, 1991).

The *Lepidium*-slick spot sites can be classified as saline. The first evidence of soluble salt accumulation is in the second-depth sample at the crust and upper-argillic interface (Table 4). Saline EC conditions (>4 mmho/cm) occur within the upper 10 cm of many *Lepidium*-slick spot profiles (Figure 5) and within 20 cm of the surface there are moderately high salinity levels, ranging from 6.9 (Kuna) to 11.8 mmho/cm (Tenmile). Soluble salts continue to increase with depth to an average of 14.1 mmho/cm for all slick spot C horizons. Although soluble-salt levels in the crusts are relatively low, the conductivity of very thin crusts are affected by higher salinity levels of the argillic horizon below.

By contrast, the shrub interspaces have significantly smaller accumulations of soluble salts. For each sampling layer, the differences between slick spot and shrub interspace EC-levels are highly significant (Table 4). At the Simco Road and Kuna Butte locations, there is some soluble salt accumulation in the subsoils but EC levels of argillic horizons are not saline (<4 mmho/cm). Soluble salts have not accumulated in the shallow shrub interspace profiles of Tenmile Ridge (Figure 5).

High salinity in arid-zone soils is typically caused by the relatively soluble Na, K, Ca and Mg cations. These are released into solution by primary mineral weathering. They accumulate near the soil surface, avoiding deep leaching when annual soil evaporation rates exceed precipitation rates, and they combine with secondary clay minerals or form carbonates, sulfates and chlorides. Chloride is the main soluble anion extracted from slick spot and shrub interspace soils (Table 4).

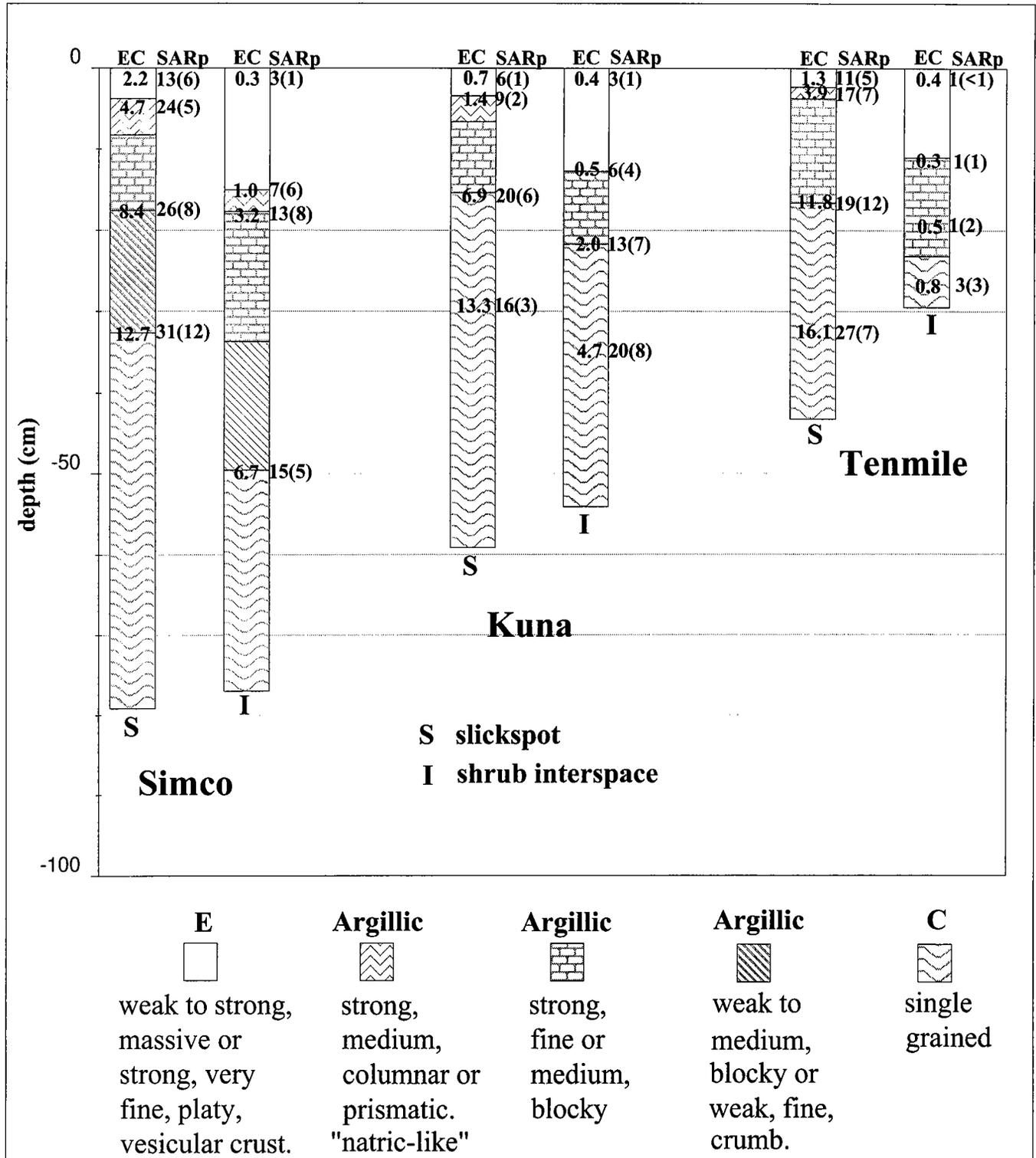
Soil properties are affected by both the ionic strength of soil solutions (related to EC) and by the relative composition of soluble cations in soil solutions. Exchangeable Na, Ca and Mg, in particular, affect the behavior of clay colloids in semi-arid soils. Higher concentrations of exchangeable Na relative to exchangeable Ca and Mg cause dispersion of clay aggregates into solution. This condition produces soils with lower porosity and lower water permeability.

A simplified index of the relative sodium status of soil solutions, the sodium adsorption ratio (SAR), is used to indicate the degree of sodicity of the soil exchange complex.

$$SAR_p = Na_T / (Ca_T + Mg_T)^{1/2}$$

where the subscript "p" indicates "practical" SAR and subscript "T" represents the total concentrations of soluble ions in the saturated-paste extract, given in mol/m<sup>3</sup> (equivalent to

**Figure 5:** Salinity (EC), and sodicity (SARp) profiles for *Lepidium papilliferum*-slick spot sites and shrub interspace sites within the Simco Road, Kuna Butte, and Tenmile Ridge *Lepidium* populations.



mmol/L) (Sposito, 1989). When the  $SAR_p$  is greater than 13, the soil condition is classified as sodic (sodium affected), implying the potential for clay dispersion and impaired soil permeability of fine-textured soils. There are also interactions of sodicity ( $SAR_p$ ) with salinity (high EC), however, which affect the degrees of dispersion. As long as the EC level of the soil solution is low (below a critical aggregation concentration that depends on the kinds of clay minerals in the soil), high relative sodium concentrations will cause clay dispersion. But at higher EC levels, the clay minerals will tend to aggregate even when the  $SAR_p$  is high.

Sodium is the dominant soluble cation in the *Lepidium*-slick spot soils (Table 4), although the degree of sodicity varies among population locations.  $SAR_p$  values exceed 13 in the upper argillic horizons of both Simco and Tenmile *Lepidium*-slick spots, increasing with depth and salinity (EC) (Figure 5), and sodic conditions also occur within 20 cm of the surface of Kuna Butte *Lepidium*-slick spot profiles. The slick spots at all locations fulfill both requirements for a natric horizon, i.e., columnar or prismatic ped structure in some part of the argillic horizon and  $SAR$  levels > 13 within 40 cm of the soil surface (Soil Survey Staff, 1992).

The shrub interspace subsoils at Simco Road and Kuna Butte are also sodic but the soils are not saline and sodium concentrations are significantly lower than in the same *Lepidium*-slick spot layers (Table 4). Sodium does not dominate the cation exchange complex of Tenmile shrub-interspace profiles. The high sodicity and relatively low salinity that occurs just below the surface of slick spots probably accounts for the massive, platy orientation of silt particles above the crust/argillic horizon interface and for the observations of slow water permeability reported on slick spot soils (Moseley, 1994).

#### **Edaphic Characteristics of *Lepidium papilliferum* Slick Spots**

The very distinctive soil characteristics of *Lepidium papilliferum*-sites occur across all of the landscapes included in this study. *Lepidium*-slick spots are distinguished from the surrounding soils by very thin surface layers (epipedons) that form light-colored, prominently vesicular crusts and by the natric-like argillic horizons that occur just below the soil surface. Both high salinity and sodicity occur within the upper 40 cm of the profiles. The saline and sodic soil solution chemistry, the apparently truncated surface horizons of slick spots, and the near-surface argillic horizons conspire to produce smooth panlike surfaces, structureless and slowly permeable when wet, moderately hard and cracked when dry. In the surrounding soils, thicker epipedons and low salinity allow a more diverse microtopography, a greater surface-soil rooting volume and crust conditions that are not so intimately influenced by the chemistry of the subsoil as they are on slick spots.

The consistency of these soil characteristics and the exclusion of most other plant species from slick spots suggests that edaphic factors have considerable bearing on where *Lepidium* grows. Similar slick spot-like crusts restricted seedling emergence and produced stress symptoms in seedlings of crested wheatgrass (*Agropyron cristatum*) and squirreltail (*Sitanion hystrix*). The strongly vesicular crusts were significantly harder than adjacent shrub coppice soils and apparently more resistant to forces produced by elongating roots than the latter soils (Wood et al., 1978).

Table 4: Saturated-paste solution chemistry for four distinctive horizons of *Lepidium papilliferum*-slick spot sites and shrub interspace sites. Analysis of variance showed highly significant differences between site types for each layer ( $p < 0.005$ , for Layer A, Sum of Cation Charge;  $p < 0.0001$  for EC, Na, and Sum of Cation Charge for all other layers ).

Soil Characteristic	Site Type	E Crust	E+Bt1 Upper Argillic	Bt1+Bt2 Argillic	C Parent Material
mean (number of samples, standard deviation)					
EC mmho/cm 1/	slick spot	1.4 (27,1.3)	3.2 (25,2.1)	8.9 (27,4.4)	14.1 (24, 3.9)
	shrubs interspace	0.4 (27,0.1)	0.6 (26,0.7)	1.8 (25,2.2)	5.1 (18,3.5)
Na <sup>+</sup> mmol/L 1/	slick spot	15 (27,16)	35 (25,22)	115 (27,71)	182 (24,57)
	shrubs interspace	2 (27,1)	6 (26,8)	23 (25,39)	60 (18,47)
Sum of Cation Charge meq/L 1/	slick spot	21 (27,26)	47 (25,22)	171 (27,106)	315 (24,90)
	shrubs interspace	7 (27,3)	11 (26,9)	35 (25,60)	93 (18,83)
Cl <sup>-</sup> mmol/L	slick spot	-	29 (27,23)	-	-
	shrubs interspace	-	3 (27,5)	-	-
SO <sub>4</sub> <sup>2-</sup> mmol/L	slick spot	-	5 (27,15)	-	-
	shrubs interspace	-	1 (27,2)	-	-

1/ The p values were calculated using the General Linear Models procedure with the model  
PARAMETER=TYPE POPULATION(TYPE) SITE(POPULATION TYPE).

On sites examined in the present study, there were usually fewer than 10 *Lepidium* plants. Many seedlings germinated on *Lepidium*-sites, as observed in 1992, but few survived the drying conditions of the following weeks in spring. Poor seedling emergence, therefore does not necessarily account for the low plant numbers observed, but seedling survival on slick spots might be predicated by successful taproot extension into the argillic horizon. The thin crusts dry out well before *Lepidium* plants mature, so to survive, plants must extract moisture from the deeper saline, sodic, natric zone. The few mature plants that were excavated had taproots to at least 20 cm below the soil surface or, on average, more than 15 cm below the upper boundary of the argillic and below the distinctively columnar argillic horizon. It seems likely that physical resistance of the crust soils and, or resistance at the interface of the surface crust and the argillic horizon stopped the taproots of a majority of *Lepidium* seedlings from growing to necessary depths. Critical survival characteristics of *Lepidium* on slick spots appear to be related to its taprooted morphology, its early germination and root elongation before the soil crusts dry out, and a tolerance of high osmotic pressures of available water in the saline, sodic argillic horizons.

There is little known about the water relationships of shrub interspaces and particularly slick spot types. Questions of water redistribution within, and evaporation from, similar soils will be addressed in a field study to be conducted in 1996 (Dr. Mark Seyfried, pers. comm.). The results will provide insights about the water availability to plants growing on and adjacent to these shrub interspaces and perhaps shed some light on why *Lepidium* is typically absent from shrub interspaces.

This study does not support the conclusion (Meyer and Quinney, 1993) that a particular tolerance for flooded-soil conditions allows *Lepidium* to grow on slick spot sites. Plant growth in saturated soils is reduced by the decreased availability of oxygen in the soil and by chemical toxicities produced under anaerobic conditions. The slick spot profiles do not indicate that anaerobic conditions occur during temporary ponding events. There is no gleying or high chroma mottling in the *Lepidium*-site profiles, although chemically reducing soil conditions might be expected if the soils were persistently saturated during the warm summer months (Howeler and Bouldin, 1971; Fisher and Stone, 1991). Apparently, summer ponding as a result of thunder showers is so transitory that it does not lead to anaerobic soil conditions.

Between January and March, 1992, the surface soil on slick spots and shrub interspaces (0 - 15 cm depth) was persistently wet. Precipitation on frozen soils and low permeability of the wet upper argillic horizon probably contributed to the high surface water contents. Although high soil moisture content limits oxygen availability, the oxygen consumption by plants and soil microbes was probably minimal at the low soil temperatures encountered (Hook, 1984). Once the soils thawed, high soil moisture contents did not persist and should be uncommon given the aridic moisture regime (Soil Survey Staff, 1992). Through the late winter season, surface soils on both site types dried at similar rates. *Lepidium* germinated in the unsaturated soil crusts and rosettes of biennial plants broke dormancy after the thaw when soil crusts were drying. Increasing soil salinity levels in the drying soils interfered with the method used for measuring soil water contents (time domain refractometry, TDR) and comparative results between site types are not available after significant drying had occurred on slick spot soils.

Earlier efforts to characterize slick spot soils (Sandoval and others, 1959; Lewis and White, 1964) were inspired by the low water permeability and poor growth observed on cultivated slick spot soils. The Chilcott-Sebree soil association was the focus of these studies and is significant here because it is mapped on the Tenmile Ridge near one *Lepidium* population included in this

study (Collette, 1980). These studies found that slick spot soils are most highly correlated with high exchangeable sodium throughout the profile, montmorillonitic-type clays (expanding clay types) in upper horizons of the soil profile, and high amorphous silicates that probably contribute to lower water permeability of the slick spots.

An early radiotracer study of water movement in and around Sebree-soil sites (Lewis et al., 1959) demonstrated the slow permeability of slick spot soils and indirectly showed that subsurface water movement must move laterally from the slick spot edges to the slick spot subsoil. By such a pathway, salts from surrounding soil might have been concentrated in the slick spot subsoils. Salts also moved upwards from the subsoil, suggesting that a similar process might be maintaining the high salt conditions near the surface of *Lepidium* slick spots. Lateral and vertical movement of soil solution was not restricted on the associated non-slick spot soils (Chilcott series), thus accounting for the lack of salt accumulation layers in these profile.

### **Correlation of *Lepidium* Sites, Landscapes and Mapped Soils**

With rare exceptions (disjunct populations in Owyhee and Bannock counties, Moseley, 1994), *Lepidium* populations are distributed on a band of low-elevation alluvial landforms and basalt plains that flank the northern and eastern shore of the lower Snake River (Figure 1). The geomorphic mapping units described were derived from general soil mapping units in the State Soil Geographic Data Base (Soil Conservation Service, 1991) for Idaho and the locations of the extant, historic and extirpated *Lepidium* populations were from another geographic data base (Conservation Data Center, 1995). According to this view, *Lepidium* occurs on four broad geomorphic areas. The most extensive and numerous populations occur on a large unit of basalt ridges and plains in the middle and southern end of the species range. A few populations occur on a lobe of dissected piedmont, adjacent to the basalt plains but formed from igneous mountains rising to the north of the lower Snake River plain. Other than the extensive population on Tenmile Ridge, the occurrences of *Lepidium* on the two remaining alluvial geomorphic units are relatively small populations. These units include (1) alluvial lake and river terraces and Bonneville flood deposits, and (2) higher alluvial deposits in the foothills.

Within these broad geomorphic areas, the actual *Lepidium* habitat is very limited and confined to small inclusions of natric-like soils within the extensive matrix of non-natric soils. Despite the very particular characteristic of *Lepidium*-slick spot sites, however, some general soil factors can describe the general soil matrix in which the species grows. *Lepidium* populations occur on regions of an aridic soil moisture regime. These soils are dry for most of the time that temperatures are suitable for plant growth. At the highest level of the Soil Taxonomy system, such soils are classified into the soil order of Aridisols. Furthermore, the *Lepidium* populations almost exclusively occur on landscapes of Aridisols that border with a xeric moisture regime (Soil Survey Staff, 1992). Xeric soils receive a greater proportion of moisture in the cool winter when potential evaporation is at a minimum and leaching potential is greatest. The implication for slick spots is that there is sufficient moisture to leach salts where soils are more permeable (shrub interspaces and shrub dune coppices), but not so much moisture to remove salts from the less permeable slick spot soils.

Elsewhere throughout the arid and semi-arid west, small natric slick spots are found on remnant Pleistocene surfaces, e.g., alluvial fans and steep hillslopes, within soil matrices of two Aridisol great groups, the Haplargids and the Durargids (Nettleton and Peterson, 1983). These belong to the suborder of Argids, which are Aridisols with diagnostic horizons of clay accumulation (argillic horizons). Haplargids are typical Argids that lack additional profile features and Durargids are Argids underlain by a silica subsurface horizon (duripan). The argillic horizons and duripans of

these soils are thought to be relicts of soil formation processes during a wetter Pleistocene climate.

Recent (Holocene) additions of eolian salts, often by loess deposition, produced the natric character of soils now found on these same landscapes (Nettleton and Peterson, 1983). A drying climate, gradual shallow leaching of salts, directed subsurface or surface movement of soil solutions, sodium-induced changes in clay chemistry and structure, and surface soil erosion, contributed to the formation of natric soil inclusions. On the semi-arid Carrizo Plain of California, a very recent expansion of slick spots within the past 300 years is related to surface erosion and eolian salt deposition (Reid et al., 1993). Under the current climatic regime, the slick spot formation is not expected to be reversible.

The landforms on which *Lepidium papilliferum* are found are also remnant Pleistocene surfaces typical of the Great Basin landforms described. Accordingly, the most common soil great groups on *Lepidium*-habitat landscapes in Elmore and Ada Counties are Haplargids and Durargids (Appendix C). Nadurargids, which in addition to a duripan have a natric horizon, and Paleargids, which have particularly strongly developed clay and calcium carbonate accumulations, are also extensive on these older landscapes. Camborthids dominate the dissected terraces and plains associated with the Snake River where there are a few smaller *Lepidium* populations. The Aridisol suborder of Orthids lack the diagnostic argillic horizon of the Argids.

Typically, slick spots are too small to be delineated on Soil Survey maps. The natric soil areas are rarely large enough, common enough, or of significant importance to the associated land uses (e.g. irrigated cropland) to be mapped. The Chilcott-Sebree soil association, however, is one exception where a natric soil (Sebree) is recognized in association with a non-natric series (Collette, 1980). Appendix D lists several other soil series found within the range of *Lepidium* populations that occur in near proximity to natric soil types or are mapped natric soils. Searches for new *Lepidium* populations or potential habitat might best focus inventories on those remnant Pleistocene land surfaces where the listed series are mapped. The Ada County soil survey (Collette, 1980) does not identify any inclusion of natric soils on the lacustrine foothills (Appendices A and C), however. This may well be an omission of information and not a true indication that natric soils are absent. At least two soil series, Lankbush (a Haplargid) and Payette (an Argixeroll, similar to the Haplargid), are similar to other non-natric soils that occur with slick spot inclusions or natric-soil neighbors.

A question remaining to be answered is whether slick spots, not bearing *Lepidium*, provide the same or similar edaphic environments as the *Lepidium*-slick spots. If they do, then there is considerable available habitat for *Lepidium* that is not being used. This study suggests that there is a very strong correlation between slick spot features (panlike often gravelly surface, lack of shrubs, perennial grasses and forbs, a microbiotic crust, a very thin vesicular crust, and a shallow, dense argillic horizon) and saline and natric soil chemistry. Other accounts suggest the same relationship (Sandoval and others, 1959; Lewis and White, 1964), bringing up the perplexing question of why *Lepidium* is not growing on a greater proportion of slick spot sites, even within habitat where the plant is present.

## Conclusions

*Lepidium papilliferum* grows on natric soil microsites, called slick spots, that occur on remnant Pleistocene surfaces within its main geographical range on the western Snake River Plain of

Idaho. These surfaces are on alluvial landforms associated with historic lakeshores and river terraces, stable piedmont and associated alluvial fans, basalt plains, and on historically dissected alluvial deposits. The habitat does not occur on active or recent (holocene) floodplains or alluvial fans, or on recently eroded slopes, and it does not occur above the lowest slopes of the foothills.

*Lepidium* microsites are small natric-soil inclusions that occur within a matrix of non-natric soils. Distinctive visual cues distinguish the *Lepidium*-sites from surrounding shrub interspaces. Very similar surface features also describe a large category of sites in the range of *Lepidium* on which the species is not growing. This suggests that there is considerable unused habitat for the species within its geographic range.

The restriction of *Lepidium papilliferum* to slick spot microsites and the absence of all perennial plant species from those sites, suggests that soil edaphic factors determine this species' distribution on the landscape. Distinctive features of the microsites are very thin vesicular crusts, a natric horizon just below the soil surface, and increasingly saline and sodic conditions with depth. Its taprooted morphology, early germination, root elongation into the argillic horizon before soil crusts dry out, and an apparent tolerance of high osmotic pressures of available water in the saline, sodic subsurface horizons, enable *Lepidium* to grow on the crusted slick spot soils.

Soils that occur on *Lepidium* habitat belong to the soil taxonomic suborder of Argids which includes soils with an aridic moisture regime (order Aridisol) and a diagnostic argillic horizon. Nearly all *Lepidium* habitat borders with the xerollic moisture regime. Typical Argids (great group Haplargid) and Argids underlain by a duripan (great group Durargid) are the predominant soil great groups found on older Great Basin landscapes where small natric slick spots are found. This is also true for *Lepidium* habitat. Holocene loess deposits on the western Snake River Plain probably account for the salt inputs needed for the formation of natric soils.

Several soil series found on *Lepidium* habitat were identified as either being natric or occurring near to natric soil series. Inventories to identify potential *Lepidium* habitat might focus on landscapes where these particular soil series have been mapped in current soil surveys.

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## APPENDIX A

General soil mapping units in Ada and Elmore Counties (Collette, 1980; Noe, 1991) where there are extant *Lepidium papilliferum* populations (Conservation Data Center, 1995).

### **Soils on Lacustrine Foothills - Ada County**

#### ***Quincy-Lankbush-Brent***

Nearly level to very steep, excessively drained and well drained, very deep soils. *Quincy* (Torripsamment): 20 percent of the map unit area; formed in eolian deposits on south-facing sideslopes of alluvial terraces. *Lankbush* (Haplargid): 20 percent of the map unit area; south and west-facing side slopes of alluvial fans and terraces. *Brent* (Paleargid): 15 percent of the map unit area; north and east-facing slopes of terraces.

### **Soils on Alluvial Terraces, Basalt Plains, Dissected Alluvial Plains, and Alluvial Fans - Ada County**

#### ***Tennile-Chilcott-Kunaton***

Nearly level to very steep, well-drained, shallow to very deep soils associated with the highest alluvial terrace south of the Boise River. *Tennile* (Haplargid): 15 percent of map unit area; steeper positions on high alluvial terraces and sideslopes of drainageways. *Chilcott* (Durargid): 15 percent of map unit area; nearly level on alluvial terraces and basalt plains. *Kunaton* (Durargid): 10 percent of map unit area; gentle ridges and slightly convex areas on the basalt plains.

#### ***Chilcott-Kunaton-Sebree***

Nearly level to sloping, well drained, shallow and moderately deep soils. Soils developed in loess or silty alluvium. *Chilcott* (Durargid): 25 percent of map unit area; mainly level high alluvial terraces and basalt plains. *Kunaton* (Durargid): 15 percent of map unit area; gentle ridges and slightly convex areas on the basalt plains. *Sebree* (Durargid): 10 percent of map unit area; mainly nearly level, on intermediate positions on the high alluvial terraces and on the basalt plains. Occur as small, subrounded, slick spots throughout areas of the Chilcott and Kunaton soils.

#### ***Power-McCain-Purdam***

Nearly level to sloping, well drained, shallow and moderately deep soils. These soils formed in loess or silty alluvium over coarser textured alluvium or basalt. *Power* (Haplargid): 35 percent of map unit area; mainly level or slightly concave; on the alluvial terraces and the basalt plain. *McCain* (Haplargid): 30 percent of map unit area; mainly on ridges and near rock outcrops on the basalt plains. *Purdam* (Durargid): 10 percent of map unit area; mainly on higher positions on the alluvial terraces.

#### ***Scism-Truesdale-Turbyfill***

Nearly level to steep, well drained, moderately deep and very deep soils. These soils developed in loess or silty alluvium and eolian deposits. *Scism* (Durorthid): 35 percent of map unit area; on basalt plains. *Truesdale* (Durorthid): 25 percent of map unit area; on basalt plains in southern part of the area. *Turbyfill* (Torriorthent): 10 percent of map unit area; on basalt plains mainly in drainageways or downslope from drainageways.

### **Soils on Dissected Piedmonts - Elmore County**

#### ***Lankbush-Chilcott-Lanktree***

Nearly level to strongly sloping; moderately and very deep; well drained soils; alluvial plains and terraces; developed from alluvium from igneous rock. *Lankbush* (Haplargid); *Chilcott* (Durargid); *Lanktree* (Haplargid).

### **Soils on Stream Terraces - Elmore County**

#### ***Timmerman-Royal-Buko***

Nearly level to strongly sloping, very steep, well and somewhat excessively drained soils; on medium and high terraces of the Snake River, formed in mixed alluvium. *Timmerman* (Camborthid); *Royal* (Camborthid); *Buko* (Camborthid);

### **Soils on Dissected Terraces and on Plains of the Snake River - Elmore County**

#### ***Royal-Buko-Davey***

Nearly level to steep, very deep, well drained and somewhat excessively drained soils; on dissected terraces of mixed alluvium. *Royal* (Camborthid); *Buko* (Camborthid); *Davey* (Camborthid).

### **Soils on Basalt Plains in Canyons and on Terraces - Elmore County**

#### ***Colthorp-Chilcott-Kunaton***

Nearly level to strongly sloping, shallow and moderately deep, well drained soils; on basalt plains formed in loess, mixed alluvium and weathered basalt.

*Colthorp* (Durargid); *Chilcott* (Durargid); *Kunaton* (Durargid).

## APPENDIX B

Soil Series from Ada and Elmore County Soil Surveys (Collette, 1980; Noe, 1991) Mapped on

Areas with Extant *Lepidium papilliferum* Populations (Conservation Data Center, 1995).

**Conservation Data Center Ecorank A**

Bennett Road (#008) - basalt plains  
Elijah-Purdam silt loams, 0 to 8 percent slopes  
Chilcott-Elijah silt loams, 0 to 12 percent slopes  
Letha-Baldock loams, 0 to 2 percent slopes (riparian/floodplain)  
Dors fine sandy loam, 0 to 4 percent slopes  
Minidoka-Minveno silt loams, 0 to 4 percent slopes  
Purdam silt loam, 0 to 4 percent slopes  
Royal fine sandy loam, 4 to 12 percent slopes  
**Simco Road (#015) - dissected piedmont**  
Lanktree-Chilcott loams, 0 to 12 percent slopes  
**Initial Point (#019) - basalt /alluvial plains**  
Scism silt loam, bedrock substratum, 0 to 8 percent slopes  
Rock outcrop-Trevino, 5 to 20 percent slopes  
Potratz silt loam, 2 to 8 percent slopes  
Power-McCain silt loams, 2 to 8 percent slopes  
Purdam silt loam, 0 to 2 percent slopes  
Purdam-Power complex, 0 to 8 percent slopes  
McCain-rock outcrop complex, 0 to 15 percent slopes  
**Kuna Butte (#024) - basalt /alluvial plains**  
Power-McCain silt loams, 0 to 8 percent slopes  
**Orchard National Guard Training Area (#027) - basalt /alluvial plains**  
Bowns stony loam, 0 to 8 percent slopes  
Bowns-rock outcrop, 0 to 15 percent slopes  
Chardoton stony silty clay loam, 0 to 2 percent slope  
Chardoton-Kiesel Variant silty clay loams, 0 to 2 percent  
Chilcott-Sebree bedrock substratum, 0 to 4 percent slope  
Power-McCain silt loams, 0 to 4 percent slopes  
Purdam silt loam, 0 to 2 percent slopes  
Power silt loam, 0 to 2 percent slope  
**Tenmile Creek (#032) - Boise R. terrace/basalt plains**  
Bram silt loam  
Brent loam, 8 to 12 percent slope  
Chilcott-Sebree, 0 to 4 percent slope  
Colthorp silt loam, 0 to 4 percent slope  
Elijah loam, 0 to 4 percent slope  
Kunaton silty clay loam, 0 to 4 percent slope  
Pipeline silty loam, 0 to 4 percent slope  
Rock Outcrop-Trevino, 5 to 20 percent slope  
Tenmile very gravelly loam, 0 to 65 percent slope  
Bissell loam, 0 to 2 percent slope (riparian)

**Conservation Data Center Ecorank B**

**Kuna Butte Southwest (#018) - basalt /alluvial plains**  
Scism silt loam, bedrock substratum, 2 to 4 percent slope  
Power-Potratz silt loam, 2 to 4 percent slope  
Rock Outcrop - Trevino Complex  
Power silt loam, 0 to 2 percent slopes  
**Crater Rings (#021) - basalt /alluvial plains**  
Colthorp-Kunaton, 0 to 8 percent slopes  
**Pleasant Valley North (#022) - Boise R. terrace/basalt plains**  
Kunaton silty clay loam, 0 to 4 percent slopes  
Kunaton-Sebree silty clay loam, 0 to 2 percent slopes  
McCain silty loam, 0 to 2 percent slopes  
Elijah silt loam, bedrock substratum, 2 to 4 percent slopes  
Colthorp silt loam, 0 to 2 percent slopes  
**Mountain Home South (#029) - basalt plains**  
Colthorp-Kunaton, 0 to 8 percent slopes  
**Soles Rest Creek (#030) - dissected piedmont**  
Lanktree-Chilcott loam  
**Orchard Southwest (#042) - basalt /alluvial plains**  
Power-Chardoton, 0 to 4 percent slopes  
Chilcott-Kunaton-Chardoton, 2 to 12 percent slopes  
**South Cole Road / Tenmile Creek South (#048) - Boise R. terrace/basalt plains**  
Kunaton silty clay loam, 0 to 4 percent slopes  
**Fivemile Creek (#049) - Boise R. terrace/basalt plains**  
Elijah silt loam, 0 to 8 percent slopes  
**Woods Gulch (#052) - lacustrine foothills**  
Lankbush-Ladd, 30 to 60 percent slopes  
Quincy-Lankbush, 30 to 80 percent slopes  
Haw-Lankbush, 15 to 25 percent slopes

## APPENDIX B (continued .....

### **Willow Creek (#056) - lacustrine foothills**

Haw loam, 12 to 30 percent slopes

Payette coarse sandy loam, 60 to 70 percent slopes

Lolalita coarse sandy loam, 30 to 60 percent slopes

### **Conservation Data Center Ecorank C**

#### **Chalk Flat (#010) - dissected terraces and plains of Snake R.**

Bahem silt loam, 0 to 4 percent slopes

#### **Soles Rest Creek (#020) - dissected piedmont**

Lanktree-Chilcott loam

#### **Initial Point Southwest (#026) - basalt/alluvial plains**

Chilcott-Brent silt loams, 0 to 2 percent slopes

Chilcott-Sebree silt loams, 0 to 2 percent slopes

Jennes fine sandy loam, 0 to 2 percent slopes (riparian)

#### **Christmas Mountain North (#028) - basalt/alluvial plains**

Bowns Rock Outcrop, 0 to 15 percent slopes

Chardoton-Kiesel Variant silty clay loams, 0 to 2 percent slopes

Chilcott-Sebree, bedrock substrate, 0 to 4 percent slopes

Elijah silt loam, bedrock substrate, 0 to 4 percent slopes

McCain silt loam, 0 to 4 percent slopes

McCain extremely stony silt loam, 4 to 12 percent slopes

Power silty loam, 0 to 4 percent slopes

Power-McCain complex, 0 to 8 percent slopes

Purdam silt loam, 0 to 2 percent slopes

Rock Outcrop-Trevino, 5 to 20 percent slopes

#### **Bowns Creek (#031) - dissected piedmont**

Haw-Farrot complex, 4 to 20 percent slopes

#### **Horse (#037) - lacustrine foothills**

Payette-Quincy complex, 35 to 60 percent slopes

#### **Orchard SSW (#041) - basalt/alluvial plains**

Searles-Ladd complex, 30 to 65 percent slopes

Ladd-Searles complex, 30 to 65 percent

#### **Westside Canal / Slade Flat West (#050) - basalt plains**

Colthorp-Kunaton, 0 to 8 percent slopes

#### **Kuna Butte Northwest (#057) - basalt/alluvial plains**

Rock Outcrop-Trevino, 5 to 20 percent slopes

Scism silt loam, 8 to 12 percent slopes

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#### **Military Reserve Park (#012) - lacustrine foothills**

Quincy-Lankbush complex, 30 to 80 percent slopes

#### **Lower Hulls Gulch - Hulls Ridge (#023) - lacustrine**

#### **foothills**

Payette-Quincy complex

#### **Melba Butte (#025) - basalt/alluvial plains**

McCain silt loam, 4 to 12 percent slopes

Rock Outcrop-Trevino

#### **Orchard Southwest (#036) - basalt/alluvial plains**

Chilcott-Sebree complex

#### **Hackberry Divide (#036) - lacustrine foothills**

Quincy-Lankbush complex, 4 to 12 and 30 to 80 percent slopes

#### **Goose Creek (#038) - lacustrine foothills**

Quincy-Lankbush, 30 to 80 percent slopes

Haw-Lankbush, 25 to 40 percent slopes

#### **Woods Gulch (#039) - lacustrine foothills**

Quincy-Lankbush, 30 to 80 percent slopes

Payette-Quincy complex

#### **Willow Creek (#047) - lacustrine foothills**

Haw-Lankbush, 15 to 25 percent slopes

Brent loam, low rainfall, 4 to 8 percent slopes

#### **Christmas Mountain (#053) - basalt/alluvial plains**

McCain extremely stony silt loam

Chilcott-Sebree complex, bedrock substratum, 0 to 2 percent slopes

#### **Glenn's Ferry Northwest (#058) - dissected terraces and plains of Snake R.**

Owsel-Purdam, 1 to 12 percent slopes

Elijah silt loam, 0 to 4 percent slopes

Elijah-Purdam complex, 0 to 8 percent slopes

## APPENDIX C

### Key to the Soil Taxonomy Classification Names of Soil Series listed in Appendix B.

Bahem:Coarse-silty, mixed, mesic Xerollic Calciorthids  
Baldock:Fine-loamy, mixed (calcareous) mesic Typic Haplaquepts  
Bissell:Fine-loamy, mixed, mesic Aridic Argixerolls (riparian)  
Bowns:Fine, montmorillonitic, mesic Xerollic Paleargids  
Bram:Coarse-silty, mixed, mesic Xerollic Calciorthids  
Brent:Fine, montmorillonitic, mesic Xerollic Paleargids  
Buko:Coarse-loamy, over sandy or sandy-skeletal, mixed, mesic Durixerollic Camborthids  
Chardot:Fine, montmorillonitic, mesic Xerollic Paleargids  
Chilcott:Fine montmorillonitic, mesic, abrupt Xerollic Durargids  
Colthorp:Loamy, mixed, mesic, shallow Xerollic Durargids  
Dors:Coarse-loamy over sandy or sandy-skeletal, mixed, mesic Typic Calciorthids  
Elijah: Fine silty, mixed, mesic, Xerollic Durargids  
Farrot:Fine-loamy, mixed, mesic Typic Argixerolls  
Haw:Fine-loamy, mixed, mesic Aridic Calcic Argixerolls  
Jennes:Coarse-loamy, mixed, nonacid, mesic Xeric Torriorthents  
Kiesel Var.:Fine, montmorillonitic, mesic Xerollic Natrargids  
Kunaton:Clayey, montmorillonitic, mesic, shallow Abruptic Xerollic Durargids  
Ladd:Fine-loamy, mixed, mesic Typic Argixerolls  
Lankbush:Fine-loamy, mixed, mesic, Xerollic Haplargids  
Lanktree:Fine, montmorillonitic, mesic, Xerollic Haplargids  
Letha:Coarse-loamy, mixed (calcareous) mesic Aeric Haplaquepts  
McCain:Fine-silty, mixed, mesic Xerollic Haplargids  
Minidoka:Coarse-silty, mixed, mesic, Xerollic Durorthids  
Minveno:Loamy, mixed, mesic, shallow Xerollic Durorthids  
Owsel:Fine-silty, mixed, mesic Durixerollic Haplargids  
Payette:Coarse-loamy, mixed, mesic Aridic Calcic Argixerolls  
Pipeline:Loamy, mixed, mesic, shallow Xerollic Durargids  
Potratz:Fine-loamy, mixed, mesic Xerollic Camborthids  
Power:Fine-silty, mixed, mesic Xerollic Haplargids  
Purdam:Fine silty, mixed, mesic, Haploxerollic Durargids  
Quincy:Mixed, mesic Xeric Torripsamments  
Royal:Coarse-loamy, mixed, mesic Xerollic Camborthids  
Scism:Coarse-silty, mixed, mesic Haploxerollic Durorthids  
Searles:Loamy-skeletal, mixed, mesic Aridic Argixerolls  
Sebree:Fine-silty, mixed, mesic Xerollic Nadurargids  
Tenmile:Clayey-skeletal, montmorillonitic, mesic, Xerollic Haplargid  
Timmerman:Sandy, mixed, mesic, Xerollic Camborthids  
Trevino:Loamy, mixed, mesic Lithic Xerollic Camborthids

## APPENDIX D

Natric Soil Series and Soil Series Associated with Natric Soils from Ada and Elmore County Soil Surveys (Collette, 1980; Noe, 1991) that are Mapped on Areas with Extant *Lepidium papilliferum* Populations (Conservation Data Center, 1995).

Chardoton:Paleargids

Chilcott:Durargids

Colthorp:Durargids

Elijah: Durargids

Kiesel Var.:Natrargids

Kunaton:Durargids

Lanktree:Haplargids

McCain:Haplargids

Owsel:Haplargids

Pipeline:Durargids

Power:Haplargids

Purdam:Durargids

Sebree:Nadurargids

Trevino:Camborthids



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