SPECIES STATUS ASSESSMENT OF *LEPIDIUM PAPILLIFERUM*

(SLICKSPOT PEPPERGRASS)

VERSION 1.0

February 2020

Idaho Fish and Wildlife Office

U.S. Fish and Wildlife Service

Boise, Idaho

Prepared by staff of the Idaho Fish and Wildlife Office (IFWO) with State of Idaho reviews by Dr. Lynn Kinter (Idaho Department of Fish and Game), Ruth Luke (Idaho Department of Lands), and Joshua Uriarte (Idaho Governor's Office of Species Conservation). Additional reviews of the draft document were provided by Dr. Ian Robertson (Boise State University), Charles Baun (Idaho Army National Guard), and Anne Halford, Elizabeth Kramer, Mark Steiger, and Amy Stillman (Idaho Bureau of Land Management (BLM)). Scientific peer review was conducted by Dr. Ethan Ellsworth, Kathi Kershaw, and Dr. Don Major of Idaho BLM and Dr. David Pyke of the United States Geological Survey (USGS).

Special appreciation goes to U.S. Fish and Wildlife Service Region 6 Science Applications Program Science Coordinator Sean Finn, who created GIS maps and tables for this document and provided expert review of the climate change section.

Suggested citation:

U.S. Fish and Wildlife Service. 2020. Species Status Assessment of *Lepidium papilliferum* (slickspot peppergrass), Version 1.0. Idaho Fish and Wildlife Office, U.S. Fish and Wildlife Service, Boise, Idaho. 157 pp. + appendices.

EXECUTIVE SUMMARY

Lepidium papilliferum (slickspot peppergrass) is an annual or biennial member of the mustard family (Brassicaceae), found primarily in soil inclusions known as slick spot microsites scattered within sagebrush steppe ecosystems of southwest Idaho. The species depends on its persistent seed bank to survive the climatically variable desert environment of the northern Great Basin. The species typically flowers and fruits in May through July, and the proportion of seeds that germinate and emerge is dependent on winter and spring rainfall levels. Successful seed production of slickspot peppergrass depends on insect pollinators. Insect pollinators of slickspot peppergrass require floral resources (for food) from early spring through fall and undisturbed nest sites in proximity to foraging resources.

Slickspot peppergrass was first listed by the U.S. Fish and Wildlife Service (Service) in 2009 as a threatened species under the Endangered Species Act of 1973, as amended (74 FR 52014) due to two primary threats: the increased frequency and intensity of wildfire and the introduction and spread of invasive nonnative plants. The Idaho District Court vacated the decision to list the species on August 8, 2012 and remanded the final rule to the Service to reconsider the definition of "foreseeable future" for this species. Slickspot peppergrass was reinstated as threatened (81 FR 55058) effective September 16, 2016. The species is currently listed as threatened.

This Species Status Assessment (SSA) assesses slickspot peppergrass viability using the three conservation biology principles of resiliency, representation, and redundancy. Specifically, we describe the species' ecological requirements for survival and reproduction at the individual, population, and species levels and identify the factors influencing slickspot peppergrass viability. We evaluate changes in resiliency, representation, and redundancy from the current time forecasted into the future.

Key resource needs for slickspot peppergrass individual plants include functional slick spot microsites that have relatively low levels of disturbance, sunlight for photosynthesis, and timely precipitation and favorable temperatures for seed germination and plant growth. Presence of native shrubs adjacent to slickspot microsites allow for increased water availability as well as reduced seed predation by Owyhee harvester ants, and minimal competition with invasive and encroaching plants. The presence of functional slick spot microsites, intact sagebrush steppe habitat within populations and the surrounding landscape, the presence of adequate insect pollinators, and a quantity of nectar and pollen from a diversity of flowering shrubs and forbs available across the growing season to support a diversity of insect pollinators maintains long-term productivity of slickspot peppergrass populations. At the species level, slickspot peppergrass needs a sufficient number and distribution of larger populations in intact sagebrush steppe habitat to withstand environmental stochasticity (resiliency), biological and physical changes in its environment (representation), and catastrophic events (redundancy).

Statistical analysis of 11 years of annual monitoring data indicates that slickspot peppergrass numbers have declined since 2005 and are projected to continue to decline (Bond 2017, p. 11). Moseley (1994, p. 5) also described slickspot peppergrass population distribution and abundance declines in the 1990s. Primary threats of increased frequency and intensity of wildfire and the introduction and spread of invasive nonnative plants, as well as threats of residential and commercial development and associated infrastructure, have resulted in extensive fragmentation and degradation of habitat conditions across the range of the species. Most populations are isolated such that insect facilitated genetic exchange (pollination) between populations is limited, increasing the risk of future loss of genetic diversity, particularly for small populations.

We expect climate change to continue to accelerate the decline of slickspot peppergrass plant numbers as well as the loss and degradation of sagebrush steppe habitat through magnifying the threats of wildfire and invasive nonnative plants (especially invasive nonnative annual grasses such as cheatgrass and medusahead) due to alterations in precipitation and temperature. Thus, the effects of climate change are expected to reduce resiliency, representation, and redundancy of the species into the future, particularly at the lower elevation extent of the species' range. We factored current and predicted alterations in precipitation and temperature for southwestern Idaho into future condition analyses.

To forecast the species viability into the future, External Species Expert input was elicited and analyses of data from field reviews was performed on the expected future condition of the species under three scenarios, which addressed the primary threats of wildfire and invasive nonnative plants and factored in effects from climate change:

- **Worse than Expected** – No new tools or conservation measures would be available to reduce the risk of wildfire and invasive nonnative plants, and adequate funding to continue currently implemented conservation measures would not be available over the next 50 years.

- **Better than Expected** – New tools to reduce the current risk levels of wildfire and to reduce the current extent of invasive nonnative plant cover would be available and adequately funded over the next 50 years.

- **Status Quo** - The current rate of wildfire and extent of invasive nonnative plant cover and their associated effects on slickspot peppergrass populations, as well as implementation of current conservation measures, would continue to occur unchanged over the next 50 years.

Under both the Status Quo and Worse than Expected scenarios, most External Species Experts indicated that it was unlikely the current downward trend in slickspot peppergrass population numbers and habitat condition rangewide would be slowed, stabilized, or improved over the next 50 years. Thus, resiliency of currently good to fair viability populations (defined as slickspot peppergrass element occurrences (EOs) and subEOs with greater slickspot peppergrass plant numbers that are located in more intact sagebrush steppe habitat) under the Status Quo and the Worse than Expected scenarios would be expected to decline, and population representation and redundancy would be reduced such that future species viability would be lower than current levels.

Under the Better than Expected scenario, most External Species Experts expressed that it was likely or there was a medium likelihood that the current downward trend in slickspot peppergrass EO and subEO plant numbers and habitat conditions range-wide would be slowed, stabilized, or improved over the next 50 years. Under the Better than Expected scenario, EOs and subEOs have a reduced risk of loss of resiliency, representation, and redundancy of slickspot peppergrass such that future viability is anticipated to maintain or improve current viability levels.

Contents

EXECUTIVE SUMMARY ii

1. Introduction and Analytical Framework 1

1.1. Background 1

1.2. Federal and State Legal Status 1

1.3. Analytical Framework 1

2. Ecology 3

2.1. Range and Distribution 3

2.1.1. Geology and Soils 4

2.1.2. Climate 6

2.1.3. Historical Range 6

2.1.4. Current Range 7

2.2. Taxonomy 13

2.3. Species Description and Life History Strategies 15

2.3.1. Species Description 15

2.3.2. Life History Strategies 15

2.3.3. Habitat 18

2.4. Individual-Level Ecology 22

2.4.1. Seed Life Stage 22

2.4.2. Seedling Life Stage 25

2.4.3. Rosette Life Stage 26

2.4.4. Flowering Annual or Biennial Plant Stage 26

2.4.5. Summary of Individual Plant Needs 28

2.5. Population-Level Ecology 31

2.5.1 Genetics 31

2.5.2 Population Dynamics and Demographic Trends 34

2.6 Species-Level Ecology 57

3. Factors Affecting the Species 59

3.1 Primary Threat: Increased Frequency and Intensity of Wildfire 59

3.2 Primary Threat: Introduction and Spread of Invasive Nonnative Plants 64

3.3 Additional Threat: Highly Competitive Nonnative Seeded Species 68

3.4 Additional Threat: Development 72

3.5 Additional Threat: Owyhee Harvester Ants 74
3.6 Additional Threat: Improper Livestock Grazing 75
3.7 Additional Threat: Climate Change 79
4. Analysis of Current Condition 84
4.1 Conservation Plans 84
4.2 Increased Frequency and Intensity of Wildfire 85
4.3 Introduction and Spread of Invasive Nonnative Plants 89
4.4 Additional Threats 95
4.4.1 Highly Competitive Nonnative Plants 95
4.4.2 Development 98
4.4.3 Owyhee Harvester Ants 99
4.4.4 Livestock Grazing 100
4.5 Current Condition of Populations 103
4.6 Summary of Current Condition 114
5. Analysis of Future Conditions – Species Viability 120
5.1 Future Scenarios 120
5.1.1 Worse Than Expected 121
5.1.2 Better than Expected 121
5.1.3 Status Quo 121
5.2 Analyzing Future Condition Using Experts 121
5.2.1 Worse Than Expected 122
5.2.2 Better than Expected 123
5.2.3 Status Quo 123
5.2.4 Summary of Future Condition Using Experts 124
5.3 Estimate of Future Condition Based on Two Primary Threats 125
5.3.1 Worse Than Expected 125
5.3.2 Better than Expected 126
5.3.3 Status Quo 127
5.4 Summary of Future Condition 128
6. Status Assessment Summary 131
7. References 132

7.1 Literature Cited ... 132
7.2 In Litteris References ... 153
7.3 Personal Communications ... 156
8. Acronyms Used ... 157
Appendix A. Glossary of Scientific and Technical Terms ... 158
Appendix B. Ongoing Conservation Efforts ... 164
Appendix C. Section 7 Consultation Cause and Effect Evaluations ... 171
Appendix D. Current Disturbance Scope and Severity within Element Occurrences ... 176
Appendix E. Primary Threats of Wildfire and Invasive Nonnative Plants from Disturbance Data Used for Slickspot Peppergrass Element Occurrence Assessments (see Appendix D) ... 184
Appendix F. Predicted Future Threats for Slickspot Peppergrass Element Occurrences ... 188
Appendix G. External Species Expert Recommended Actions to Increase Future Viability of Slickspot Peppergrass ... 195

List of Tables

Table 1. Distribution and landownership of slickspot peppergrass extant Element Occurrences and subElement Occurrences by geographic area

Table 2. Individual resource needs of slickspot peppergrass by life stage

Table 3. Minimum viable population (MVP) guidelines applied to slickspot peppergrass

Table 4. Criteria used for calculating slickspot peppergrass Element Occurrence and subElement Occurrence rankings

Table 5. Descriptions of slickspot peppergrass Element Occurrence and subElement Occurrence E-, F-, H-, and X-rankings

Table 6. Numbers and acreages of slickspot peppergrass Element Occurrences by ranking category

Table 7. Slickspot peppergrass populations currently meeting viability criteria

Table 8. Geographic locations of slickspot peppergrass population groupings with good to fair viability

Table 9. Disturbance observed during IDFG slickspot peppergrass EO/subEO field assessments

Table 10. Summary of current disturbance condition and acreages of 105 EOs and subEOs relative to the primary threats of wildfire and invasive nonnative plants by geographic area and EO rank.

Table 11. Summary of requirements, factors affecting survival, and current conditions of slickspot peppergrass individuals and populations, and the species' viability (representation, redundancy, and resiliency)

Table 12. Verbal descriptions of probability and associated numeric ranges

Table 13. Summary of External Species Expert exercises examining the expected impacts of wildfire and invasive nonnative plants (especially nonnative annual grasses) on slickspot peppergrass under each of three future scenarios

Table 14. Future slickspot peppergrass resiliency, representation, redundancy, and viability under three future scenarios

List of Figures

Figure 1. Species Status Assessment Framework

Figure 2. Distribution and ranking of extant slickspot peppergrass Element Occurrences within the Foothills, Snake River Plain, and Jarbidge geographic areas

Figure 3. Satellite imagery showing development of lands within the historic range of slickspot peppergrass, which is particularly evident across the Snake River Plain

Figure 4. Slickspot peppergrass Element Occurrence rangewide acreage by land ownership categories

Figure 5. Slickspot peppergrass flowering plant

Figure 6. Life cycle diagram for slickspot peppergrass showing annual and biennial life history strategies and the persistent seed bank

Figure 7. Slickspot peppergrass rosettes

Figure 8. Slick spot microsite with flowering slickspot peppergrass plants on the Idaho Army National Guard's Orchard Combat Training Center

Figure 9. Genetic relationships between slickspot peppergrass populations located in the Snake River and populations in the Jarbidge

Figure 10. Map illustrating the location of Habitat Integrity and Population (HIP) monitoring transects, State of Idaho Candidate Conservation Agreement Management Areas (MAs), and geographic areas for slickspot peppergrass

Figure 11. Total number of slickspot peppergrass plants observed annually along Habitat Integrity and Population Monitoring transects rangewide and by geographic area from 2005 through 2018

Figure 12. Numbers of slickspot peppergrass plants observed annually along Habitat Integrity and Population monitoring transects from 2005 through 2018 within Management Areas as described in the Candidate Conservation Agreement for Slickspot Peppergrass

Figure 13. Rangewide acreages of slickspot peppergrass Element Occurrences by rank

Figure 14. Cumulative acreages of slickspot peppergrass Element Occurrences by geographic area and by rank

Figure 15. Cumulative slickspot peppergrass Element Occurrence acreages by rank for each individual geographic area

Figure 16. State and transition model for a mesic/aridic Wyoming big sagebrush ecological type with low to moderate ecological resilience and low ecological resistance

Figure 17. Root extent of deep-rooted, mid-rooted, and shallow-rooted native perennial plants relative to cheatgrass

Figure 18. A climate niche model for Wyoming big sagebrush projected for three decades and two greenhouse gas emission scenarios

Figure 19. Wildfire recurrence levels in landscapes across the range of slickspot peppergrass

Figure 20. Invasive nonnative annual grass cover across the range of slickspot peppergrass

Figure 21. Vegetation Management Areas in the BLM Jarbidge Field Office area as of 2011 showing the extent of areas dominated by seeded highly competitive nonnative species

Figure 22. Number of Habitat Integrity and Population monitoring transects with livestock hoof print thresholds exceeded by year and by region

Figure 23. Invasive nonnative plant and wildfire disturbance condition summarized for EOs and subEOs rangewide.

Figure 24. Invasive nonnative plants and wildfire disturbance condition of slickspot peppergrass EOs and subEOs by geographic area.

Figure 25. Invasive nonnative plant and wildfire disturbance condition of slickspot peppergrass EO and subEO acreages rangewide.

Figure 26. Invasive nonnative plants and wildfire disturbance condition of slickspot peppergrass EO and subEO acreages by geographic area.

1. Introduction and Analytical Framework

1.1. Background

This Species Status Assessment (SSA) is a comprehensive status review of *Lepidium papilliferum* (slickspot peppergrass) to inform the recovery planning and implementation process and guide ongoing conservation efforts such as 5-year reviews and section 7 consultations. Slickspot peppergrass is an annual or biennial member of the mustard family (Brassicaceae) found primarily in soil inclusions known as slick spot microsites scattered within sagebrush steppe ecosystems of southwest Idaho. This SSA will be updated as new information becomes available to ensure it supports all functions of the Service's Endangered Species Program.

1.2. Federal and State Legal Status

A decision to list slickspot peppergrass as a threatened species under the Endangered Species Act of 1973, as amended, was published in the Federal Register on October 8, 2009 (74 FR 52014-52064). On August 8, 2012, the U.S. District Court for the District of Idaho reversed and remanded the 2009 listing decision to the Service for further consideration on the grounds that the term "foreseeable future" was not adequately defined (Otter v. Salazar 2012). The Service addressed the need for a specific definition of foreseeable future for slickspot peppergrass in the final rule published on August 17, 2016 (81 FR 55058-55084), which reinstated slickspot peppergrass as a threatened species effective September 16, 2016.

Critical habitat was proposed for slickspot peppergrass on May 10, 2011 (76 FR 27184-27215). On February 12, 2014, the Service amended the original critical habitat proposal to include recently discovered slickspot peppergrass locations that met critical habitat designation criteria (79 FR 8402-8413). Final designation of critical habitat for slickspot peppergrass has not yet occurred.

Idaho State statutes do not contain specific protections for slickspot peppergrass. The Idaho Department of Fish and Game (IDFG) works with Federal, State, and private landowners to provide technical assistance regarding the condition and location of slickspot peppergrass populations. Information is collected and housed in the Idaho Fish and Wildlife Information System (IFWIS) database. IDFG also determines the viability of each slickspot peppergrass population through ranking categories and identifies conservation opportunities for the species across land ownerships (IDFG *in litt.* 2018, pp. 3, 6).

1.3. Analytical Framework

The SSA framework (Figure 1; USFWS 2016, entire) provides the Service with a process to assemble, review, and summarize information, incorporating the best available scientific and commercial data, to conduct an in-depth review of a species' biology and threats, evaluate its biological status, and assess the resources and conditions needed to maintain long-term viability. The framework includes an evaluation of the species needs, current condition, and viability into the future using the concepts of resiliency, representation, and redundancy. For the purpose of this assessment, we define the viability of slickspot peppergrass as its ability to sustain populations in the wild beyond the end of a specified period. Using the SSA framework, we consider what the species needs to maintain viability through an assessment of its resiliency, representation, and redundancy.

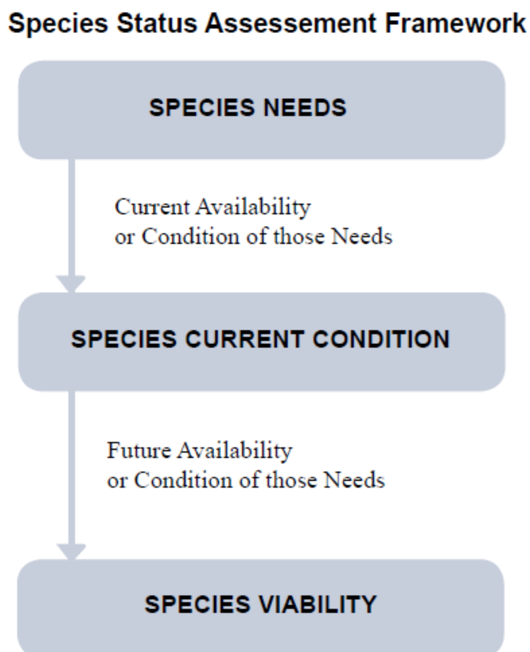


Figure 1. Species Status Assessment Framework.

Species resiliency, representation, and redundancy are defined by the Service as follows:

- **Resiliency** is having sufficiently large populations for the species to withstand stochastic events (arising from random factors). We can measure resiliency based on metrics of population health; for example, birth versus death rates and population size. Resilient populations are better able to withstand disturbances such as random fluctuations in birth rates (demographic stochasticity), variations in rainfall (environmental stochasticity), or the effects of anthropogenic activities.

- **Representation** refers to the genetic diversity, both within and among populations, necessary to conserve long-term adaptive capability. Representation is having the breadth of genetic makeup of the species to adapt to changing environmental conditions. It can be measured through the genetic diversity within and among populations and the ecological diversity (also called environmental variation or diversity) of populations across the species' range. The flow of genetic material within and among populations contributes to representation. The more representation, or diversity, a species has, the more it is capable of adapting to changes (natural or human caused) in its environment. In the absence of species-specific genetic and ecological diversity information, we evaluate representation based on the extent and variability of habitat characteristics within the geographical range.

- **Redundancy** refers to the number and geographic distribution of populations or sites necessary to endure catastrophic events. Redundancy is about spreading the risk and can be measured through the duplication and distribution of populations across the range of the species. The greater the number of populations a species has distributed over a larger landscape, the better it can withstand catastrophic events.

In summary, this SSA is a scientific review of the available information related to the biology and conservation status of slickspot peppergrass.

2. Ecology

This chapter compiles the scientific information upon which this species status assessment is based, including numerous past and ongoing research studies and monitoring efforts that provide information on slickspot peppergrass life history, genetics, habitat, insect pollinators, and seed predation. Botanists, biologists, and researchers representing multiple entities collaborated on inventory and monitoring efforts for slickspot peppergrass over several decades. These research and monitoring efforts, as well as the recent rangewide population assessment for the species, provide the best scientific and commercial data available, and we refer to them throughout this SSA.

Slickspot peppergrass population trends and habitat characteristics have been quantitatively monitored across the range of the species since 2004 through annual Habitat Integrity and Population (HIP) monitoring. Ten years of rangewide HIP monitoring data collected by IDFG between 2005 and 2016 have been used in statistical analysis to identify parameters important to slickspot peppergrass conservation. Additional long-term monitoring efforts continue to be conducted by the Idaho Army National Guard for populations located on the Orchard Combat Training Center (previously named the Orchard Training Area) and by the Mountain Home Air Force Base for the population located on the Air Force's Juniper Butte Range. The Bureau of Land Management (BLM) has also conducted tens of thousands of acres of inventory to search for new slickspot peppergrass populations or expand existing populations of the species. In addition, IDFG botanists completed a rangewide assessment of slickspot peppergrass populations in 2016 (Kinter and Miller 2016, entire). The 2016 IDFG rangewide population assessment for slickspot peppergrass provides updated rangewide occurrence data, which we use as a basis to inform our projections of likely future trajectories for slickspot peppergrass.

2.1. Range and Distribution

Slickspot peppergrass occurs only in southwestern Idaho in Ada, Canyon, Gem, Elmore, Payette, and Owyhee counties. This species is from three geographic areas based on landform: the Foothills geographic area, the Snake River Plain geographic area, and the Jarbidge geographic area (Kinter and Miller 2016, p. 9). The Snake River Plain and the adjacent Foothills geographic areas contain populations scattered within an area of approximately 90 by 25 miles. The smaller disjunct (separated from other populations by a long distance) Jarbidge geographic area contains groups of populations located about 45 miles to the south in the eastern Owyhee Uplands, where populations and subpopulations are within an area of approximately 11 by 12 miles (Figure 2).

2.1.1. Geology and Soils

Slickspot peppergrass is associated with basalt ridges and plains, stable piedmont, and alluvial floodplains and deposits (Fisher *et al.* 1996, pp. 14, 16). The species occurs from 2,490 feet to 5,407 feet in elevation (Kinter and Miller 2016, p. 2). Although most populations occur on flat to gently sloping terrain, some foothill populations occur on ridge tops or steep slopes with rolling terrain. Both the Snake River Plain and the Jarbidge geographic areas are underlain by basalt or rhyolitic rock deposited during the Tertiary geologic period (about 66 million to 2.6 million years ago) (Moseley 1994, p. 8). The Foothills geographic area includes the rolling terrain of the Boise Foothills and Sand Hollow areas and is underlain by lacustrine deposits (sedimentary rock formations formed at the bottom of ancient lakes), formed more recently during the Pliocene/Quaternary geologic periods (about 2.5 million years ago to the present).

Soils that occur within the range of slickspot peppergrass belong to the soil taxonomic suborder Argids that includes soils with an aridic moisture regime (order Aridsol) and a diagnostic argillic horizon. 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 there are small natric (saline) slick spots (Fisher *et al.* 1996, p. 16).

Slickspot peppergrass plants are typically found in visually distinct microsites known as slick spots, which are interspersed within sagebrush steppe habitat of southwest Idaho (Moseley 1994, p. 7). Slick spot microsites are shallow depressions that are usually a few centimeters lower than the surrounding soil surface where rain and snowmelt collect. Slick spots are visually distinct openings characterized by natric soils and distinct clay layers; they tend to be highly reflective and relatively light in color, making them easy to detect on the landscape (Fisher *et al.* 1996, p. 3). Slick spots are distinguished from the surrounding sagebrush matrix as having the following characteristics: microsites where rainfall pools (Fisher *et al.* 1996, pp. 2, 4); sparse vegetation, distinct soil layers with a columnar or prismatic structure, higher alkalinity and clay content, and higher sodium salt content (Fisher *et al.* 1996, pp. 15–16; Meyer and Allen 2005, pp. 3–5, 8; Palazzo *et al.* 2008, p. 378); and reduced levels of organic matter and nutrients due to lower biomass production (Meyer and Quinney 1993, pp. 3, 6; Fisher *et al.* 1996, p. 4). Fisher *et al.* (1996, p. 11) describe slick spots as having a "smooth, panlike surface" that is structureless and slowly permeable when wet, moderately hard and cracked when dry. Slick spots range in area from less than 1 square meter (about 11 square feet) to over 50 square meters (over 538 square feet) (Kinter and Miller 2016, p. 1). Slick spot microsites are often irregularly shaped, with a few long crooked "arms" or branches radiating from the central mini-playa (Kinter and Miller 2016, p. 1). Historically slick spots were likely much larger and more playa-like (a desert basin with no outlet that periodically fills with water to form a temporary lake) before disturbance changed the soil surface and allowed both native and nonnative species to invade (A. Stillman pers. comm. 2018).

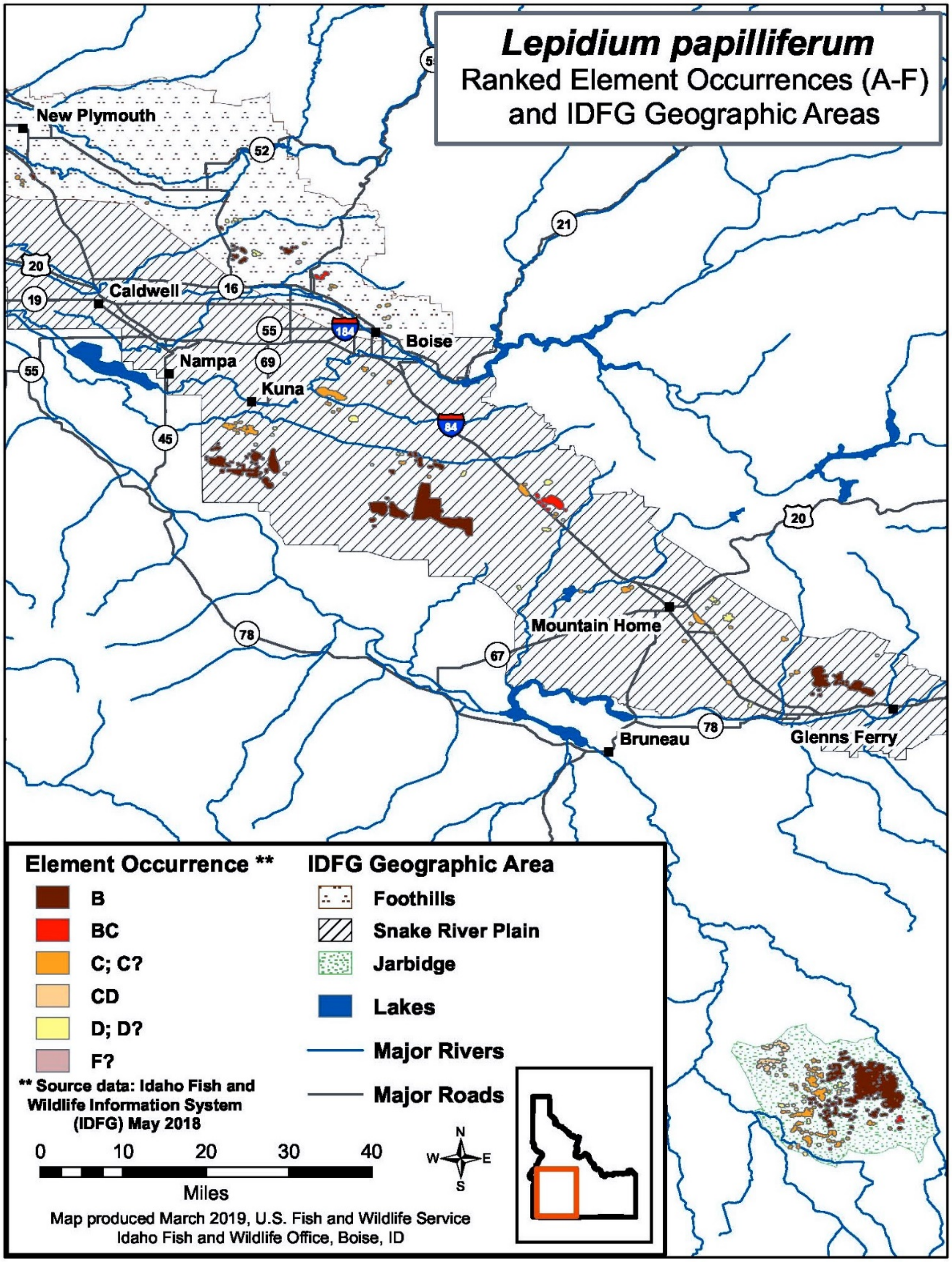


Figure 2. Distribution and ranking of extant slickspot peppergrass Element Occurrences (EOs) within the Foothills, Snake River Plain, and Jarbidge geographic areas. EO ranking letters (B-F) are defined in Tables 5 and 6 of this document.

Fine soil particles and salts in slick spot microsites form a habitat with conditions that contrast sharply with the surrounding native plant communities. The soils of slick spot microsites contrast strongly with surrounding areas that are primarily dominated by big sagebrush (*Artemisia tridentata*), which are typically *Artemisia tridentata* ssp. *wyomingensis* (Wyoming big sagebrush) and *Artemisia tridentata* ssp. *tridentata* (basin big sagebrush). Few plant species can tolerate the soil and hydrologic conditions that occur within relatively undisturbed slick spot microsites. Slickspot peppergrass is well adapted to slick spot conditions and is usually restricted to slick spot microsites or areas immediately adjacent to them (IDFG *in litt*. 2018, p. 2). However, a BLM species expert with extensive field experience recently noted that when slick spots soils are disturbed or when wind-blown soils are deposited into slick spots, both native and nonnative plants may become established (Stillman pers. comm., 2018); establishment of other plant species in slick spots can reduce the ability of slick spots to support slickspot peppergrass plants. Slick spot microsites cover a small cumulative area within the larger sagebrush steppe matrix, and only a small percentage of slick spots are currently known to be occupied by slickspot peppergrass.

How long slick spot microsites take to form is unknown, but it is hypothesized to take several thousands of years (Nettleton and Peterson 1983, p. 193; Seronko 2006, *in litt.* p. 2). Climate conditions that allowed slick spot formation in southwest Idaho likely occurred during a wetter Pleistocene period. Holocene additions of wind-carried salts (often loess deposits) produced the natric soils characteristic of slick spots (Nettleton and Peterson 1983, p. 191; Seronko 2006, *in litt.*, p. 2). Several hundred years may be necessary to alter or lose slick spots through natural climate change or severe natural erosion (Seronko 2006, *in litt.* p. 2). However, some researchers hypothesize that new slick spots are no longer created in southwest Idaho given current climatic conditions (Nettleton and Peterson 1983, pp. 166, 191, 206). As slick spot microsites in southwest Idaho appear to have formed during the Pleistocene and current climate conditions may not allow for the formation of new slick spots, the loss of slick spot microsites within the range of slickspot peppergrass appears to be permanent.

2.1.2. Climate

Climate within the range of slickspot peppergrass is arid, with little precipitation from July to September. Annual precipitation in Boise, which is centrally located between the Foothills and the Snake River Plain geographic areas of the species' range, averages 11.7 inches (in.), with the lowest average monthly minimum temperature of 22.6 degrees Fahrenheit (ºF) in January and the highest average monthly maximum temperature of 90.9 ºF in July (Western Regional Climate Center 2016a, entire). Conditions at Murphy Hot Springs, near the southeastern end of the species' range, are moister and cooler. The average annual precipitation at Murphy Hot Springs is 13.25 in., with the lowest average monthly minimum temperature of 16.1 ºF in December and highest average monthly maximum temperature of 86.4 ºF in July (Western Regional Climate Center 2016b, entire).

2.1.3. Historical Range

The historic extent of slickspot peppergrass is unknown. Although slickspot peppergrass botanical surveys and population monitoring were initiated a few decades ago (IDFG *in litt.* 2018, p. 6), this plant is thought to have been fairly common and widely distributed in this area prior to the late 1800s because many botanists collected slickspot peppergrass between 1892 and 1950 on the Snake River Plain and vicinity (Moseley 1994, p. 5). Holmgren *et al*. (2005, p. 260) noted that this species was probably much more common in the past before habitat loss to development, agriculture, and large wildfires. Around 1840, development of roads, trails (such as the Oregon Trail), towns, and agricultural fields began across the range of slickspot peppergrass, particularly on the Snake River Plain. Over the past 150 years, large acreages of sagebrush steppe have been permanently lost where they have been plowed, paved, or otherwise extensively altered, such as by wildfire (Figure 3). Much of the remaining habitat has been degraded by nonnative plant species as a result of historic levels of livestock grazing, drought, increased wildfire frequency, wildfire rehabilitation plantings, military activities, and other soil-disturbing activities (U.S. Department of the Interior 1996, pp. vii, 14, 21-22; Knick and Rotenberry 1997, pp. 294-295; Knick 1999, pp. 53, 55; Pyke *et al.* 2016, p. 314), reducing the quality of habitat available for slickspot peppergrass.

It is unknown whether all populations of slickspot peppergrass were ever continuously distributed, and if so, when these populations became separated into the Snake River Plain and the Jarbidge geographic areas. Extensive searches of the intervening areas between the two geographic areas have not revealed any populations (M. Mancuso, personal communication, as cited in Stillman 2006, p. 33). What was previously described by the IDFG Idaho Natural Heritage Program (INHP) database (currently the Idaho Fish and Wildlife System (IFWIS) database) as a historic, disjunct population in Bannock County was determined to be in error and is no longer included in the IDFG database (USFWS 2006, p. 15).

2.1.4. Current Range

The current distribution of slickspot peppergrass populations is described by the IFWIS database using Element Occurrences (EOs) (Kinter and Miller 2016, entire; Colket *et al*. 2006, entire). NatureServe defines an EO as an area where a species or community is or was present. Within this SSA, the terms EO and population are used interchangeably when referring to slickspot peppergrass.

The IFWIS defines EOs of slickspot peppergrass by grouping occupied slick spot microsites that occur within 1 kilometer (0.6 miles) of each other; all occupied slick spots and the surrounding plant community within a 0.6-mile distance of another occupied slick spot microsite are aggregated into a single EO. The definition of a single slickspot peppergrass EO is based on the approximately 0.6-mile distance believed to facilitate slickspot peppergrass genetic exchange through insect pollinators (Colket and Robertson 2006, *in litt.* pp. 1-2).

There are 115 extant slickspot peppergrass EOs and subEOs within the IFWIS database (IFWIS data, July 2018). This represents an increase in the number of occupied EOs since the 2009 final Listing Rule (74 FR 52014), when 80 extant slickspot peppergrass EOs were known. Surveys have resulted in the discovery of new EOs (17 since 2009), the expansion of some existing EOs, and, in some cases, merging of EOs, if occupied slick spots of expanded EOs occur within 0.6 miles of other EOs. The IFWIS database also contains ten EOs considered extirpated as habitat has been lost through development or cultivated agriculture. Five EOs are categorized as historic (Kinter and Miller 2016, p. 7).

The 115 EOs and subEOs include 22 subEOs that make up metapopulation EO 16 in the Jarbidge geographic area. The relatively high numbers of EOs and subEOs in the Jarbidge geographic area are not directly comparable to EO numbers within the remainder of the species range because metapopulation EO 16 was divided into discrete subEOs (using a 0.75-kilometer, or about a 0.47-mile separation distance) for management purposes (Colket *et al.* 2006, p. 2). These subEOs within metapopulation EO 16 were assessed individually, while other subEOs across the range of the species were assessed collectively in context of the entire EO (Kinter and Miller 2016, p. 1).

The total area of known extant EOs and subEOs from July 2018 IFWIS data is about 16,279 acres (Table 1). The EO total acreage represents an increase of 478 acres (about a 3 percent increase) from the total 2009 EO acreage of 15,801 acres when the species was first listed. Despite the expansion of existing EOs and the discovery of new EOs associated with increased inventory efforts, the range of slickspot peppergrass has not significantly expanded since 2002 when the species was originally proposed for listing. The area occupied by slickspot peppergrass is only a small fraction of the total EO acreage rangewide, since slick spot microsites occupy only a small percentage of the landscape and the majority of slick spot microsites are not occupied by slickspot peppergrass. Furthermore, with the exception of the 321-acre EO 122 located in the Snake River Plain geographic area in 2016, 13 of the 14 new EOs discovered since the 2009 listing have been small (less than 1 acre in size) (IFWIS data, July 2019).

The vast majority of slickspot peppergrass EO acreage rangewide is located on public lands. As shown in Figure 4 and Table 1, approximately 87 percent (14,182 acres) of the total extant slickspot peppergrass EO acreage rangewide occurs on Federal lands (BLM, U.S. Air Force, Bureau of Reclamation). Of these Federal acres, approximately 7,879 Federal EO acres (56 percent) are located within the boundaries of two military training areas (Mountain Home Air Force Base's Juniper Butte Range and the Idaho Army National Guard's Orchard Combat Training Center). An additional nine percent (1,502 acres) of EO acres are located on State lands. The remaining four percent of slickspot peppergrass EO acreage rangewide (about 594 acres) is privately owned. The relatively low acreage of slickspot peppergrass populations known to occur on private lands may be tied to habitat loss associated with past and current development or other activities on private lands, the lack of surveys on private lands, or a combination of these.

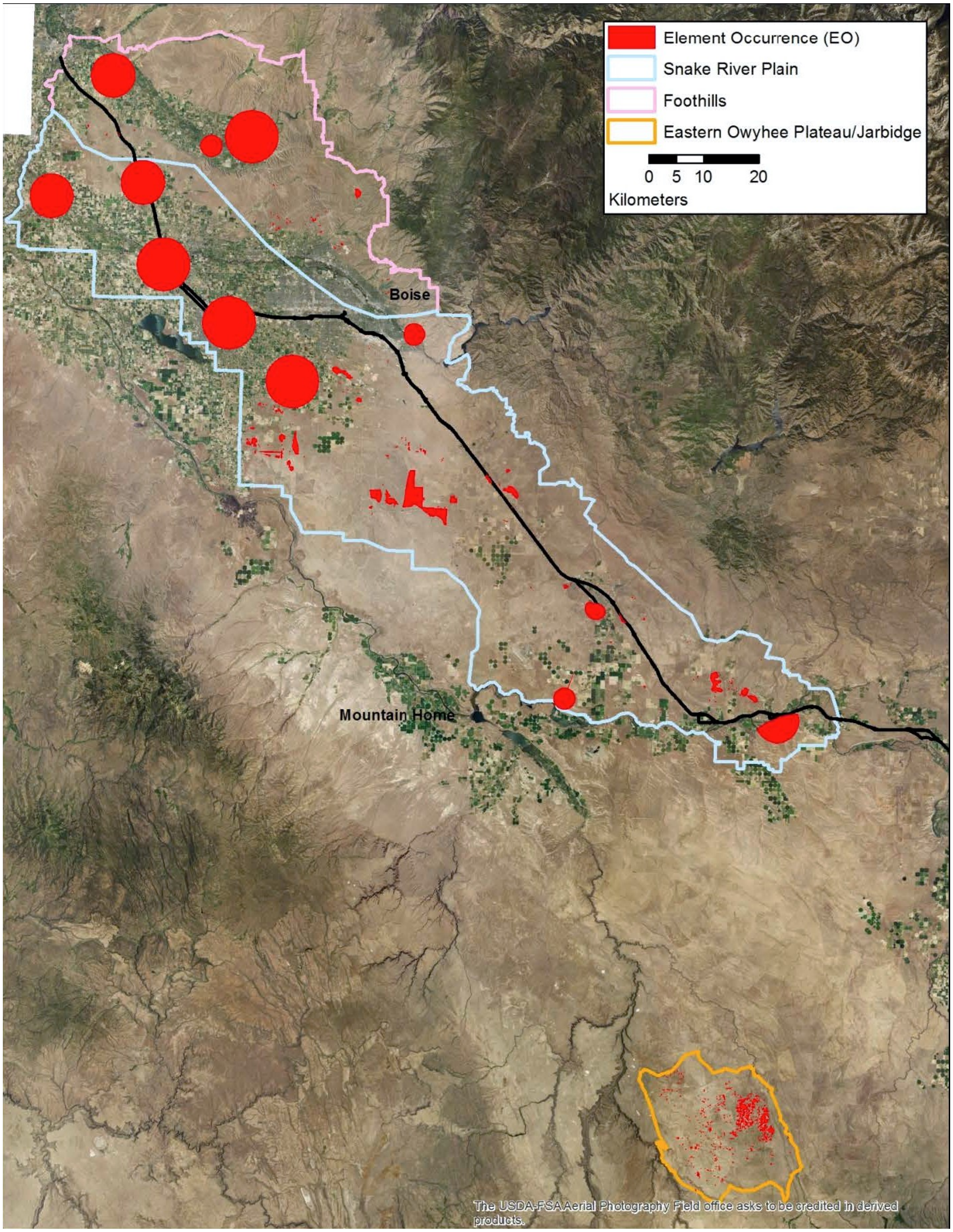


Figure 3. Satellite imagery showing development of lands within the historic range of slickspot peppergrass, which is particularly evident across the Snake River Plain (from IDFG in litt. 2018, p. 11). The large circular Element Occurrences are indicative of geographically vague population location data associated with historic and extirpated locations for the species.

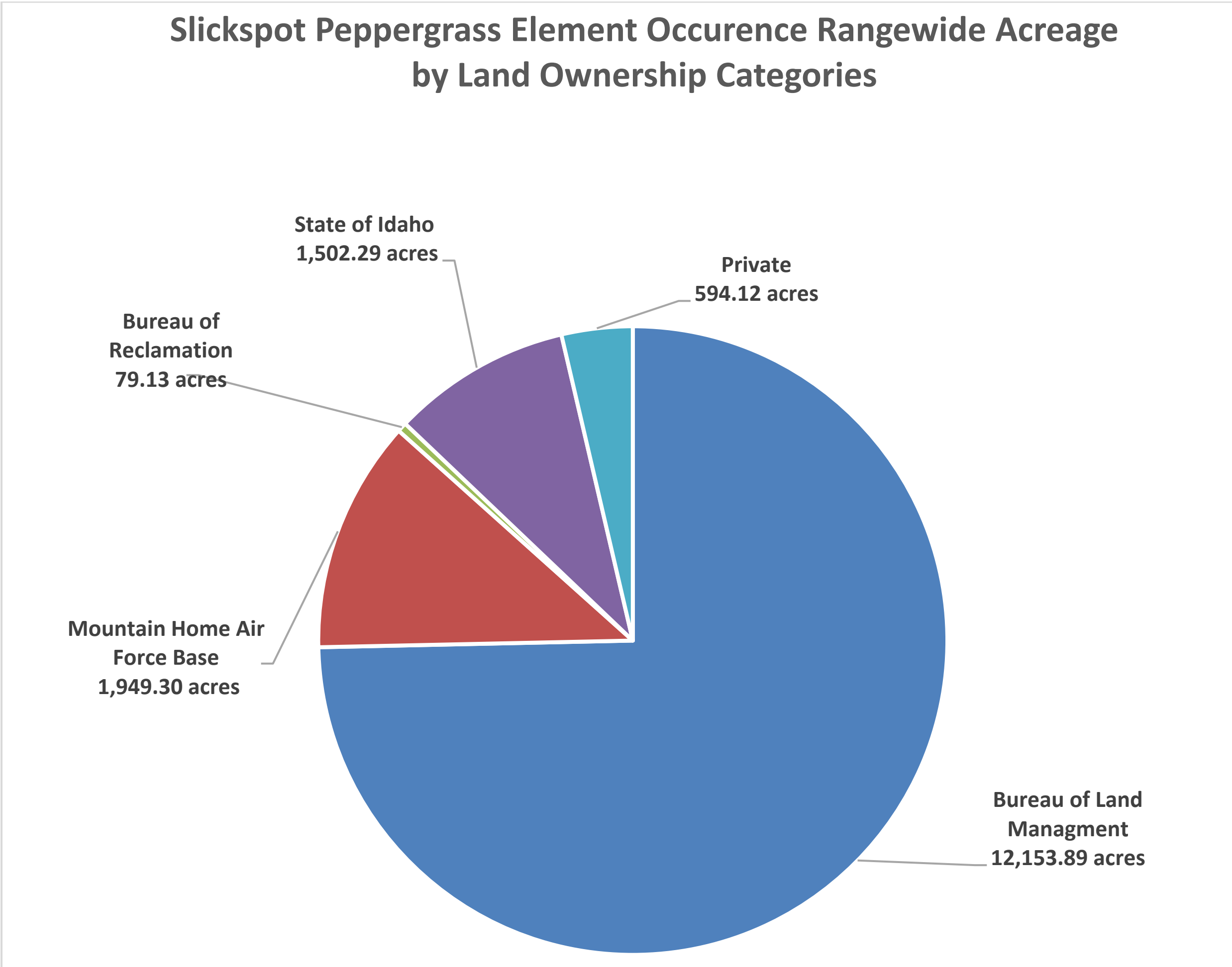


Figure 4. Slickspot peppergrass Element Occurrence rangewide acreage by land ownership categories.*

*Note that Element Occurrence acreages located within the Idaho Army National Guard's Orchard Combat Training Center are included within Bureau of Land Management and State of Idaho Element Occurrence acreages. The Orchard Combat Training Center is not located on lands withdrawn for military training or testing in support of national defense requirements by the Secretary of Interior or Congress. Military training and related activities on the Orchard Combat Training Center by the Idaho Army National Guard occur through BLM and the State of Idaho lease agreements.

Table 1. Distribution and landownership of slickspot peppergrass A- though F-ranked EOs and subEOs[1] by geographic area (IDFG July 2018). All areas are estimates; acreages and percentages may not total exactly due to rounding.

Geographic Area	**Slickspot Peppergrass EOs and subEOs**		**Federal**		**State**		**Private**		**Total**	
	Number	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Foothills	18	16%	82	0.5%	0	0%	67	0.4%	149	1%
Jarbidge	46[1]	40%	2,570	16%	133[2]	1%	0	0%	2,703	17%
Snake River Plain	51	44%	11,530	71%	1,369[3]	8%	527	3.2%	13,427	82%
All Extant EOs	**115[4]**	**100%**	**14,182**	**87%**	**1,502**	**9%**	**594**	**4%**	**16,279**	**100%**

[1] EO 16, which is located in the Jarbidge geographic area, is represented by its 22 individual subEOs in the extant EO and subEO total. If only extant EOs are considered, a total of 94 extant EOs are described by IDFG as of July 2018.

[2] Of these 133 acres of State land located within the Jarbidge geographic area, about 76 acres (57 percent) are located within subEO 704 and are managed under the Mountain Home Air Force Base's INRMP.

[3] Of these 1,369 acres of State land located within the Snake River Plain geographic area, about 1,269 acres (93 percent) are managed under the Idaho Army National Guard's Orchard Combat Training Center INRMP.

[4] The three new EO and 3 new subEOs discovered since 2016 have not yet been assessed for population viability by IDFG.

Of the Federal agencies described above that manage activities within slickspot peppergrass populations, the BLM manages 75 percent (about 12,154 acres) of the total rangewide EO acreage, including land uses within the Idaho Army National Guard's Orchard Combat Training Center boundary. BLM has identified four categories of habitat for slickspot peppergrass for land management purposes: extant EOs with surrounding 0.5 mile Habitat Integrity Zones (HIZ), Potential Habitat, Slickspot Peppergrass Habitat, and Unoccupied Habitat.

- Extant EOs with surrounding 0.5 mile HIZ buffers are intended to provide habitat for the species and its insect pollinators. Prior to 2019, extant EOs with surrounding 0.5 mile HIZ buffers[4] were referred to as "Occupied Habitat". Occupied Habitat was defined by BLM as "the location where slickspot peppergrass has been documented or identified as an EO, and the surrounding area within 0.5 mile radius of that occurrence. The 0.5 mile radius buffering area is important to maintain or improve habitat integrity, and pollinator populations and habitat necessary for species conservation." (USBLM 2009, p. B–2).
- Potential Habitat is defined as areas within the known range of slickspot peppergrass that have general soil and elevation characteristics indicating the potential for the area to support slickspot peppergrass, although the presence of slick spot microsites or the plant is unknown.
- Slickspot Peppergrass Habitat includes areas that contain slick spot microsites of unknown occupancy that are yet to be surveyed during three years of adequate spring rainfall (e.g., March through May precipitation levels of at least 60 percent of average spring precipitation), which would increase the probability of detecting above ground slickspot peppergrass plants. For the Boise area [Foothills and western Snake River Plain geographic areas], 60 percent of average spring precipitation (March through May) is calculated to be approximately 2.4 inches (NOAA precipitation data, 1971-2009); for the Three Creek area [Jarbidge geographic area], this would be approximately 2.5 inches (NOAA precipitation data, 1940-1987); for the Glenns Ferry area [eastern Snake River Plain geographic area], this would be about 1.4 inches (NOAA precipitation data, 1948-2006) (USBLM 2010 *in litt.* p. 4).
- Unoccupied Habitat encompasses areas where slick spot microsites appear to have characteristics to support slickspot peppergrass, but no above ground plants were observed during three years of inventory when March through May precipitation levels would be expected to contain at least some above ground plants if a seed bank was present (e.g., at least 60 percent of average March through May precipitation levels).

Although most areas currently identified by BLM as slickspot peppergrass Potential Habitat in southwest Idaho have been surveyed, additional slickspot peppergrass sites may still be found outside of areas currently known to be occupied. The BLM has inventoried thousands of acres to identify whether slick spot microsites are present in Potential Habitat areas, and if so, whether slickspot peppergrass plants occur in the Potential Habitat re-categorized as Slickspot Peppergrass Habitat areas once slick spot microsites are observed. Slick spot microsites and

[4] A one kilometer (0.6 mile) maximum separation distance was used by the Idaho Department of Fish and Game for designation of individual EOs as 0.6 miles was identified as the maximum distance believed to facilitate genetic exchange of slickspot peppergrass by insect pollinators. The Bureau of Land Management designated a 0.5 mile radius surrounding all slickspot peppergrass EOs to provide for habitat needs of slickspot peppergrass and its insect pollinators.

expansions of known populations of slickspot peppergrass have been documented in areas that were not originally identified as Potential Habitat within the Snake River Plain geographic area (A. Stillman pers. comm. 2018); thus, the current definition of Potential Habitat may not include all areas where the species may occur. In addition, a predictive distribution model of slickspot peppergrass to identify additional Potential Habitat was developed by IDFG in 2008 (Colket 2008, p. 1). However, surveys conducted in 2008 in areas identified as previously unsurveyed habitat that the model predicted as high potential to contain the species did not result in any new locations of the species (Colket 2008, pp. 4–6).

Slickspot peppergrass has also been searched for during botanical inventories in eastern Oregon, but the species has not been found there (Findley 2003 *in litt.*, p. 1). The Service has no records indicating that slickspot peppergrass has been found outside of its present range in southwest Idaho. Slick spot microsites extend beyond the occupied range of the species on the Jarbidge and Snake River Plain geographic areas, and into eastern Oregon. Unoccupied slick spot microsites are also known to be present in other arid areas such as California's Central Valley (Reid *et al.* 1993, as cited in Fisher *et al.* 1996, p. 13) and in central Oklahoma (Bakhtar and Gray 1971, p. 93). It is unknown why slickspot peppergrass does not occupy all areas where slick spot microsites occur in southwest Idaho and elsewhere as habitat appears suitable in many unoccupied areas (IDFG *in litt.* 2018, p. 3; Fisher *et al.* 1996, p. 15).

2.2. Taxonomy

Slickspot peppergrass is a member of the Mustard Family (Brassicaceae). The genus *Lepidium* has over 100 species worldwide, with some rare and others weedy and invasive. This genus is found on all continents except Antarctica (Hitchcock *et al.* 1964, p. 512).

The genus name *Lepidium* is from Greek *lepis* "scale" (referring to the silicle fruit) (Hitchcock *et al*. 1964, p. 512); the specific epithet *papilliferum* refers to the small hairs (papillae) that cover the plant and *fero* meaning to bear or carry in Latin. Louis Henderson originally described slickspot peppergrass as *L. montanum* var. *papilliferum* in 1900. It was renamed *L. papilliferum* by Aven Nelson and J. Francis Macbride in 1913 based on its distinctive growth habit, short lifespan, and unusual pubescence (Nelson and Macbride 1913, p. 474). Hitchcock regarded slickspot peppergrass as *L. montanum* var. *papilliferum* influencing several publications including Flora of Idaho and Flora of the Pacific Northwest (Davis 1952, p. 347; Hitchcock *et al.* 1964, p. 516; Hitchcock and Cronquist 1973, p. 170; Steele 1981, p. 55; Moseley 1994, p. 2). In a 1993 review of taxa in the mustard family (Brassicaceae), Reed Rollins maintained the species based on differences in the physical features between the slickspot peppergrass and *L. montanum* (mountain pepperweed):

- Slickspot peppergrass has trichomes (hair-like structures) occurring on the filaments of stamens (part of flower that produces pollen), but mountain pepperweed does not;
- All the leaves on slickspot peppergrass are pinnately divided whereas mountain pepperweed has some leaves that are not divided;
- The shape of the silicle [silique] (seed capsule) of slickspot peppergrass is different from that of mountain pepperweed; and

- The silicle of slickspot peppergrass has no wings, or even vestiges of wings, at its apex (end of the capsule), unlike that of mountain pepperweed (Rollins 1993, p. 578; Moseley 1994, p. 2).

A review of the taxonomic status by R. Lichvar (2002, *in litt.,* entire) concluded that, using classic morphological features and study of herbarium specimens, slickspot peppergrass has distinct morphological features relative to mountain pepperweed that warrant species recognition. While the initial description of slickspot peppergrass as a variety of mountain pepperweed has influenced botanists over the last century to assume that mountain pepperweed would be its closest relative, phylogenetic analyses have demonstrated that slickspot peppergrass is more closely related to *L. fremontii* (desert pepperweed) than mountain pepperweed (Smith *et al.* 2009, p. 160). Public comments received prior to the 2004 and 2007 decisions for withdrawal of the species for potential listing, as well as prior to the 2009 listing of the species, have suggested that slickspot peppergrass is a local variation of mountain pepperweed and therefore would not qualify as an entity eligible for listing under the Endangered Species Act (Air Force *in litt.* 2003, pp. 11-13). However, slickspot peppergrass is accepted as a valid species by Intermountain Flora, the U.S. Department of Agriculture's "PLANTS Database" and the Biota of North America Project (Holmgren *et al.* 2005, p. 259) as well as by the Integrated Taxonomic Information System (ITIS Taxonomic Serial Number 503383).

In a recent unpublished study, disjunct Jarbidge geographic area populations were observed to exhibit the following morphological differences relative to populations in the remainder of the species' range:

- greater average upper cauline leaf division,
- greater average lower cauline leaf division,
- no trichomes on anther filaments,
- greater average length of lower branches, and
- greater average stem hair density.

These five morphological differences were statistically significant (Barbour and Mansfield *in litt* 2012, entire), suggesting that the disjunct Jarbidge geographic area slickspot peppergrass populations could represent a new variety of the species (Barbour and Mansfield *in litt.* 2012, entire). However, as these findings have not yet been evaluated under the International Code of Nomenclature for algae, fungi, and plants, no taxonomic change has been made to date (Mansfield 2019 pers. comm.).

Common names for this plant include slickspot peppergrass (Holmgren *et al.* 2005, p. 259), slick spot peppergrass (Moseley 1994, p. 1), and Idaho pepperweed (ITIS 2018, p. 1). The common name refers to its typical habitat—in or near slick spot microsites, and the peppery taste of the seeds. 'Grass' is a misnomer, and most members of the genus *Lepidium* are referred to as peppercress, pepperweed, or pepperwort (IDFG in litt. 2018, p. 2). Throughout this SSA, we refer to the species as slickspot peppergrass.

2.3. Species Description and Life History Strategies

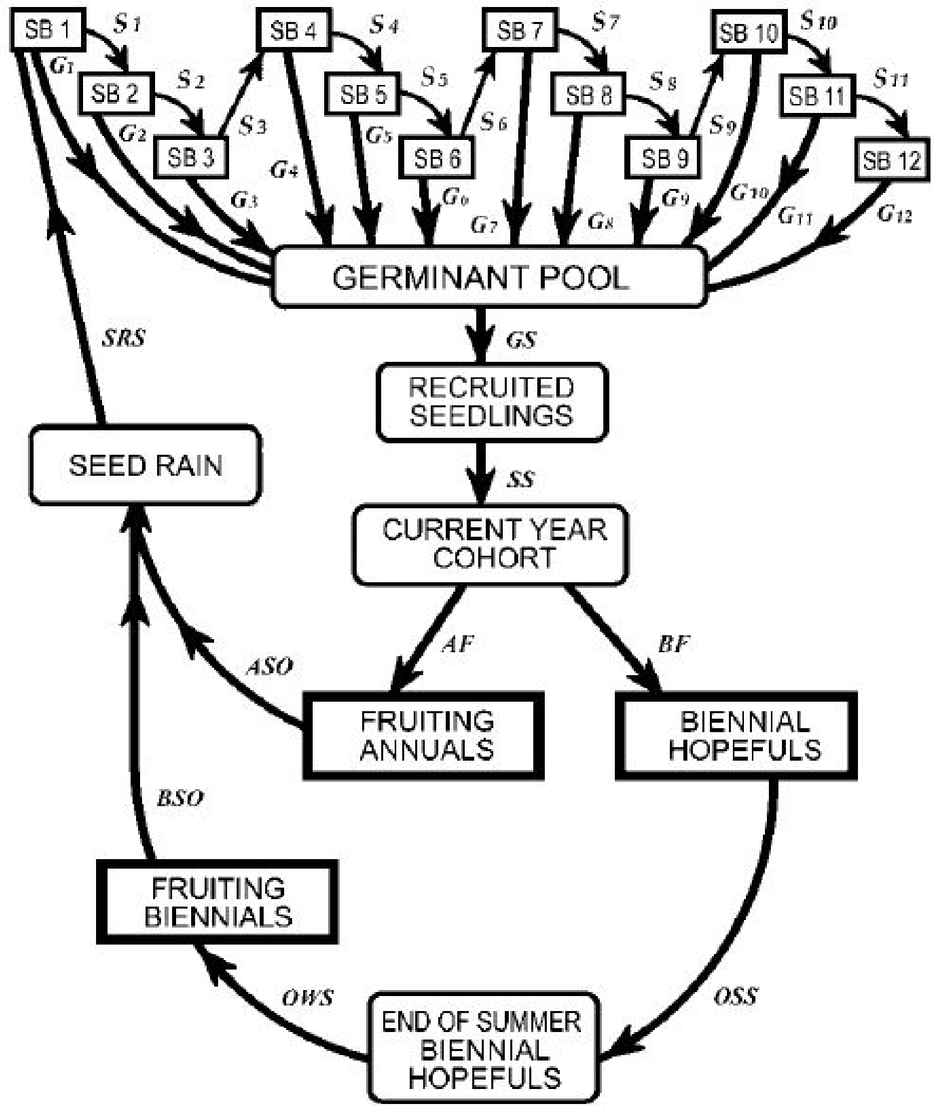
2.3.1. Species Description

Slickspot peppergrass is an intricately branched, tap-rooted plant, averaging 2 to 8 in. tall, but occasionally reaching up to 16 in. tall. Leaves and stems are covered with fine, soft hairs, and the leaves are divided into linear segments. Flowers are numerous, 0.11 to 0.15 in. in diameter, white, and four-petalled (Figure 5). Fruits (silicles, which are seed capsules that are less than twice as long as they are wide) are 0.10 to 0.15 in. wide, round in outline, flattened, and two-seeded (Moseley 1994, pp. 3, 4; Holmgren *et al.* 2005, p. 260).

Figure 5. Flowering slickspot peppergrass plant (photo by Barbara Schmidt).

2.3.2. Life History Strategies

Slickspot peppergrass is monocarpic (flowers once and then dies) and displays two different life history strategies: an annual form and a biennial form (Figure 6). The annual form reproduces by flowering and setting seed in its first year and dies within one growing season. The biennial life



Stages (square cornered boxes) describe population status each year before seed dispersal at the end of June. The time step from one stage to the next is 1 year. Intermediate variables (round cornered boxes) describe intermediate steps in the life cycle that take place during the year. The age-structured seed bank is represented by stages SB1-SB12. Transitions: S_1-S_{11} = seed bank survival from one year to the next, G_1-G_{12} = germinating fractions for seeds of each age, GS = fraction of germinants surviving to recruitment, SS = fraction of recruited seedlings surviving to June; AF = fraction of surviving cohort to flower and fruit as annuals; BF = fraction of surviving cohort to remain vegetative and potentially biennial; OSS = fraction of biennial hopefuls to survive the summer; OWS = fraction of biennial hopefuls to survive the winter and fruit the following year; ASO = seed output of an annual; BSO = seed output of a biennial; SRS = fraction of the seed rain that enters the seed bank.

Figure 6. Life cycle diagram for slickspot peppergrass showing annual and biennial life history strategies and the persistent seed bank (from Meyer *et al.* 2006, p. 894).

form initiates growth in the first year as a vegetative rosette (Figure 7) but does not flower and produce seed until the second growing season. A single slickspot peppergrass plant was observed to live for 4 years within a greenhouse setting (photograph by A. Palazzo, as documented in Bashore *in litt*. 2014, p. 1). White and Robertson (2009a, p. 289) also described an unusual slickspot peppergrass life history strategy observed in the wild in which some rosettes that survived the summer grew one to several stalks that flowered and set seed in fall, overwintered as rosettes, and flowered and set seed in spring similar to biennial slickspot peppergrass plants. These unusual life histories are thought to be associated with phenotypic plasticity of the species.

Figure 7. Slickspot peppergrass rosettes (photo by Barbara Schmidt).

When above ground plants are present, their white flowers usually open in late May and June (IDFG *in litt.* 2018, p. 2); however, timing of flowering can vary both within and between seasons as well as between sites (I. Robertson 2018, pers. comm. p. 13). Flowering ends and the seeds are typically released from fruits in late June through mid-July, with seeds from some plants released well into late July and in some cases even into September, depending upon variation in site conditions and annual weather conditions (I. Robertson 2018, pers. comm. p. 13). Fruits produced from fertilized flowers reach full size approximately two weeks after pollination (Robertson and Klemash 2003, p. 334; Robertson and Ulappa 2004, p. 1706). Each fruit typically bears two seeds that drop to the ground when the fruit dehisces (splits open; Billinge and Robertson 2008, p. 1003). Above ground plants represent only a portion of the population; the seed bank (a reserve of dormant seeds generally found in the soil) contains the other portion of the population, and in many years, constitutes the majority of the population (Mancuso and Moseley 1998, p. 1).

Depending on an individual plant's vigor, the effectiveness of its pollination, and whether it is functioning as an annual or a biennial, each slickspot peppergrass plant produces varying numbers of seeds (Quinney 1998, pp. 15, 17). Biennial plants normally produce a much greater number of seeds than annual plants. For example, average seed output for annual plants at the Idaho Army National Guard's Orchard Combat Training Center during a two-year study was 125 seeds and 46 seeds per plant, respectively, while seed production of biennials averaged 787 and 105 seeds per plant, respectively. Another study reported the average number of slickspot peppergrass seeds for plants less than 5 centimeters (cm; less than about 2 in.) in diameter, 5-20 cm (about 2 to about 8 in.) in diameter, and greater than 20 cm (greater than about 8 in.) in diameter to be 215, 1,577, and 8,106 seeds, respectively (Schmasow 2015, p. 14). However, in situations where slickspot peppergrass annual plants significantly outnumber biennial plants, annuals contribute more than biennials to the replenishment of the seed bank (Meyer *et al*. 2006, p. 898; Meyer *et al*. 2005, p. 20).

The mechanisms that lead to the two predominant life histories of slickspot peppergrass are not well understood. Meyer *et al.* (2005, p. 21) suggest that phenotypic plasticity is the most likely explanation for the annual versus biennial life histories in slickspot peppergrass, based on the premise that genotypic differences in life histories would lead to the elimination of the less fit strategy and their finding that biennials have lower mean lifetime fitness than annuals because of higher mortality. The phenotypic plasticity hypothesis maintains that all slickspot peppergrass germinants have the potential to become either annuals or biennials, and that the life history trajectory depends on the reaction norm between its physiological state (e.g., size, nutrient reserves) and local microclimate (e.g., soil moisture, nutrient availability). Specifically, larger rosettes will flower and produce seed in their first season, whereas smaller rosettes that stand less chance of successfully setting seed in their first season will delay reproduction until the following spring. Thus, the biennial life form is maintained, despite the higher risk of mortality.

2.3.3. Habitat

Slick Spot Microsites

Slickspot peppergrass plants are primarily found within specialized soil inclusions known as slick spot microsites (Figure 8). Slick spots that support slickspot peppergrass contain three distinct soil layers: a surface silt layer, the heavy clay restrictive layer, and an underlying moist clay layer. Slick spots vary in the thickness of surface silt and underlying soil layers. Although slick spots can appear homogeneous on the surface, the actual depth of the silt and restrictive layer can vary throughout the slick spot (Meyer and Allen 2005; Tables 9, 10, and 11; B. Colket, ICDC, pers. comm. 2006 as cited in USFWS 2006, p. 18). On the Orchard Combat Training Center, the top two layers (surface silt and restrictive) of slick spots are normally very thin; the surface silt layer varies in thickness from 0.1 to 1.2 in. in slick spot microsites known to support slickspot peppergrass, and the restrictive layer varies in thickness from 0.4 to 1.2 in. (Meyer and Allen 2005, p. 3). Similar surface silt layer thicknesses were observed during rangewide measurements of slick spot silt layer depths taken directly adjacent to live slickspot peppergrass plants, where although all slick spots had variations in silt thickness, the silt layer was consistently measured at approximately 0.4 in. (B. Colket, ICDC, pers. comm. 2006 as cited in USFWS 2006, p. 18).

Figure 8. Slick spot microsite with flowering slickspot peppergrass plants on the Idaho Army National Guard's Orchard Combat Training Center (photo by Barbara Schmidt).

Measurements taken by Mountain Home Air Force Base contractors on the Juniper Butte Range found the average depth to the clay layer in slick spot microsites measured adjacent to slickspot peppergrass plants as 2.5 in., with a range in depths from 1.2 to 4.7 in. (CH2MHill 2007, p. 12). The thicker slick spot silt layers documented at Juniper Butte Range were similar to the silt layer thicknesses observed in non-slick spot soils on the Orchard Combat Training Center, which had a mean depth of 4.7 in. (Meyer and Allen 2005, pp. 3-5, 8). A 0.5 in. mean slick spot soil crust depth was calculated for slick spots at 22 EOs and subEOs on the BLM lands also located in the

Jarbidge geographic area (ICDC 2007, p. 41). It is likely that differing collection parameters may have been used to determine slick spot soil layer depths on BLM lands and the Juniper Butte Range. As described in Section 2.4.1 below, a slick spot silt layer thickness that does not exceed 1.2 in. is most capable of supporting slickspot peppergrass over the long term.

Some slick spot microsites subjected to past light disturbance may be capable of reforming (Seronko 2006, *in litt.* p.2). However, disturbances that alter the physical properties of the soil layers, such as deep disturbance and the addition of organic matter, may lead to the destruction and permanent loss of slick spot microsites. For example, deep soil tilling and adding organic matter and gypsum were recommended to eliminate slick spots from agricultural lands in Idaho (Peterson 1919, p. 11; Rasmussen *et al.* 1972, p. 142). Slick spot soils are especially susceptible to mechanical disturbances when wet (Rengasamy *et al.* 1984, p. 63; Seronko 2004, *in litt.* pp. 1–2). Such disturbances disrupt the soil layers important to slickspot peppergrass seed germination and seedling growth and alter hydrological function. Meyer and Allen (2005, p. 9) suggest that if sufficient time passes following light disturbance of slick spot soil layers, the slick spot soil layers may regain their pre-disturbance configuration yet not support the species. Thus, while the slick spot microsite appears to have regained its former character, some essential component required to sustain the life history requirements of slickspot peppergrass has apparently been lost, or the active seed bank is no longer present. Disturbance of slick spot microsites can reduce population resiliency and representation of populations by creating areas for spread of invasive nonnative plants, which can compete directly with slickspot peppergrass. Ground disturbance can also result in localized deep burial of seeds and plants within slick spots, reducing population viability.

The vast majority of slickspot peppergrass rosettes and flowering plants documented over the past 20 years of surveys and monitoring for the species were observed within slick spot microsite habitats (USFWS 2006, p. 20). Within slick spot microsites, slickspot peppergrass plants appear to be distributed patchily but consistently across the slick spot surface (Meyer and Allen 2005, pp. 5, 6, 8; Palazzo *et al.* 2005, p. 8). Slickspot peppergrass rosettes and flowering plants have infrequently been documented outside of slick spots, such as on badger mounds and two-track roads, either adjacent to slicks spots or where slick spots apparently existed prior to disturbance (IDFG *in litt.* 2018, p. 4; CH2MHill 2003, p. 4; USFWS *in litt.* 2018, p. 1). At sites where plants are not associated with slick spot soils, it is unknown whether slickspot peppergrass located outside of slick spot microsites would persist over time.

Vegetation

Slickspot peppergrass occurs within the greater semiarid sagebrush (*Artemisia* spp.) steppe ecosystem of southwest Idaho, with intact sagebrush steppe habitat supporting populations with higher slickspot peppergrass plant numbers. For the purposes of this SSA, intact sagebrush steppe habitat is defined as vegetation assemblages represented by native bunchgrasses, shrubs (primarily Wyoming big sagebrush and basin big sagebrush), and forbs, with biological soil crusts present within plant interspaces. Native shrubs in sagebrush steppe habitats that support slickspot peppergrass include Wyoming big sagebrush, basin big sagebrush, *Purshia tridentata* (bitterbrush), *Chrysothamnus viscidiflorus* (green rabbitbrush), and *Ericameria nauseosa* (rubber rabbitbrush). Native grasses that occur with slickspot peppergrass include *Pseudoroegneria spicata* (bluebunch wheatgrass), *Achnatherum thurberianum* (Thurber's needlegrass), *Achnatherum hymenoides* (Indian ricegrass), *Aristida purpurea* var. *longiseta* (purple threeawn), *Poa secunda* (Sandberg's bluegrass), and *Elymus elymoides* (bottlebrush squirreltail). Native forbs found in sagebrush steppe habitats that support slickspot peppergrass include *Phacelia heterophylla* (varileaf phacelia), *Eriogonum strictum* (Blue Mountain buckwheat), *Achillea millefolium* (common yarrow), *Crepis* sp. (hawksbeard), *Machaeranthera canescens* (hoary tansyaster), *Astragalus purshii* (woollypod milkvetch), and *Phlox longifolia* (longleaf phlox) (Moseley 1994, p. 9; Colket 2005, pp. 2-3).

Slickspot peppergrass benefits from intact sagebrush steppe habitat that maintains insect pollinator assemblages and enables pollinators to forage among populations of slickspot peppergrass. Forbs with showy flowers are important for maintaining pollinators within the sagebrush steppe ecosystem (IDFG *in litt.* 2018, p. 5). In addition, shrub species with showy flowers such as such as bitterbrush, which flowers in spring, and green rabbitbrush, which flowers in late summer, provide sources of pollen and nectar for insect pollinators (Tilley *et al.* 2013, pp. 37, 41, 53). Diverse forbs and shrubs in areas that support slickspot peppergrass provide season-long sources of nectar and pollen for diverse insect pollinator populations. While important components of slickspot peppergrass habitat, native grasses and big sagebrush are wind pollinated and do not depend on insect pollinators for seed production, and their flowers do not provide food resources for insect pollinators. However, this is not the case for forbs (such as slickspot peppergrass) and shrubs with showy flowers that require insect pollinators for optimal seed production.

Vegetation surrounding occupied slick spots influences the physical and biological features of slick spot microsites important for growth of slickspot peppergrass plants. Shrubs, such as Wyoming big sagebrush and rabbitbrush, are important components of slickspot peppergrass habitat. These native shrubs increase the availability of water by providing shade to reduce soil temperatures and associated evaporation, acting as snow fences to retain snow important for spring moisture, and making deep soil moisture and nutrients available closer to the drier soil surface through hydraulic lift (Sturm *et al.* 2000, p. 341-343; Moro *et al.* 1997, p. 430; Caldwell *et al.* 1998, p. 153; Welch 2005, pp. 137-138). Cooler air and soil temperatures associated with shrub presence slow snow melt and water evaporation, which allows soil moisture to be available longer for slickspot peppergrass use. As previously described, rabbitbrush also provides an important late summer source of pollen and nectar, contributing to season-long availability of food resources for insect pollinators (Tilley *et al.* 2013, pp. 37, 41, 53).

Biological soil crust, also known as a microbiotic crust or cryptogamic crust, is also an important habitat component for slickspot peppergrass. Biological soil crusts occur both within slick spots and within surrounding intact sagebrush steppe vegetation. Biological soil crusts are commonly found in semiarid and arid ecosystems and are formed by living organisms, primarily bryophytes, lichens, algae, and cyanobacteria, that bind together surface soil particles (Moseley 1994, p. 9; Johnston 1997, p. 4). Biological soil crusts play an important role in stabilizing the soil and preventing erosion, increasing the availability of nitrogen and other nutrients in the soil, and regulating water infiltration and evaporation levels (Johnston 1997, pp. 8–10). In addition, biological soil crust appears to aid in preventing the establishment of invasive plants (Brooks and Pyke 2001, p. 4 and references therein; Serpe *et al.* 2006, pp. 174, 176) that can directly compete with slickspot peppergrass plants. Prevention of invasive plant establishment by biological soil crusts may also reduce wildfire risk through the reduction of fine fuels within interspaces.

Biological soil crusts are sensitive to disturbances such as compression from livestock trampling or off highway vehicle (OHV) use and are subject to damage by wildfire; recovery of biological soil crusts from disturbance is possible but occurs very slowly (Johnston 1997, pp. 10–11). Depending on environmental conditions, cyanobacteria may fully recover between 14 and 34 years following disturbance on the Colorado Plateau (Belnap *et al.* 2001, p. 56). In contrast, lichens may require over 100 years to fully recover following disturbance in the Northern Great Basin (Belnap *et al.* 2001, p. 59).

Native plant communities across the range of slickspot peppergrass have been severely degraded by invasive nonnative plant species over the past century. Invasive nonnative plants currently within sagebrush communities in the range of slickspot peppergrass include *Bromus tectorum* (cheatgrass), *Taeniantherum caput-medusae* (medusahead), *Sisymbrium altissimum* (tall tumblemustard), *Salsola tragus* (prickly Russian thistle), *Ceratocephala testiculata* (bur buttercup), *Lepidium perfoliatum* (clasping pepperweed), and other non-native annuals. State of Idaho designated noxious weeds such as *Centaurea biebersteinii* (spotted knapweed), *Centaurea diffusa* (diffuse knapweed), *Chondrilla juncea* (rush skeletonweed), and *Onopordum acanthium* (scotch thistle) are also found in areas within and near slickspot peppergrass populations. These nonnative plants reduce resiliency of populations to stochastic events as well as representation of populations across the range of the species due to fragmentation of native sagebrush steppe habitat as well as direct competition with slickspot peppergrass and other native forbs essential to insect pollinators.

Lands across the west, including within and adjacent to slickspot peppergrass populations, have been planted with highly competitive nonnative plant species such as *Agropyron cristatum* (crested wheatgrass), *Psathyrostachys juncea* (Russian wildrye), *Thinopyrum intermedium* (intermediate wheatgrass), *Bassia prostrata* (forage kochia) or other nonnative perennials (IDFG *in litt.* 2018, p. 2). These highly competitive nonnative plants were established to improve rangeland conditions and stabilize soil following disturbance such as improper livestock grazing and wildfire, compete with invasive nonnative plants such as *Halogeton glomeratus* (halogeton) and cheatgrass, and to provide livestock forage (Gunnell *et al.* 2011, p. 132).

2.4. Individual-Level Ecology

The life history of slickspot peppergrass consists of four distinct life stages: seed, seedling, rosette, and flowering annual or biennial plant. The needs of each of these life stages are described below.

2.4.1. Seed Life Stage

Slickspot peppergrass has a persistent seed bank (a reserve of dormant seeds generally found in the soil or surface litter) that contributes a portion of, and in many years constitutes the majority of, populations (Mancuso and Moseley 1998, p. 1). Seeds produced in a given year typically do not germinate in the first winter; thus, seeds in a cohort are dormant for at least one year before any germination takes place. Following this year of dormancy, approximately six percent of the initially viable seeds produced in a given year germinate annually in March, April, and May, if soil moisture is adequate (Quinney 1998, p. 15; Meyer *et al.* 2005, pp. 17–18). When combined with an average annual three percent loss of seed viability, approximately nine percent of the original seed cohort per year is lost after the first year. This constant proportion of the total seeds produced in a cohort that germinate or die each year is not a function of precipitation or other environmental variables (Meyer *et al.* 2006, p. 892). After 12 years, all seeds in a given cohort will likely have either died or germinated, resulting in a maximum estimated longevity of 12 years for seeds in the seed bank (Meyer *et al.* 2005, p. 18). The selective advantage to linear seed bank attrition may be that it spreads germination out uniformly across years, exposing seeds to wide environmental variation, thus increasing the chances of encountering highly favorable years for seed bank replenishment (which are infrequent events in the desert environment where the species is found) (Meyer *et al.* 2006, p. 900).

While many theoretical and empirical studies predict that increased variation in environmental conditions (environmental stochasticity) increases the likelihood of population extinction (Higgins *et al.* 2000, p. 516; Lande 1993, pp. 921-923), in the case of slickspot peppergrass, increased environmental stochasticity in the southwest Idaho desert increases the chances of exceptionally favorable years that allow restocking of the seed bank. The persistent seed bank also buffers slickspot peppergrass populations from the effect of poor years that result in little or no reproduction (Meyer *et al.* 2006, p. 901). Population viability modeling determined that slickspot peppergrass could not persist over time if environmental conditions and associated seed production were average every year; thus, slickspot peppergrass depends on periodic high seed production years to persist (Meyer *et al.* 2006, p. 901).

Seeds of slickspot peppergrass are found primarily within slick spot microsites where flowering plants and rosettes are found (Meyer and Allen 2005, pp. 5–6). Slickspot peppergrass seeds have been found in slick spots with no above ground plants present (Meyer *et al.* 2005, p. 22; Palazzo *et al.* 2005, p. 10). Effects of environmental factors, such as wildfire, on slickspot peppergrass seed dormancy and viability are unknown, although analysis of rangewide monitoring data have shown that slickspot peppergrass abundance is significantly reduced in the year following burns (Bond 2017, p. 12).

Slickspot peppergrass seeds appear to be distributed patchily but consistently across the surface of slick spot microsites (Meyer and Allen 2005, pp. 5, 6, 8; Palazzo *et al.* 2005, p. 8). Seeds and plants may be found in the center and edges of slick spots and occasionally outside of slick spots. Slickspot peppergrass seeds located near the soil surface show higher rates of germination and viability (Meyer and Allen 2005, pp. 6–8; Palazzo *et al.* 2005, p. 10) and the greatest seedling emergence success (Meyer and Allen 2005, pp. 6–8). The upper 0.08 in. of slick spot soils are considered optimal for germination (Meyer and Allen 2005, pp. 6–8). Slick spots with silt layers not exceeding 1.2 in. appear to be the most capable of supporting slickspot peppergrass over the long-term (Meyer and Allan 2005, p. 8).

Surface disturbance can result in too-deep burial and subsequent loss of seeds from the active seed bank. The majority of slickspot peppergrass seeds in undisturbed slick spot microsites are largely distributed within the top 2 in. of soil (Palazzo *et al.* 2005 pp. 8, 10). Slickspot peppergrass seeds are only about 1.2 millimeters long (Holmgren *et al*. 2005, p. 260), so seeds have limited food reserves available to fuel growth until seedlings are able to produce their own food through photosynthesis. Slickspot peppergrass seedlings are unlikely to emerge from depths greater than about 1 in. (Meyer and Allen 2005, p. 8). Deep burial of slickspot peppergrass seeds (average depths greater than 5.5 in.) can entomb viable seeds and may preserve them beyond the

12-year period modelled as the maximum period of viability for slickspot peppergrass seeds (Meyer and Allen 2005, pp. 6, 9). However, seeds buried at such depth, even if they remain viable, are unlikely to reach the surface for successful germination. Slickspot peppergrass seed stored under laboratory conditions may also remain viable for a longer period, as laboratory stored seed had 80 percent viability 18 years after it had been collected (I. Robertson, pers. comm. 2018).

Studies and modelling suggest that slickspot peppergrass seed and pollen dispersal occurs over short distances. For example, spatial structures of both small and large slickspot peppergrass populations are similar, and spatial structuring within slick spot microsite habitats suggests that both pollen dispersal and seed dispersal are low for this species and occur over short distances (Robertson *et al.* 2006, p. 3; Billinge and Robertson 2008, pp. 1005–1006). In addition, dispersal and seed dormancy modeling of desert annual plants predicts that plants with long-range dispersal will have few seed dormancy mechanisms and quick germination (Venable and Lawlor 1980, p. 272). Slickspot peppergrass has delayed germination (Meyer *et al.* 2005, pp. 17–18), and, therefore, according to the model, may not disperse long distances. These relatively short dispersal distances as well as the scattered location of slick spot microsites across the landscape make the potential for colonization of unoccupied slick spots by slickspot peppergrass relatively low.

The primary seed dispersal mechanism for slickspot peppergrass is not known (Robertson and Ulappa 2004, p. 1708), although viable seeds have been found outside of slick spots, indicating that some seed dispersal is occurring beyond slick spot habitat (Palazzo *et al.* 2005, pp. 10, 20). Slickspot peppergrass seeds are likely dispersed by gravity, and although wind and water may play a role in seed dispersal, seeds have no structures to facilitate either of these dispersal mechanisms (Moseley 1994, p. 13). Like other species in the genus *Lepidium*, slickspot peppergrass seeds possess a mucilaginous coat (Loffredo *et al.* 2010, p. 187), which, upon hydration, can adhere seeds to the slick spot surface. It is possible that hydrated seeds may adhere to small mammals or birds for long-distance seed dispersal (Mummenhoff *et al.* 2004, p. 259; Mummenhoff *et al.* 2001, pp. 2058, 2060). In addition, entire dried biennial plants and some larger annual plants have been observed to break off at the base and be transported by wind (A. Stillman, personal observation, as described in Stillman 2006, p. 32), which may have historically resulted in occasional long-distance seed dispersal. Native Owyhee harvester ants (*Pogonomyrmex salinus*), an efficient slickspot peppergrass seed predator, are not considered a likely disperser of slickspot peppergrass seeds. All seeds observed to be transported by harvester ants were taken into the nest so were likely lost from the seed bank (Robertson and White 2007, p. 11). Since the occurrence of slickspot peppergrass plants outside of slick spots is atypical, slickspot peppergrass seeds found outside of slick spots may no longer be part of the seed bank.

In summary, slickspot peppergrass seeds require relatively undisturbed slick spot microsites for the seed bank to remain at an optimum soil depth until seed germination, adequate quantities of annual winter and spring rainfall, and native shrubs surrounding slick spot microsites that facilitate water availability for germination.

2.4.2. Seedling Life Stage

Seedling development starts with germination of the seed. Seedlings of nearly all plant species depend on energy reserves stored in the seed until they reach the soil surface, where sunlight initiates photosynthesis to allow plants to produce their own food. Greenhouse trials determined that slickspot peppergrass seedlings are unlikely to emerge from depths greater than about 1 in., which is likely due to limited energy reserve capacity of relatively small slickspot peppergrass seeds (Meyer and Allen 2005, p. 8). Slickspot peppergrass population viability modeling also suggests that the survival of seedlings is critical to the number of slickspot peppergrass rosettes and flowering plants and their subsequent contributions to the seed bank (Meyer *et al.* 2006, p. 901). Thus, deep burial of seeds or seedlings due to ground disturbance or sediment deposition may limit seedling survival, which ties directly to reduced future rosette and flowering plant numbers and their subsequent contributions to the seed bank.

Similar to other plants, slickspot peppergrass seedlings require adequate light for photosynthesis once plants reach the ground surface, as well as adequate water and nutrients for growth. Germinating seeds are very sensitive to both water logging and drought as their level of metabolism is high (Akhtar and Nazir 2013, p. 34). In general, seedlings may have high mortality due to water stress, if roots do not achieve adequate contact with the soil. Reduced growth or mortality may also occur if seedling roots are exposed to too much water, which promotes oxygen deficiency and impacts nutrient availability (Steffens *et al.* 2005, pp. 545, 549). Depending on the weather patterns in any particular year, slickspot peppergrass seedlings may be exposed to either too little or too much water, which can reduce seedling survival rates.

Sufficient precipitation levels during the growing season, late winter, and spring are important to slickspot peppergrass germinant survival (Meyer *et al.* 2006, p. 901). During years with drier, warmer springs, the low permeability of slick spots can hold moisture for a longer period than surrounding non-slick spot soils, making moisture available for seedlings (Moseley 1994, p. 8). However, once the thin silt layer dries out, slickspot peppergrass seedling survival depends on its ability to extend its taproot into the argillic horizon (soil layer with high clay content) to extract moisture from the deeper soil natric zone (Fisher *et al.* 1996, p. 13).

The lack of competition with other plants is also a factor for slickspot peppergrass survival. Slickspot peppergrass is thought to be a poor competitor with other plants. Slick spot microsites with minimal ground disturbance, soil deposition, or litter accumulation have a reduced risk of establishment of other plants that may compete with slickspot peppergrass plants for soil moisture, nutrients, sunlight, and space.

Levels of humic acid (organic acids formed by the natural decay of plant and animal materials) in slick spot soils may contribute to seedling emergence and success. Humic acid greenhouse trials have shown that slickspot peppergrass germination appears to be enhanced by humic acid concentrations of 50 and 200 milligrams per liter^{-1} (mg L). Seedling root growth and shoot growth were shown to be positively influenced by the humic acid concentrations (50 mg L $^{-1}$ and 50 and 200 mg L $^{-1}$, respectively) and nutrient levels characteristic of slick spot surface silt layers (Loffredo *et al.* 2010, p. 189).

2.4.3. Rosette Life Stage

Successful slickspot peppergrass seedlings become rosettes after reaching the soil surface and growing true leaves (Figure 7). A rosette is a circular arrangement of leaves radiating from a central stalk. Rosettes typically have a prostate growth pattern. Sufficient precipitation during the growing season, late winter, and spring is important to rosette spring survival (Meyer *et al.* 2006, p. 901). Because their higher clay and sodium levels are less favorable for growth of many plants relative to surrounding soils, slick spot microsites appear to provide slickspot peppergrass rosettes with access to sunlight, water, nutrients, and space with less competition from other plants.

A slickspot peppergrass rosette may grow into an annually flowering plant during the spring of germination. In contrast, a biennial slickspot peppergrass rosette may persist until the following spring before flowering. Biennial slickspot peppergrass rosettes must survive dry summer conditions; consequently, many biennial rosettes die before flowering and producing seed (Meyer et al 2005, p. 21; Meyer *et al.* 2006, pp. 895). Overwinter survival of biennial rosettes decreased with higher levels of winter (November through January) precipitation, possibly due to effects of slick spot flooding on rosettes (Meyer *et al.* 2006, p. 896). The number of prior-year rosettes is positively correlated with the number of flowering plants present the following year (ICDC 2008, p. 9; Unnasch 2008, p. 14; Sullivan and Nations 2009, p. 44).

2.4.4. Flowering Annual or Biennial Plant Stage

Sufficient precipitation is important to seed outputs of annual and biennial slickspot peppergrass flowering plants (Meyer *et al.* 2006, p. 901). Population modeling found that growing season precipitation (February through May) was a good predictor of the proportion of spring rosettes that developed into flowering annuals, with higher growing season precipitation resulting in a larger fraction of flowering annuals. A wetter growing season appears to allow rosettes to grow to a threshold size for flowering the same spring as germination (Meyer *et al.* 2006, p. 896). Higher than average spring rainfall is also associated with larger annual and biennial flowering plants, with biennial plants always growing larger than annual plants in any given year. Larger flowering plants produce a significantly greater number of seeds that contribute to the seed bank, with biennial plants producing more seeds than annual plants. In contrast, years with low spring rainfall produce fewer and smaller flowering plants, and the associated seed production for both annual and biennial plants is significantly reduced (Meyer *et al*. 2005, p. 17). In general, annual plants outnumber biennial plants (Moseley 1994, p. 12).

Slickspot peppergrass is thought to be a poor competitor with other plants. Ground disturbance due to wildfire, recreation, or other activities as well as deposition of soil or litter can facilitate establishment of other native or nonnative plants within slick spot microsites, reducing the ability of slick spots to support slickspot peppergrass. Vegetation within slick spots, especially strong competitors (such as cheatgrass) may outcompete slickspot peppergrass for resources such as water and nutrients, reducing slickspot peppergrass vigor and survival. Disturbance can facilitate the establishment of other plant species within slick spot microsites. Within disturbed slick spots, cheatgrass can dominate to the extent that slick spot microsites are no longer recognizable (Kinter et al. 2010, p. 84). Similarly, slick spot microsites are highly susceptible to invasion by forage kochia (Colket 2009, pp. 16, 130), a highly competitive nonnative subshrub seeded in vegetated fuel breaks or burned areas due to its wildfire-resistant characteristics. Forage kochia has been documented to dominate slick spot microsites and displace slickspot peppergrass (Debolt *in litt*. 2002, entire; Colket 2009, p. 22; Gray 2011, pp. 67-68).

Pollination

Slickspot peppergrass is primarily an outcrossing species requiring pollen from separate plants for more successful fruit production, demonstrating low seed set in the absence of insect pollinators (Robertson 2003a, p. 9; Robertson and Klemash 2003, p. 339; Robertson and Ulappa 2004, p. 1707; Billinge and Robertson 2008, pp. 1005–1006). Slickspot peppergrass can self-pollinate, with a selfing rate (rate of self-pollination) of 12 to 18 percent (Billinge 2006, p. 40; Robertson *et al.* 2006, p. 40). In pollination experiments where researchers moved pollen from one plant to another, percent fruit set increased as a function of distances that ranged from 1 meter (m; about 3.3 feet) from nearest neighbors, to 75-100 m (about 246 – 328 feet) between slick spots within a population, and then 6.5-20 kilometers (about 4–12.4 miles) between populations. Highest fruit set occurred at outcrossing distances of 6.5-20 kilometers; however, these values were not statistically different from the 75-100 m treatment (Robertson and Ulappa 2004, p. 1708). In another study, percent fruit set increased as a function of outcrossing distance up to a distance of 3 m (about 10 feet), and then declined slightly (but not significantly) at distances 20-50 m (about 66-164 feet) and 2.5-7 kilometers (about 1.5 – 4.3 miles) (Billinge and Robertson 2008, p. 1003).

Known slickspot peppergrass insect pollinators include several families of bees and wasps (Hymenoptera), including Apidae, Halictidae, Sphecidae, and Vespidae; beetles (Coleoptera), including Dermestidae, Meloidae, and Melyridae; flies (Diptera), including Bombyliidae, Syrphidae, and Tachinidae; and others (Robertson and Klemash 2003, p. 336; Robertson and Leavitt, 2011, pp. 384-385). Most of these insects are solitary and nest outside of slick spot microsites in the surrounding sagebrush steppe vegetation, both in the ground and within vegetation (USFWS 2010, p. 27191). A strong positive correlation was found between insect diversity and the number of slickspot peppergrass plants flowering at a site (Robertson and Hannon 2003, p. 8); however, this result may have been influenced by other factors such as more intensive surveys for pollinators conducted at sites with greater numbers of slickspot peppergrass plants (Robertson and Hannon 2003, p. 6). Measurements of fruit set per visit revealed considerable variability in the effectiveness of pollination by different types of insects, ranging from 0 percent in dermestid beetles to 85 percent per visit in honeybees (*Apis mellifera*) (Robertson and Leavitt, 2011, p. 384).

Past pollination studies have indicated that seed set of flowering slickspot peppergrass plants does not appear to be limited by the abundance of pollinators (Robertson *et al*. 2004, p. 14). However, in a recent slickspot peppergrass seed introduction study located outside of known slickspot peppergrass populations, the lack of sufficient forbs to support insect pollinators in the surrounding cheatgrass monoculture may have been a factor when only one of four flowering slickspot peppergrass plants was observed to develop fruits (LTT in litt. 2016, p. 2).

Within slickspot peppergrass populations, individual plants are concentrated within slick spot microsites, which creates locally abundant food sources for pollinators. Because slickspot peppergrass appears to have limited capacity for seed dispersal and colonization of new habitat

(Robertson and Ulappa 2004, p. 1706), maintenance of diverse and robust pollinator communities is likely critical to the species' long-term survival. Low native forb density and diversity have been documented across the range of slickspot peppergrass. A broad, localized resource base for pollinators may help support pollinator communities, particularly in years when slickspot peppergrass numbers are low.

2.4.5. Summary of Individual Plant Needs

In summary, key resource needs for slickspot peppergrass individuals include functional slick spot microsites with relatively low levels of disturbance, sufficient sunlight for photosynthesis, adequate timely precipitation and favorable temperatures for seed germination and plant growth, presence of shrubs and a diversity of forbs adjacent to slick spot microsites, diverse insect pollinator communities for seed production, and a lack of competition with other plants. A summary of requirements of individual slickspot peppergrass plants by life cycle stage is in Table 2 below.

Table 2. Individual resource needs of slickspot peppergrass by life stage. Resource function is described as: H = Habitat, N = Nutrition (includes water), R = Reproduction.

Life stage	**Resource and circumstances needed for individuals to complete life stage**	**Resource function (HNR)**
Seed	Adequate winter and spring **precipitation** to allow for spring germination	N
	Functional **slick spot microsites** with relatively low disturbance levels, particularly when soils are saturated, to hold the seed bank until germination occurs	H
	Shrubs surrounding slick spot microsites for shading and increased water availability	H, N
Seedling	Sufficient winter and spring **precipitation**	N
	Nutrients	N
	Functional **slick spot microsites** with relatively low disturbance levels during seedling growth periods	H
	Lack of competition with other plants	H, N
	Sunlight for photosynthesis	N
	Shrubs surrounding slick spot microsites for shading and increased water availability	H, N
Rosette	Higher spring and summer **precipitation;** lower fall and winter **precipitation**	N
	Nutrients	N
	Functional **slick spot microsites** with relatively low disturbance levels when soils are saturated during rosette growth periods	H
	Lack of competition with other plants	H, N
	Sunlight for photosynthesis	N

Life stage	Resource and circumstances needed for individuals to complete life stage	Resource function (HNR)
	Shrubs surrounding slick spot microsites for shading and increased water availability during dry summer months and to retain snow during winter months	H, N
Flowering and Fruiting Annual or Biennial Plant	Adequate winter and spring **precipitation and temperatures**	N
	Nutrients	N
	Functional **slick spot microsites** with relatively low disturbance levels during spring active growth and flowering and fruiting periods	H
	Lack of competition with other plants	H, N
	Diverse **insect pollinators** to allow for cross-pollination and successful seed production	R
	Relatively **intact sagebrush steppe habitat,** including insect pollinated forbs, to support diverse insect pollinators for successful seed production	R
	Sunlight for photosynthesis	N
	Shrubs surrounding slick spot microsites for shading and increased water availability during flowering periods	H, N
Resource needs derived from Meyer *et al*. 2005, entire and IDFG *in litt*. 2018, p. 4.		

2.5. Population-Level Ecology

2.5.1 Genetics

Adequate representation for slickspot peppergrass populations depends upon the continued persistence of all population genotypes rangewide. The greater the genetic diversity within and among slickspot peppergrass populations, the more capable the species is to adapt to natural or human-caused changes in its environment. Habitat specificity and restricted geographic distribution can cause rare plant populations to become genetically isolated and may result in decreased genetic diversity and increased genetic differentiation among populations.

Although rare plants typically have lower genetic diversity within populations and high levels of genetic differentiation among populations than more common plants, slickspot peppergrass genetic diversity within populations and differentiation among populations was determined to be high relative to other rare plant species (Stillman 2006, p. 18). This may be due in part to slickspot peppergrass being a tetraploid (i.e., it has four sets of each chromosome rather than the two sets of each chromosome that define diploids) (Stillman 2006, pp. 18-19, 24; Larson *et al.* 2010, p. 58); thus, tetraploids such as slickspot peppergrass may exhibit greater genetic diversity than diploid plants. Of the total genetic differentiation documented in slickspot peppergrass, 89 percent of genetic differentiation resided within populations (Stillman 2006, p. 22). Only about 11 percent of the genetic differentiation resides among slickspot peppergrass populations. Rangewide, the persistent seed bank of slickspot peppergrass may provide an additional source of genetic variation across generations as each seed cohort is viable in the soil for up to 12 years, retaining genetic variation over time (Stillman 2006, p. 27).

High rates of outcrossing may aid slickspot peppergrass in maintaining higher levels of genetic diversity. Higher rates of outcrossing are reflected in the high levels of observed heterozygosity for Jarbidge geographic area populations relative to levels observed in populations in the Snake River Plain (Stillman 2006, pp. 26-27, 30). Populations in the Jarbidge geographic area are located in closer proximity, providing opportunities for increased gene flow among these populations than in the remainder of the species' range. The disjunct Jarbidge geographic area also has fewer anthropogenic disturbances relative to the Snake River Plain; these lower levels of habitat fragmentation may further reduce barriers to insect pollinator movement among Jarbidge geographic area populations.

Small populations (defined as sites supporting less than 100 plants) are vulnerable to environmental disturbances such as wildfire, herbicide drift, and nonnative plant invasions (Given 1994, pp. 66–67) and have significantly less genetic diversity than larger populations, particularly in the Snake River Plain geographic area (Stillman 2006, pp. 28-29). This is consistent with the expectation that small populations experience high levels of inbreeding and reduced genetic variability (Ellstrand and Elam 1993, pp. 217–237) due to little or no outcrossing with other populations (Ellstrand and Elam 1993, pp. 218-219). Significant positive correlations between population size and genetic diversity suggest that smaller populations of slickspot peppergrass have become vulnerable to inbreeding and loss of genetic diversity through genetic drift (Stillman 2006, p. 29). The reduced genetic diversity detected in smaller populations of slickspot peppergrass in comparison to large populations is cause for concern. Small isolated populations, particularly within the Foothills and Snake River geographic areas, appear to be at risk of experiencing a reduction in genetic diversity through genetic drift and inbreeding (Stillman 2006, p. 36). Populations with lowered genetic diversity are more prone to extirpation (Barrett and Kohn 1991, pp. 4, 28). Smaller populations generally have lower genetic diversity, and lower genetic diversity may lead to even smaller populations by decreasing the species' ability to adapt, thereby increasing the probability of population extinction (Newman and Pilson 1997, p. 360). Adverse effects of inbreeding in slickspot peppergrass were illustrated by Billinge and Robertson (2008, p. 1006), who found that inbreeding resulted in lower leaf number and leaf size in seedlings. Effects of inbreeding in later stages of development, including reproduction, have not been studied. Long-term survival and evolutionary adaptability of slickspot peppergrass requires that adequate genetic variability in the species is preserved and maintained.

The majority of genetic differences for the species among populations are between the disjunct Jarbidge geographic area populations and the remainder of the range of the species (Stillman 2006 p. 31-32; see also Figure 9 below). However the Snake River Plain geographic area populations and Jarbidge geographic area populations still exhibited a 94 percent similarity in allelic diversity (Stillman *et al*. 2005, pp. 6, 8-9). Smith *et al.* (2009, p. 160) suggest that the genetic and morphologically unique characters of these two subgroups are most likely the result of more recent isolation and perhaps indicative of genetic divergence and incipient speciation that could not be detected with the enzyme electrophoresis technique use by Stillman *et al*. (2005). Thus, slickspot peppergrass may have had a historically continuous distribution of populations that could have occurred as recently as the mid-1800s (Smith *et al.* 2009, p. 160; Stillman 2006, pp. 31-32). Habitat fragmentation and destruction associated with European settlement may have reduced the distribution of populations to smaller, more isolated groups. As populations in the Jarbidge and the Snake River Plain became increasingly isolated from one another, gene flow has not been able to overcome genetic drift. Consequently, populations of the two regions are less similar to one another than populations within these regions.

Despite increased levels of habitat fragmentation associated with human activities over the past century that effectively increased geographic distance and genetic distance between populations, genetic isolation by distance was not evident among populations within the Snake River Plain (Stillman 2006, pp. 31-32). Populations within the Snake River Plain may not have been isolated from one another over a sufficient time for a positive relationship between geographic distance and genetic distance to exist.

Genetic studies suggest reduced gene flow between populations may be a relatively recent event. The high genetic diversity and low genetic differentiation observed within and between slickspot peppergrass populations is likely a reflection of historic distribution, with polyploidy (i.e. genetic variation where plants can have multiple sets of chromosomes) and high rates of outcrossing contributing to the maintenance of genetic diversity (Stillman 2006, p. 36). Genetic diversity in slickspot peppergrass is spread relatively uniformly across the species' range and is not concentrated in divergent populations. Stillman *et al*. (2005, p. 8) suggest this indicates that slickspot peppergrass gene flow has been or is being exchanged among populations, but caution that they are unable to assess if the flow is current or historic. The authors suggest the gene flow may be historic rather than recent because insect pollinators (which are primarily responsible for slickspot peppergrass genetic exchange) cannot fly over distances that now separate many populations.

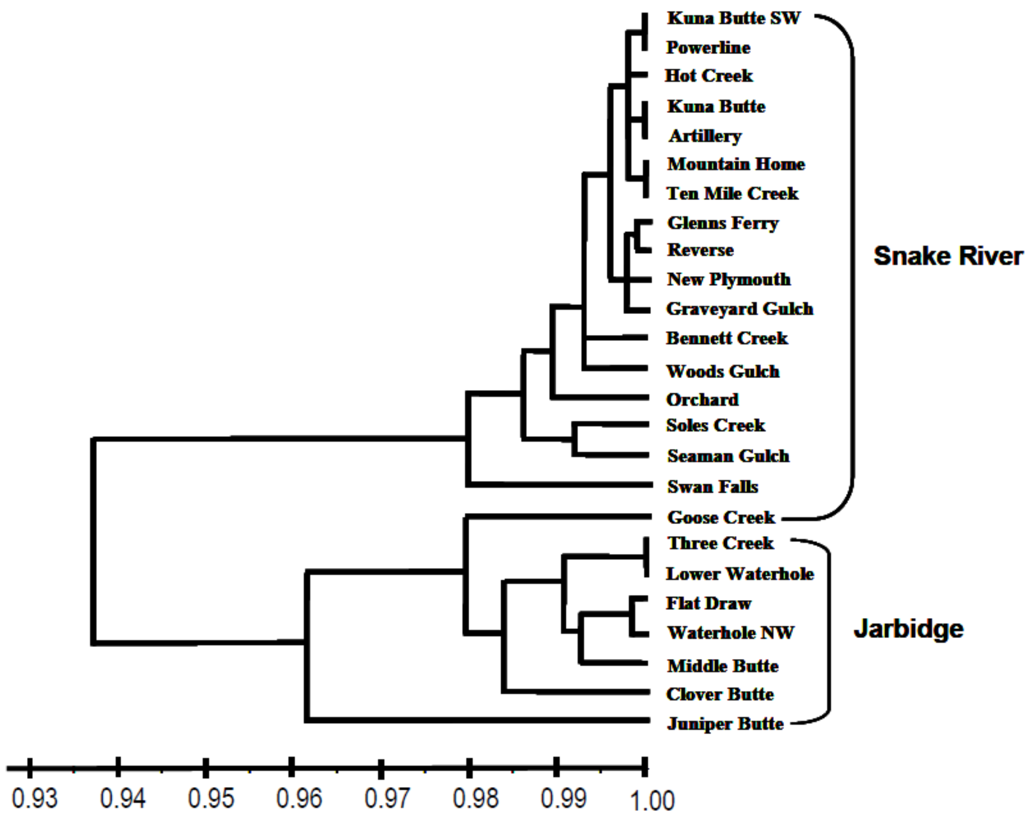


Figure 9. Genetic relationships between slickspot peppergrass populations located in the Snake River (currently divided into the Snake River Plain geographic area and the Foothills geographic area) and populations in the Jarbidge geographic area from Stillman (2006, p. 61, Figure 1.5) entitled "UPGMA of twenty-five populations of *L. papilliferum* based on Nei's (1972) genetic identity".

Slickspot peppergrass populations are spatially structured (Robertson and Ulappa 2004, p. 1709), so neighboring individuals are often more closely related to one another than to distant individuals due to limited pollen flow and seed dispersal. Plant species with limited means for long distance fruit or seed dispersal, such as slickspot peppergrass, may be at risk of inbreeding depression due to matings between related neighbors in spatially structured populations (Robertson and Ulappa 2004, p. 1708; Billinge and Robertson 2008, p. 1002). Evidence for inbreeding depression was reported by Billinge and Robertson (2008, p. 1006-1007), where both leaf number and leaf length in seedlings increased as a function of parental outcrossing distance; however, only the latter trait was statistically significant. In addition, percent fruit set in slickspot peppergrass increased as outcrossing distance increased up to 3 m (about 10 feet); then declined slightly with further distance (Billinge and Robertson 2008, p. 1005). This relatively rapid increase in fruit set over relatively short outcrossing distances suggests either genetic relatedness among individuals declines sharply as a function of distance or that slickspot peppergrass is tolerant of low levels of inbreeding (Billinge and Robertson 2008, p. 1005). This finding suggests that the majority of current gene flow in the species occurs within populations over relatively short distances (Stillman 2006, p. 8).

While genetic studies suggest that representation of the disjunct Jarbidge geographic area populations is high, representation is more limited for smaller populations located in the Snake River Plain and Foothills geographic areas, where smaller populations separated by greater geographic distances have lower genetic diversity. Maintaining connectivity within and between populations to the extent possible would be important to continued genetic diversity of slickspot peppergrass populations.

2.5.2 Population Dynamics and Demographic Trends

Population persistence depends on stable or increasing demographic trends and recruitment of new individuals must equal or exceed mortality. Recruitment requires successful reproduction. Successful reproduction of slickspot peppergrass is associated with production of viable seeds to replenish the persistent seed bank. Adequate replenishment of the seed bank to allow for stable or increasing demographic trends is associated with favorable weather years, which are infrequent events in the desert environment where the species occurs.

Estimating the abundance of slickspot peppergrass is difficult for several reasons, but trend data suggest that slickspot peppergrass is declining across its range. Recent statistical analyses of 11 years of rangewide monitoring data demonstrated that across all three geographic areas, slickspot peppergrass is declining, with the steepest declines in the Jarbidge geographic area, and similar declining trends in the Snake River Plain and Foothills areas (Bond 2017, p. 11).

In order to track population trends as well as habitat and disturbance attributes, annual Habitat Integrity and Population (HIP) monitoring is conducted by IDFG along permanently marked transects across the range of the species (Figure 10). The HIP monitoring tracks slickspot peppergrass population trends as well as to evaluate performance metrics associated with the State of Idaho's Candidate Conservation Agreement for Slickspot Peppergrass (CCA) (State of Idaho 2003, entire). HIP monitoring transects are primarily located within 10 of the 12 CCA Management Areas (Figure 10), which were designated around clusters of slickspot peppergrass populations to facilitate area-specific conservation needs of the species (State of Idaho 2003, p. 26).

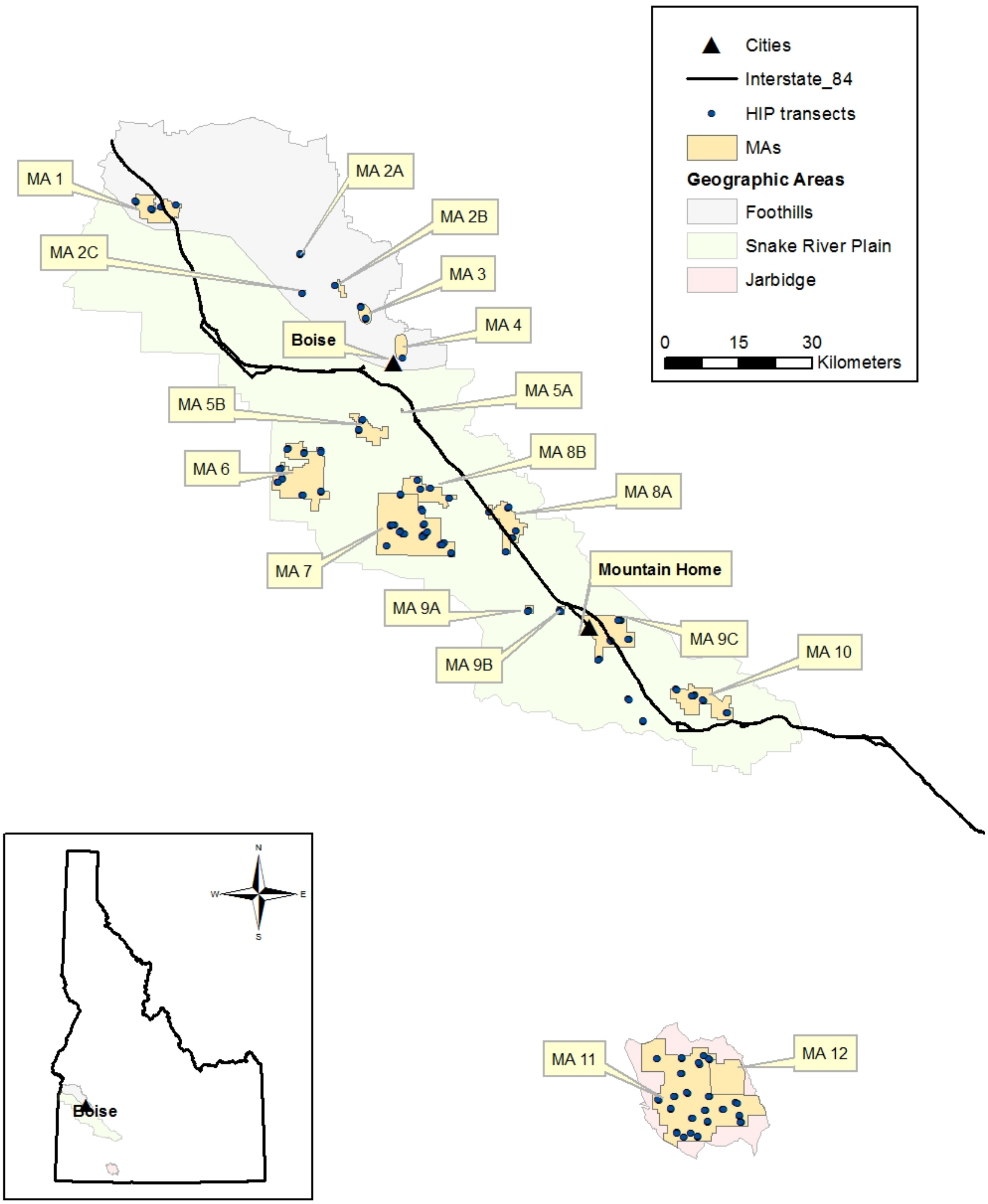


Figure 10. Map illustrating the location of Habitat Integrity and Population (HIP) monitoring transects, State of Idaho Candidate Conservation Agreement Management Areas (MAs), and geographic areas for slickspot peppergrass (from Kinter et al. 2014, p. 31).

Fluctuations in plant numbers have been documented through annual rangewide monitoring of HIP transects (Figures 11 and 12), where a subset of the total number of flowering plants and rosettes in populations across the range of the species are counted to estimate population trends. The four CCA Management Areas (MAs) that contain populations with high plant numbers (e.g., MA 1 - New Plymouth, MA 2 - Boise Foothills/BLM, MA 6 - Kuna, and MA 7 - Orchard Combat Training Center) are located in the Foothills and Snake River Plain geographic areas. These four areas contribute significantly to higher plant number years for the species (Figure 12). The locations of these MAs are in Figure 10. In contrast to the four MAs that support high plant numbers, relatively low plant numbers have been consistently observed within the disjunct Jarbidge geographic area over 12 years of annual HIP transect monitoring.

Like many short-lived plants growing in arid environments, above ground numbers of slickspot peppergrass plants can fluctuate widely from year to year, depending on seasonal precipitation patterns (Mancuso and Moseley 1998, p. 1; Meyer *et al.* 2005, pp. 4, 12, 15; Palazzo *et al.* 2005, p. 9; Menke and Kaye 2006a, p. 8; Menke and Kaye 2006b, pp. 10, 11; Sullivan and Nations 2009, p. 44; Bond 2017, p. 12). Mancuso and Moseley (1998, p. 1) note that populations with thousands of above ground plants one year may have none the next, and vice versa. Furthermore, since individuals may act as either annuals or biennials, in any given year there will be varying numbers of plants acting as spring-flowering annuals versus overwintering rosettes. The relative proportions of these two life history forms can fluctuate annually depending on precipitation, temperature, and the abundance of rosettes produced the previous year.

Effects of precipitation in combination with temperature on slickspot peppergrass plant numbers is complex. While late winter (February and March) and spring (April and May) precipitation is associated with increased slickspot peppergrass plant numbers, precipitation effects are complicated by interactions with temperature. In an analysis of 10 years of slickspot peppergrass monitoring data, increased slickspot peppergrass numbers were associated with increased late winter total precipitation, increased number of late winter growing degree days, and increased early winter (November, December, and January) growing degree days. In contrast, increased spring average temperatures, increased early winter total precipitation, and increased spring growing degree days were associated with decreased slickspot peppergrass numbers (Bond 2017, p. 12).

The relationship between slickspot peppergrass plant numbers, precipitation, and temperature are likely confounded by multiple factors (Bond 2017, p. 10) and are not fully understood. For example, if higher spring temperatures are associated with a decrease in slickspot peppergrass numbers, it may be that these temperatures directly impede slickspot peppergrass growth. Higher spring temperatures may encourage growth of competitors that reduce availability of water, nutrients, and space, resulting in lower slickspot peppergrass numbers. Higher spring temperatures also result in higher evaporation rates; thus, less water is available for slickspot peppergrass plant growth.

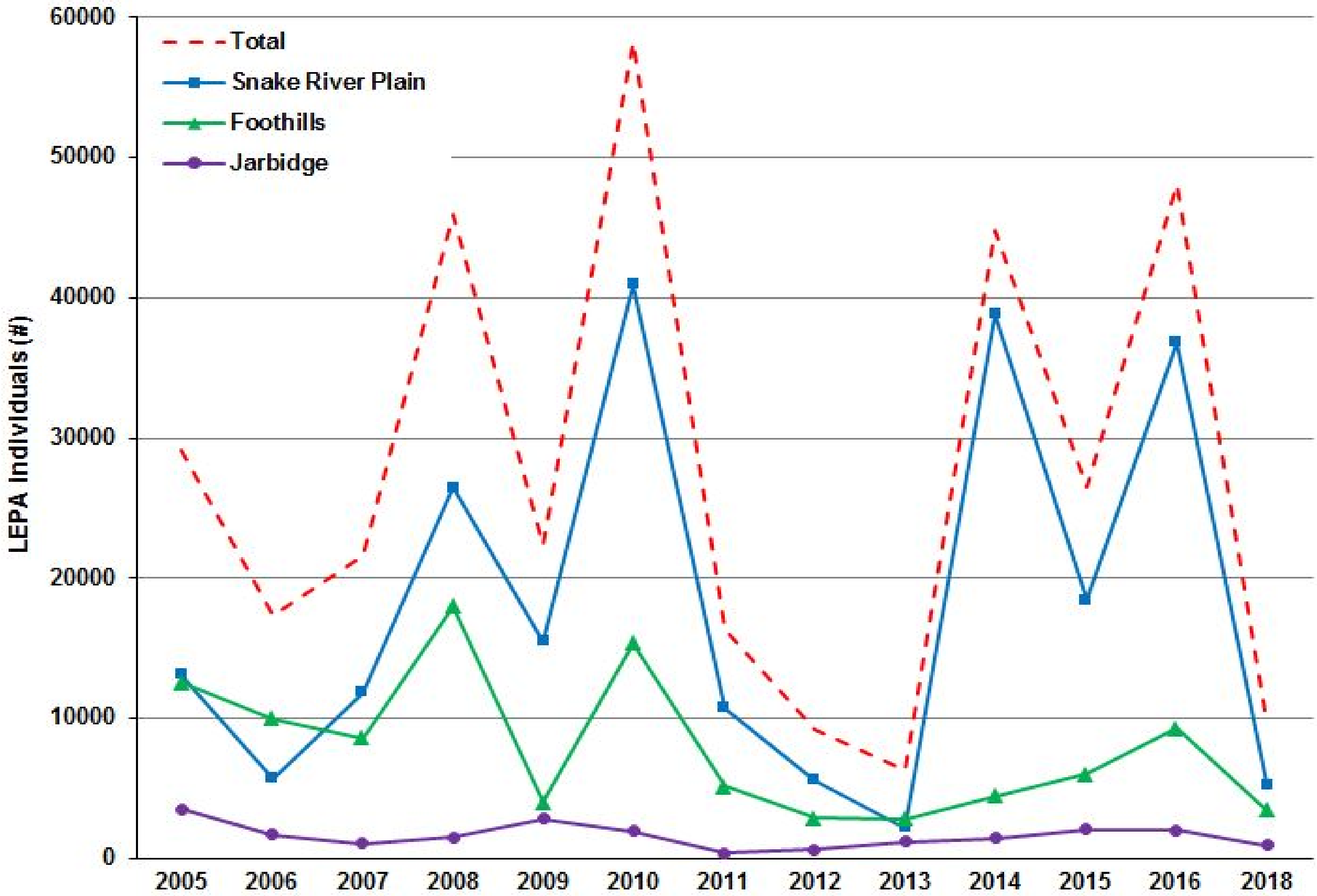


Figure 11. Total number of slickspot peppergrass plants observed annually along Habitat Integrity and Population Monitoring (HIP) transects rangewide and by geographic area from 2005 through 2018 (from Kinter *in litt.* 2019). HIP monitoring transect data were not collected in 2017.

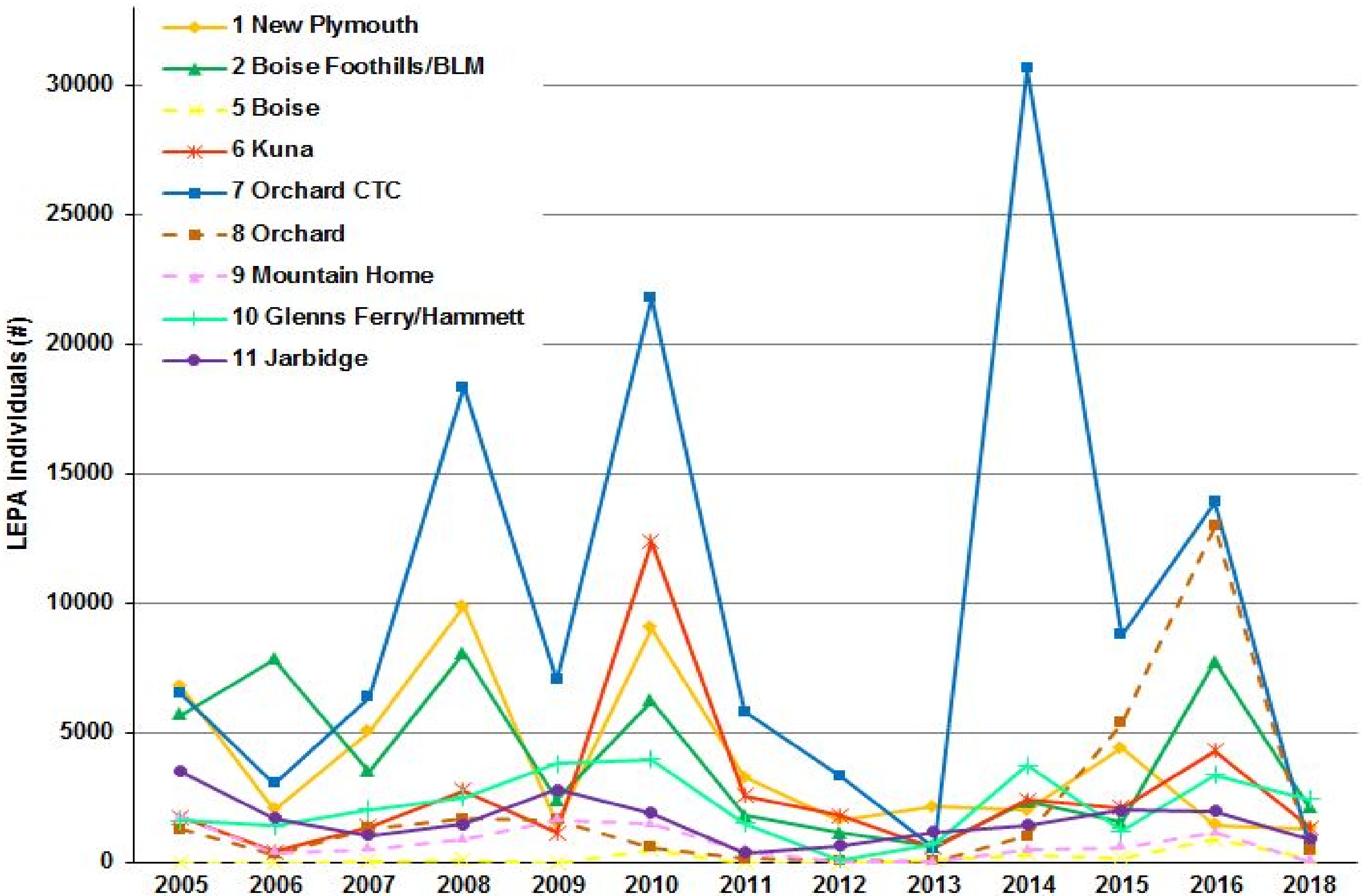


Figure 12. Numbers of slickspot peppergrass plants observed annually along Habitat Integrity and Population (HIP) monitoring transects from 2005 through 2018 within Management Areas as described in the Candidate Conservation Agreement for Slickspot Peppergrass (State of Idaho 2006, entire; data from Kinter *in litt.* 2019). HIP monitoring transect data were not collected in 2017.

Above ground plants represent only a portion of the population; the seed bank contains the other portion, and in many years, constitutes the majority of the population (Mancuso and Moseley 1998, p. 1). Seed banks are widely considered as adaptations for survival in a "risky environment" because they buffer a species from stochastic (random) impacts, such as lack of soil moisture (Baskin and Baskin 2001, p. 160), which contributes to slickspot peppergrass population resiliency. The destructive nature of seed bank sampling makes estimates of seed bank size for populations located across the range of slickspot peppergrass challenging, but in general, populations with lower flowering plant numbers in favorable winter-spring precipitation years contain a reduced seed bank relative to populations supporting higher flowering plant numbers.

Due to its occupancy of patchily distributed slick spots, the habitat of slickspot peppergrass is somewhat naturally fragmented. For example, of the over 61,000 slick spot microsites observed on the Mountain Home Air Force Base's Juniper Butte Range, only 2,546 (about 4 percent) contained slickspot peppergrass (Air Force 2002, p. 9). In addition, the density of slick spots per linear distance surveyed ranged from a high of about 65 slick spots per kilometer (km) surveyed to less than one slick spot per km surveyed within Snake River Plain and Foothills EOs (Miller and Kinter 2018, pp. 5, 8). However, increased habitat fragmentation associated with wildfires, increased invasive nonnative plants (especially nonnative invasive annual grasses), and various forms of development has occurred throughout the range of the species. Large-scale fragmentation can pose problems for slickspot peppergrass by creating barriers in the landscape that prevent effective genetic exchange between populations. As seed dispersal for slickspot peppergrass likely occurs only over very short distances, pollinators and pollen dispersal are the primary means for reproductive and genetic exchange between slickspot peppergrass sites (Robertson and Ulappa 2004, pp. 1705, 1708-1709; Stillman *et al.* 2005, pp. 1, 6–8; Billinge and Robertson 2008, p. 1006).

Barriers or too much distance between slick spot microsites and pollinating insect habitats can reduce the effective range of insects important to slickspot peppergrass pollination (Robertson *et al.* 2004, pp. 2–4). Barriers can include urban development, large expanses of annual and perennial grass monocultures, and agricultural fields that do not support diverse and suitable floral resources such as nectar or edible pollen for pollinators. Slickspot peppergrass habitats separated by distances greater than the effective range of available pollinating insects (about 0.6 mi. as described in Colket and Robertson *in litt.* 2006, p. 1) are at a genetic disadvantage and may become vulnerable to effects of loss of genetic diversity (Stillman *et al.* 2005, pp. 1, 6–8) and a reduction in fruit set (Robertson and Ulappa 2004, pp. 1707, 1709), which would in turn influence seed production. Large-scale habitat fragmentation has occurred such that many slickspot peppergrass populations are too distant for pollinators to transfer pollen between populations.

2.5.2.1 Estimates of Minimum Viable Populations and Population Viability Analysis

Minimum viable population (MVP) is a widely used scientific concept that refers to the smallest population size that has a high probability of persisting in the wild over a prescribed period of time. For example, Mace and Lande (1991, p. 151) propose that species or populations be classified as vulnerable when the probability of persisting 100 years is less than 90 percent. Determinations of MVP usually consider the effective population size. Effective population size is the number of individuals in an idealized population that has a value of any given genetic quantity that is equal to the value of that quantity in the population of interest. For example, ten genetically identical individuals (i.e., clones) would have an effective population size of one. Effective population size is typically smaller than the total number of individuals in the population of interest.

Although MVP has not yet been calculated for slickspot peppergrass, we can estimate its MVP by comparison to species with similar life histories (i.e., surrogates) for which MVPs have been calculated, using nine factors adapted from Pavlik (1996, p. 137, see Table 3 below). Species with MVPs around 50 individuals (column A) would have traits that would mostly be associated with being long lived and located in stable environments. Those species with MVPs around 2,500 (column C) would mostly have traits indicative of a short-lived species in a changing environment. An intermediate column (B) was added to Pavlik's table to account for species with intermediate or unknown traits. Values for slickspot peppergrass are in bold text in Table 3.

Application of factors adapted from Pavlik resulted in five of nine factors that recommend greater than 2,500 individuals (breeding system, growth form, ramet production, environmental variation, and successional status), with three additional factors classified as recommending greater than 1,000 individuals (longevity, fecundity, and survivorship). Only one of nine factors (seed duration) recommends as few as 50 individuals to achieve or maintain population viability. The resulting alignment of these nine factors suggests an estimated MVP in an intermediate range (1,000 individuals) for slickspot peppergrass.

Table 3. Minimum viable population (MVP) guidelines applied to slickspot peppergrass as bold text (adapted from Pavlik 1996, p. 137).

Factor	A. MVP of 50 individuals for species with these traits	**B. Intermediate MVP Range for species with intermediate or unknown traits (≥1,000 above ground plants in at least 1 of the past 6 years)**	C. MVP of 2,500 individuals for species with these traits
Longevity	Perennial	**Annual or Biennial**	Annual
Breeding System	Selfing		**Outcrossing**
Growth Form	Woody		**Herbaceous**
Fecundity	High	**Seed set can be high, depending on favorable precipitation and temperature conditions, which can be infrequent events**	Probably Low
Ramet Production (clones)	Common		**Rare or None**
Survivorship	High	**Survivorship of above ground plants is dependent on years of favorable precipitation and temperature, which can be infrequent events** **Survivorship of seed cohorts in the persistent seed bank is high (up to 12 years per cohort)**	Low
Seed Duration	**Long (up to 12 years per seed cohort)**		Short
Environmental Variation	Low		**High**
Successional Status	Climax		**Seral or Ruderal**

The current estimated viability of slickspot peppergrass populations was derived from a recent assessment of 125 EO and subEO rankings conducted by IDFG (Kinter and Miller 2016, entire) using a protocol developed by NatureServe (2002, entire). EO rankings are used for assessing estimated viability or probability of persistence as well as for prioritizing conservation planning or actions (NatureServe 2002, p. 36). IDFG botanists ranked each EO and subEO based on measures of habitat quality (EO and subEO condition and surrounding landscape context) and species abundance (Tables 4 and 5). Weighted calculations were used to determine the ranking of each EO and subEO as follows:

- 33 percent of the EO ranking score was based on the EO/subEO size (highest number of plants observed in at least 1 of up to the past 6 years of available IDFG data)
- 45 percent of the EO ranking score was based on habitat condition within EOs/subEOs as documented during IDFG recent field reviews, and
- 22 percent of the EO ranking score was based on habitat condition of the landscape within 0.6 miles of EOs/subEOs as documented during IDFG recent field reviews.

Using these NatureServe protocols, IDFG assessment of individual EOs and subEOs resulted in EOs and subEOs ranked as having good viability (B-ranked) to poor viability (D-ranked) (Table 6). Overall, there appears to be a relatively high level of population redundancy, as good to fair viability populations (B-, BC-, and C-ranked EOs and subEOs) are well distributed across the range of the species (Table 6, see also Figure 2). The majority of the 115 extant populations (66 percent) ranked by IDFG fall within the good to fair population viability categories. When considering the combined acreage of populations rangewide, 83 percent (13,402 acres) of slickspot peppergrass EO and subEO acreage is ranked as having good viability (B-ranked) (Figure 13). No EOs or subEOs were ranked A (excellent viability) or AB (excellent to good viability).

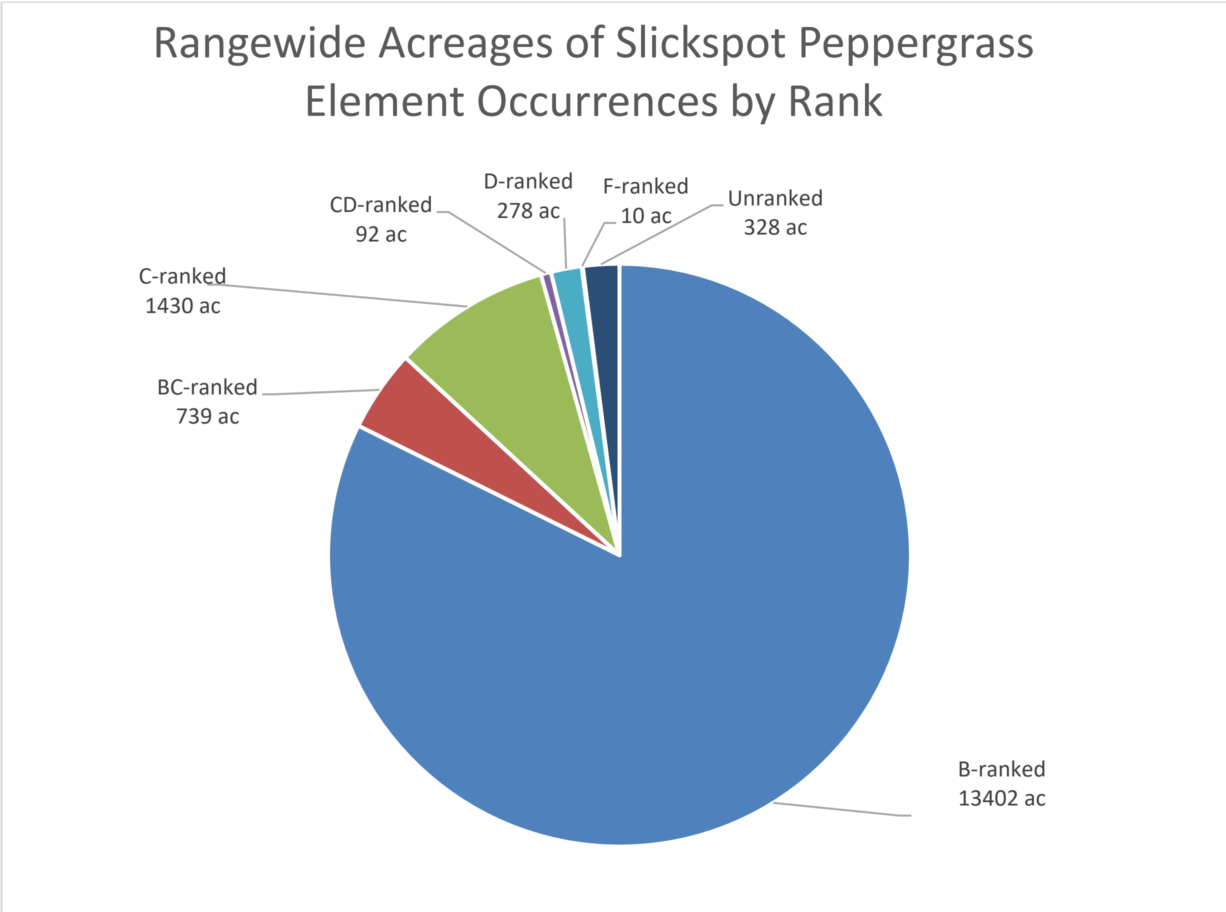


Figure 13. Rangewide acreages of slickspot peppergrass Element Occurrences by rank (acreage data from IDFG May 2018 IFWIS database).

Table 4. Criteria used for calculating slickspot peppergrass Element Occurrence and subElement Occurrence rankings using a protocol developed by NatureServe (compiled from Colket et al. 2006, pp. 3–4 and Kinter and Miller 2016, pp. 3-6).

EO and subEO RANKING FACTORS	**SCALE**			
	4	**3**	**2**	**1**
EO and subEO SIZE				
Plant Count	≥ 1,000 individuals.	400–999 individuals.	50–399 individuals.	1–49 individuals.
EO and subEO RANKING FACTORS	**SCALE (LETTER)**			
	4 (A)	**3 (B)**	**2 (C)**	**1 (D)**
EO and subEO CONDITION				
Native Plant Community	Intact; zero to low nonnative plant cover.	Intact; low to moderate nonnative plant cover.	Partially intact; moderate to high nonnative plant cover.	Almost gone; high nonnative plant species cover.
Human Disturbance	Minimal.	Low to moderate.	Moderate to high.	High.
LANDSCAPE CONTEXT (within 0.6 miles of EOs and subEOs)				
Fragmentation	Unfragmented.	Partially fragmented.	Moderately fragmented.	No longer intact.
Ecological and Hydrological Processes	Intact.	Intact.	Intact.	No longer intact.

The Human Disturbance category under the EO and subEO Ranking Factors section included drill seeding, roads, two-tracks, power lines, cattle trails, and off highway vehicle tracks within EOs (Kinter and Miller 2016, p. 4). Drill seeding in the context of EO ranking definitions refers to past or current drill seeding projects that impact slickspot peppergrass by: 1) establishment of highly competitive nonnative species through or in the vicinity of EOs, and 2) ground disturbance associated with some seeding techniques (such as use rangeland drills without depth bands), which impact individual plants and slick spot microsites (L. Kinter, pers. comm. September 24, 2018).

The Fragmentation category under the Landscape Context section included highways, residential and commercial development, and farm fields (Kinter and Miller 2016, p. 5).

A "?" qualifier may be used with the most appropriate rank if there is incomplete information on the EO and subEO Size, EO and subEO Condition, and Landscape Context factors.

Table 5. Descriptions of slickspot peppergrass Element Occurrence and subElement Occurrence E-, F-, H-, and X-rankings (compiled from Colket et al. 2006, pp. 3–4 and Kinter and Miller 2016, pp. 3-6).

EO and subEO Rank	**Description**
E-Rank (Extant)	EO has been verified extant, but population size, condition, and landscape context have not been assessed.
F-Rank (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. The F-rank was first standardized by NatureServe (2002) and was not implemented for slickspot peppergrass before 2006.
H-Rank (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. Locations associated with these herbarium records are typically geographically vague and may be simply indicated by the name of a town.
X-Rank (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 received an F-rank five times within a 12-year period.

A “?” qualifier may be used with the most appropriate rank if there is incomplete information on the EO size, EO condition, and landscape context factors.

Note that no G-rank exists in the NatureServe ranking system used for slickspot peppergrass.

Table 6. Numbers and acreages of slickspot peppergrass Element Occurrences by ranking category +.

Element Occurrence Ranking	**Geographic Areas**						**TOTAL**	
	Foothills		**Snake River Plain**		**Jarbidge**			
	Number of EOs (% EOs in region)	**EO Acreage (% acres in region)**	**Number of EOs (% EOs in region)**	**EO Acreage (% acres in region)**	**Number of EOs/subEOs (% EOs in region)**	**EO/subEO Acreage (% acres in region)**	**Number of EOs/subEOs (% EO/ subEO)**	**EO/subEO Acreage (% acres)**
A-Ranked Excellent Viability	0 **(0%)**	0 ac **(0%)**	0 **(0%)**	0 ac **(0%)**	0 **(0%)**	0 ac **(0%)**	0 **(0%)**	**0 ac** **(0%)**
AB-Ranked Good-Excellent Viability	0 **(0%)**	0 ac **(0%)**	0 **(0%)**	0 ac **(0%)**	0 **(0%)**	0 ac **(0%)**	0 **(0%)**	**0 ac** **(0%)**
B-Ranked Good Viability	6 **(33%)**	82 ac **(55%)**	9 **(18%)**	10,958 ac **(82%)**	10 **(22%)**	2,362 ac **(87%)**	25 **(22%)**	**13,402 ac** **(83%)**
BC-Ranked Good-Fair Viability	1 **(5%)**	28 ac **(19%)**	1 **(2%)**	702 ac **(5%)**	2 **(4%)**	9 ac **(<1%)**	4 **(3%)**	**739 ac** **(5%)**
C-ranked Fair Viability	5 **(28%)**	13 ac **(9%)**	21 **(39%)**	1,210 ac **(9%)**	14 **(30%)**	207 ac **(8%)**	40 **(34%)**	**1,430 ac** **(9%)**

Element Occurrence Ranking	**Geographic Areas**						**TOTAL**	
	Foothills		**Snake River Plain**		**Jarbidge**			
	Number of EOs (% EOs in region)	**EO Acreage (% acres in region)**	**Number of EOs (% EOs in region)**	**EO Acreage (% acres in region)**	**Number of EOs/subEOs (% EOs in region)**	**EO/subEO Acreage (% acres in region)**	**Number of EOs/subEOs (% EO/ subEO)**	**EO/subEO Acreage (% acres)**
CD-ranked Fair-Poor Viability	1 **(5%)**	6 ac **(4%)**	5 **(10%)**	4 ac **(<1%)**	4 **(9%)**	82 ac **(3%)**	10 **(9%)**	**92 ac** **(<1%)**
D-Ranked Poor Viability	3 **(17%)**	10 ac **(7%)**	15 **(29%)**	232 ac **(2%)**	11 **(24%)**	36 ac **(1%)**	29 **(25%)**	**278 ac** **(2%)**
E-ranked Verified Extant	0 **(0%)**	0 ac **(0%)**	0 **(0%)**	0 ac **(0%)**	0 **(0%)**	0 ac **(0%)**	0 **(0%)**	**0 ac** **(0%)**
F?-ranked Failed to Find	2 **(11%)**	10 ac **(7%)**	0 **(0%)**	0 ac **(0%)**	0 **(0%)**	0 ac **(0%)**	2 **(2%)**	**10 ac** **(<1%)**
Unranked New EOs/subEOs discovered since 2016	0 **(0%)**	0 ac **(0%)**	1 **(2%)**	321 ac **(2%)**	5 **(11%)**	7 ac **(<1%)**	6 **(5%)**	**328 ac** **(2%)**

Element Occurrence Ranking	**Geographic Areas**						**TOTAL**	
	Foothills		**Snake River Plain**		**Jarbidge**			
	Number of EOs (% EOs in region)	**EO Acreage (% acres in region)**	**Number of EOs (% EOs in region)**	**EO Acreage (% acres in region)**	**Number of EOs/subEOs (% EOs in region)**	**EO/subEO Acreage (% acres in region)**	**Number of EOs/subEOs (% EO/ subEO)**	**EO/subEO Acreage (% acres)**
EXTANT EO/subEO TOTALS	**18** (100%)	**139 ac** (100%)	**51** (100%)	**13,427 ac** (100%)	**46** (100%)	**2,703 ac** (100%)	**115** (100%)	**16,279** (100%)
H-Ranked - Historical	*2*	-	*3*	-	*0*	-	*5*	**-**
X-Ranked - Extirpated	*2*	-	*8*	-	*0*	-	*10*	**-**

+Slickspot peppergrass EO rankings and physiographic regions were derived from Kinter and Miller 2016. EO acreages and new EO information were derived from IFWIS July 2018 data.

Population viability associated with EO ranks were based on NatureServe EO rank descriptions (Kinter and Miller 2016, p. 7).

Cumulative EO acreages as well as the distribution of population viability rankings vary by geographic area (Figures 14 and 15, see also Table 6). The Foothills geographic area contains only about one percent (149 acres) of the rangewide acreage for the species (Figure 14), with a little over half of the total EO acreage in the Foothills geographic area (82 acres) categorized as B-ranked (Figure 15). In contrast, the Snake River Plain geographic area contains about 82 percent (13,427 acres) of the rangewide EO acreage for the species (Figure 14), with approximately 84 percent of the total EO area in the Snake River Plain (10,958 acres) categorized as B-ranked (Figure 15). About 65 percent of the B-ranked acreage in the Snake River Plain area is located within the Idaho Army National Guard's Orchard Combat Training Center (about 7,173 acres). The Jarbidge geographic area contains about 17 percent (2,704 acres) of the rangewide EO acreage for the species (Figure 14), with about 88 percent of the total EO and subEO acreage in the Jarbidge geographic area (2,362 acres) categorized as B-ranked (Figure 15). About 82 percent of the B-ranked acreage in the Jarbidge area is located within the Mountain Home Air Force Base's Juniper Butte Range (1,948 acres).

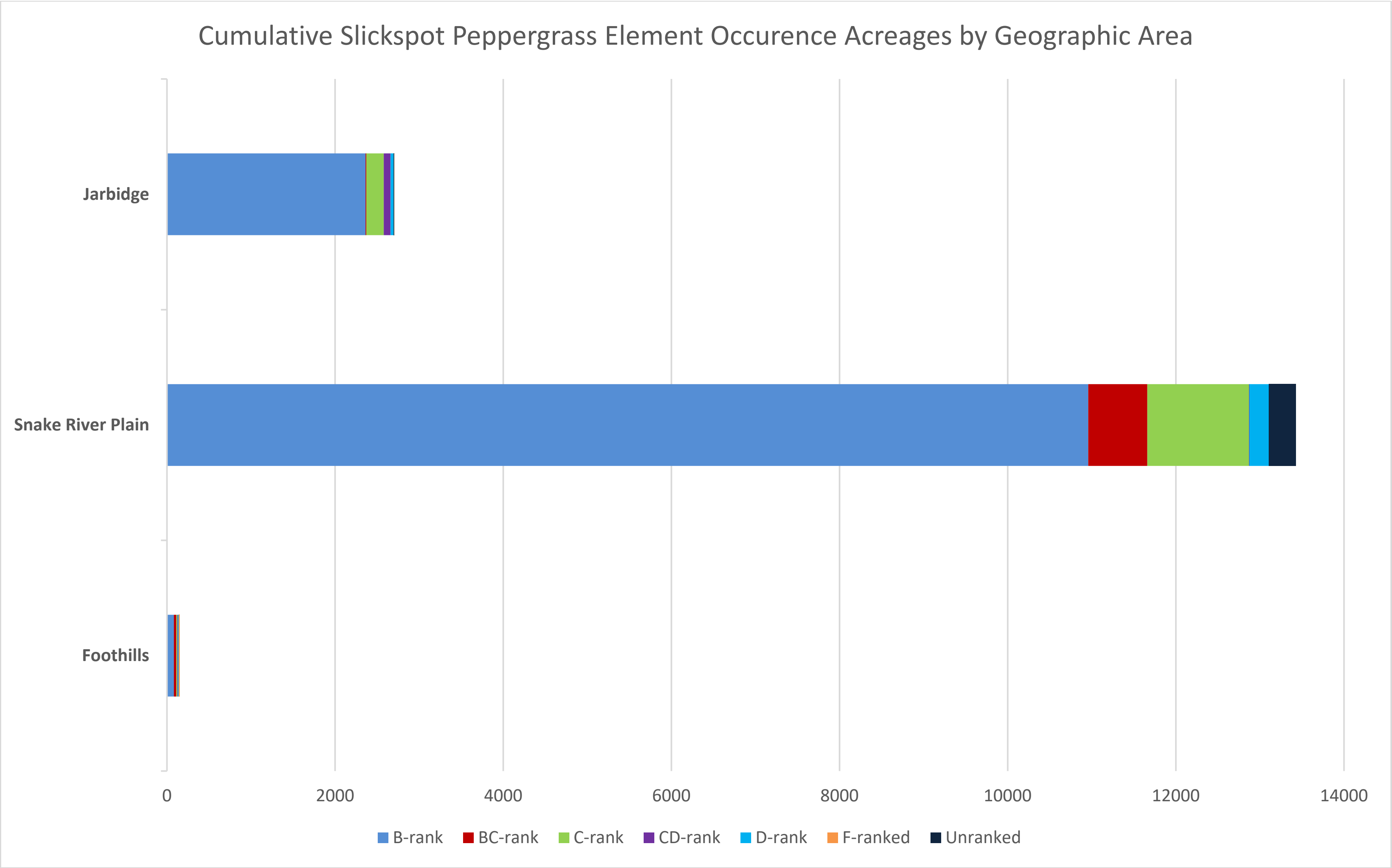


Figure 14. Cumulative acreages of slickspot peppergrass Element Occurrences by geographic area (acreage and ranking data from IDFG May 2018 IFWIS database). Colors signify acreages by EO rank. No Element Occurrences are currently ranked A or AB.

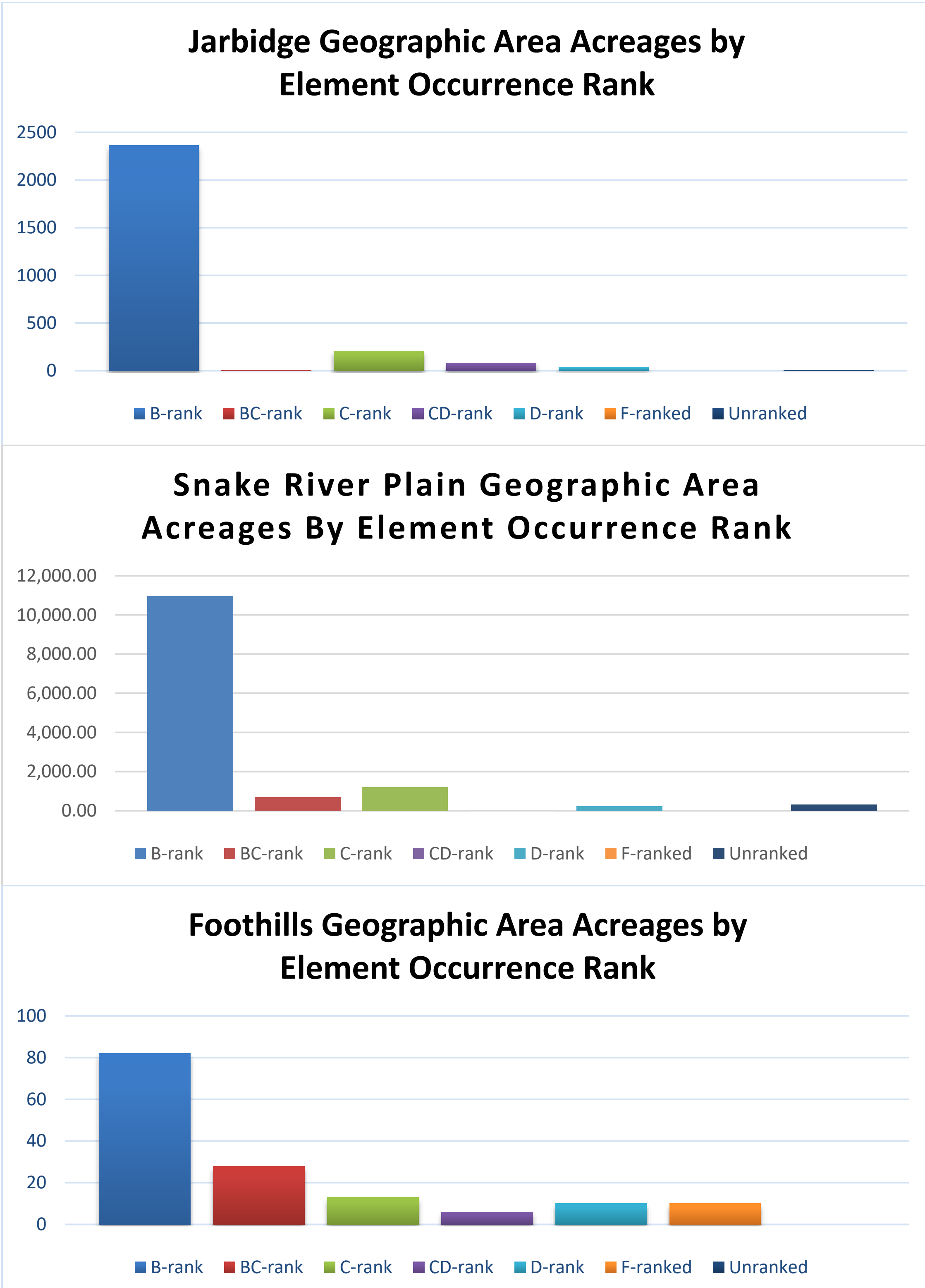


Figure 15. Cumulative slickspot peppergrass Element Occurrence acreages by rank for each individual geographic area (acreage and ranking data from IDFG May 2018 IFWIS database).

Slickspot peppergrass plants are desert annuals and biennials whose numbers vary depending on precipitation timing and amount; therefore, we emphasize the condition of habitat for the species rather than the number of plants present in any given year. Populations of desert annuals change drastically in response to annual weather conditions; hence, habitat condition is a much better long-term measure of annual plants' population viability (Elzinga *et al.*1998, p. 55). A substantial portion of each slickspot peppergrass population is associated with its persistent seed bank, and expression of above ground plants is associated with higher winter and spring precipitation years, which are infrequent events in the desert environment where the species occurs. We consider assessing above ground plant numbers over multiple years to be a more accurate method for evaluating viability because the probability of at least one year of higher winter and spring rainfall with higher flowering plant numbers (and associated replenishment of the seed bank) would increase. Therefore, we suggest a minimum viable population as having an above ground population of at least 1,000 individuals observed over one of six consecutive years that is located within habitat defined by IDFG EO ranking criteria as good to excellent quality. These six consecutive year periods consider infrequent favorable conditions for seedling survival, rosette and flowering plant growth, and replenishment of the persistent seed bank. Use of these six consecutive year periods in conjunction with good to excellent habitat quality parameters to identify minimum viable populations also assumes no significant reduction in habitat quality (i.e., no wildfires or other major ground disturbance) within the six-year period. Use of a six-year period to take into account weather-related fluctuations in slickspot peppergrass population numbers is consistent with the methodology used by IDFG to estimate population size for the recent rangewide slickspot peppergrass population assessment (Kinter and Miller 2016, pp. 3, 52-56). We consider these provisional parameters to serve as a guide for our conservation efforts, subject to revision in the future based on accumulated data.

We categorized slickspot peppergrass populations as meeting minimum population viability criteria by examining numbers of plants observed at EOs as well as the area (patch size) of relatively intact sagebrush habitat that encompasses those populations. We defined a viable population as containing 1,000 or more plants within an area at least 500 acres of relatively intact native sagebrush steppe habitat. Based on the 2016 assessment, nineteen EOs and subEOs contained 1,000 or more slickspot peppergrass plants in at least one of the past six years. The Service considers these 19 EOs and subEOs (17 B-ranked and 2 BC-ranked) to have the highest viability of all slickspot peppergrass populations (Kinter and Miller 2016, pp. 52-56). C-ranked EO 32 contained over 1,000 plants during a 2013 field assessment (Kinter and Miller 2018, raw data); however, this population was excluded from this analysis. We do not consider EO 32 to be a higher viability population due to the degraded habitat conditions within this EO and the high level of habitat fragmentation in the surrounding landscape associated with wildfire, invasive nonnative plant dominance, and gravel mining.

We further categorized the 19 B- and BC-ranked EOs and subEOs slickspot peppergrass populations meeting minimum population size criteria (i.e., at least 1,000 or more plants observed at least once over the past 6 years) by examining the area (patch size) of relatively intact habitat that encompasses those populations. Of these 19 EOs and subEOs, 6 populations also have the estimated minimum patch size (500 acres) required for minimum population viability (Table 7). Five of these six populations are scattered across the Snake River Plain geographic area, with one population located in the Jarbidge geographic area. No populations in the Foothills geographic area meet minimum viability criteria due to their low acreages.

Table 7. Slickspot peppergrass populations currently meeting minimum viability criteria.

EO and subEO Number	Geographic Area	Slickspot Peppergrass Management Area (MA)	EO Rank	Acreage
8	Snake River Plain	Glenns Ferry/Hammett (MA 10)	B	1,021
18	Snake River Plain	Kuna (MA 6)	B	1,818
26	Snake River Plain	Glenns Ferry/Hammett (MA 10)	B	708
27	Snake River Plain	Orchard Combat Training Center (MA 7)	B	7,164
30	Snake River Plain	Orchard (MA 8)	BC	702
704	Jarbidge	Jarbidge & Juniper Butte (MA 11 & 12)	B	2,216
TOTAL ACREAGE				**13,629**

The 13 populations (68 percent) with at least 1,000 plants that did not meet minimum patch size criteria are less than 100 acres in size. Ten of these 13 populations range from 2 to 40 acres in size.

The majority of slickspot peppergrass populations do not meet minimum viability criteria for population size (at least 1,000 plants) and minimum patch size (at least 500 acres) suggested in this SSA. However, some populations may be unique; and therefore, important for population representation and redundancy. For example, none of the populations in the Foothills geographic area met Service minimum population viability criteria due to their low acreages. Due to the high levels of habitat fragmentation in the Foothills geographic area associated with wildfire, invasive nonnative plants, and development as well as the patchwork of land ownership, it likely would not be feasible to achieve the 500-acre patch size suggested for minimum viability criteria at slickspot peppergrass Foothills populations. As some Foothills populations represent the lower elevation extent of the species, their conservation would be important to preserve slickspot peppergrass genetic diversity and unique habitats despite smaller habitat patch sizes (and in some cases, lower plant numbers). A combination of habitat enhancement or threat reduction actions within populations considered to be unique, regardless of whether they meet suggested minimum population viability criteria, may be appropriate to maintain (and possibly increase) population representation and species redundancy over time.

Although based on essentially the same type of baseline data and calculation as MVP, Population Viability Analysis (PVA) addresses the survival probability of specific populations. Viability of slickspot peppergrass populations is important as populations with higher viability also have higher resiliency, and have a higher likelihood of regaining plant numbers following random stochastic events such as drought or localized ground disturbance. PVA is not an absolute measure of whether a population is or is not viable, but rather is a tool used to assess how natural or man-caused changes in conditions may influence population viability.

Using IDFG rangewide population assessments, we identified six groupings of good to fair viability populations in relatively close geographic proximity that are scattered across the species' range (Table 8, see also Figure 2). These groupings of higher viability populations are indicative of population strongholds, and may provide for genetic exchange among populations within the same grouping. EOs and subEOs identified as having higher population viability within these six groupings increase resiliency to stochastic events, and their distribution across the range of the species contributes to species representation and redundancy. With the exception of the two groupings within the Jarbidge geographic area, these groupings of higher viability populations are located too distant for insect pollinators to facilitate genetic exchange among the groupings. In addition, some lower viability EOs either within a grouping or in a more isolated location may also be important for population representation and redundancy due to their genetic uniqueness or other characteristics.

Table 8. Geographic locations of slickspot peppergrass population groupings with good to fair viability.

Geographic Area	Management Area (MA) Number and Name	EO Number (rank)
Foothills	MA 1 – New Plymouth	68 (B), 69 (C), 70 (B)
Snake River Plain	MA 6 – Kuna	18 (B), 24 (C), 25 (B)
	MA 7 - Orchard Combat Training Center	27 (B), 28 (C), 67 (B)
	MA 10 - Glenns Ferry	8 (B), 26 (B)
Jarbidge	MA 11 - Jarbidge	74 (B), 75 (B), 78 (C), 79 (C), 81 (BC), 83 (B), 84 (B), 85 (C), 87 (C), 90 (C), 93 (C), 94 (C), 96 (C), 97 (B), 98 (BC), 99 (B), 700 (B), 701 (C), 702 (B), 703 (C), 704 (B) – see also MA 12, 712 (B), 715 (C), 716 (C), 720 (C), 725 (C)
	MA 12 - Jarbidge/Juniper Butte	704 (B) – see also MA 11

2.5.2.2 Unique Habitats

A few populations of a species may use unique habitats relative to the majority of its populations. For example, a few populations of *Sclerocactus brevihamatus* ssp. *tobuschii* (Tobusch fishhook cactus) occur in riparian habitats, while the majority of populations occur in upland woodland and savanna areas. For slickspot peppergrass, unique habitats are limited to the high and low elevation extremes where the species is found. Elevations for slickspot peppergrass populations range from a low of 2,480 feet at EO 68 south of New Plymouth, Idaho (MA 1 – New Plymouth in the Foothills geographic area) to a high of 5,425 feet at EO 97 south of the Juniper Butte Range (MA 11 – Jarbidge in the Jarbidge geographic area). Both high and low elevation extreme areas contain populations assessed by IDFG as having good population viability (B-ranked), although the lower elevation populations of the Foothills geographic area are smaller in area and more isolated, as they are located in more fragmented habitats. Due to current higher fragmentation levels and projected future increased risk for wildfire and invasive nonnative plants (particularly cheatgrass), lower elevation populations are expected to be more vulnerable to effects of climate change than the higher elevation populations in the Jarbidge geographic area (see Appendix D and E for data illustrating the current disturbance scope and severity at individual EOs). Loss of these small, low elevation populations would reduce population representation and rangewide redundancy.

2.5.2.3 Habitat Patch Size

The amount of contiguous area within habitat patches that support slickspot peppergrass is likely important for minimum population viability, although it is unknown if there is a critical lower patch size threshold to maintain minimum population viability or what that size the threshold would be. Habitat patch sizes for the 19 slickspot peppergrass populations considered to meet criteria for minimum viable population plant numbers and habitat condition range from about 2 acres to 7,164 acres. Identifying optimal habitat patch size for the species is further confounded by EO and subEO acreages that vary within geographic regions, with some relatively small habitat patches supporting high numbers of slickspot peppergrass plants. For example, B-ranked EOs within the Foothills geographic area range in size from less than 1 acre to about 32 acres. The relatively small patch size of Foothills EOs may likely be the result of past habitat fragmentation in the region due to frequent wildfire, pervasive invasive nonnative plants, and extensive development as opposed to being a true representation of the optimal patch size needed by the species. In contrast, the nine populations identified as meeting minimum viability criteria in the nearby Snake River Plain geographic area range from about 10 acres to about 7,164 acres, while the three populations in the Jarbidge geographic area range from about 40 acres to 2,216 acres.

In general, larger habitat patches are likely more conducive to species viability, since they have the potential to support larger populations, provide greater genetic diversity, and contain more habitat upon which the species and its insect pollinators depend. Populations that occur over larger acreages may also have greater resiliency when exposed to stochastic events as a larger area may avoid stressors over every acre. For example, a population that is located on less than one acre has a greater risk of the entire population burning when exposed to wildfire than a population that occurs over thousands of acres, where suppression efforts or physical features could limit the fire size relative to the population. As gene flow appears to be limited to relatively short distances (Stillman *et al.* 2005, p. 8), habitat patches would likely need to be located in close proximity to allow for potential exchange of genetic material through insect pollination. During a recent meeting called to elicit External Species Expert input, about 39 percent of participants believed that 100-500 acres patch size would be sufficient for species conservation, with another 39 percent of participants indicating that 500 acres or more would be the patch size needed to ensure future species viability. Furthermore, since habitat characteristics change over time due to ecological succession, climate change, exposure to primary threats such as wildfire and invasive nonnative plants (especially invasive nonnative annual grasses), or other causes, larger habitat patches are expected to support larger populations with greater genetic diversity into the future.

We examined use of median patch size as well as use of the 25th and 50th percentile patch size of all B-ranked EOs in an attempt to identify a minimum patch size expected to maintain good viability populations. These calculations resulted in patch sizes of 23 acres or less, which were far smaller than the 100-500 acres or the 500+ acres patch sizes identified by External Species Experts as optimal for a good viability population. Because of high levels of habitat fragmentation across the range of slickspot peppergrass, we believe that the current patch sizes of many B-ranked EOs are not representative of the areas of continuous habitat needed for good viability populations. In the absence of data that reveals the minimum optimal sizes of habitat patches, and based on the average size of B-ranked EOs and subEOs rangewide as well as on an intermediate patch size value elicited from slickspot peppergrass External Species Experts, a provisional patch size of at least 500 acres was chosen as optimal for good viability populations. To maximize functionality for slickspot peppergrass, these habitat patches should contain relatively intact native sagebrush steppe habitat as well as an abundance of slick spot microsites with minimal ground disturbance to support both slickspot peppergrass and its insect pollinators. Populations that reflect this patch size should maximize resiliency to stochastic events such as drought and ground disturbance.

Currently, of 19 EO and subEOs identified as meeting minimum viable population numbers (1,000+ plants) and habitat quality criteria, only six populations are greater than 500 acres in area. The area of the remaining 13 EOs that support 1,000+ plants range from 2 to 91 acres. No EOs documented to contain 1,000+ plants are 100 to 500 acres in size. Relative to larger acreage populations, these smaller acreage populations would be more vulnerable to stochastic or catastrophic events, such as ground disturbance or wildfire, respectively. Thus, good viability populations with smaller acreages may have reduced resiliency relative to larger acreage good viability populations. There is also an increased risk of reduced viability or loss of good viability populations though catastrophic events such as wildfire that occur over the entire area of a smaller acreage population, which could reduce overall representation and redundancy for the species.

2.5.2.4 Distribution of Habitat Patches

The distance between slickspot peppergrass populations may also affect population persistence over time. Greater distance reduces the potential for gene flow between EOs and subEOs through pollinators vectoring pollen or through seed dispersal. Thus, the persistence of entire populations would require relatively large landscapes where discontinuous suitable habitats (slick spot microsites surrounded by intact sagebrush steppe vegetation) are distributed and populated with high enough plant numbers for insect pollinators to vector genes between them.

Although capable of self-fertilization to a limited degree, most slickspot peppergrass reproduction occurs through out-crossing. Out-crossing requires genetically diverse slickspot peppergrass populations within the foraging range of insect pollinators and is less likely to occur in small, isolated populations. Conservation of native pollinators is essential for successful reproduction of slickspot peppergrass. Healthy (reduced susceptibility to disease, predators, and parasites) and diverse insect pollinator populations, in turn, require intact, diverse, native plant communities. Slickspot peppergrass insect pollinators benefit from a diversity of native plants whose blooming times overlap to provide flowers for foraging throughout the seasons and to provide nesting and egg-laying sites; appropriate nesting materials; and sheltered, undisturbed places for hibernation and overwintering of pollinator species (USFWS 2010, p. 27205). While insect pollinators may use some nonnative plants as a source of edible pollen and nectar with no detectable effects, other studies show impacts at a range of scales (Stout and Tiedenken 2019, p. 41). For example, nonnative plants can have important consequences for the structure of the plant-pollinator network by decreasing pollinator visits to native species (particularly in situations where floral resources are scarce) (Bartemeus *et al.* 2008, pp. 767, 769). Nonnative plant pollen may also have reduced nutritional value relative to native flowering plants (Drossart *et al.* 2017, pp. 2-5). Thus, nonnative flowering plants may not adequately provide for insect pollinators or may direct pollinators away from slickspot peppergrass, which may impact representation and redundancy of the species.

In general, insect pollinators focus on small areas where floral resources are abundant; however, occasional longer distance pollination may occur infrequently. Insect pollinators of slickspot peppergrass are relatively small, thus, their foraging ranges are expected to be limited (Greenleaf *et al.* 2007, entire). The abundance and diversity of native shrubs, grasses, and forbs within the vicinity of slickspot peppergrass populations is particularly important for successful slickspot peppergrass reproduction; a maximum distance that insect pollinators could travel between slickspot peppergrass sites is suggested to be 0.6 miles (Colket and Robertson *in litt.* 2006, entire). This aligns with the average foraging distance for native pollinators of 50 feet to 0.5 miles as described by the Natural Resource Conservation Service (NRCS 2008, p. 1), with native bees foraging between 200 feet and 0.5 mile (NRCS 2016, p. 1). In addition, pollinators require reduced risk of agricultural pesticide exposure within their foraging ranges; pesticide exposure risk to insect pollinators important to slickspot peppergrass is expected to be highest where slickspot peppergrass populations and connectivity corridors are located near development or cultivated agricultural fields. Pesticide exposure risk would depend on the toxicity and persistence of the pesticide used as well as the distance of spray drift or movement of plant parts that incorporated the pesticide both during and following application.

2.6 Species-Level Ecology

The viability of a species requires multiple persistent populations that capture the breadth of species' genetic and ecological diversity distributed across a large enough landscape to ensure species resiliency, redundancy, and representation (Shaffer and Stein 2000, pp. 307–310). Resiliency refers to population sizes; larger populations are more likely to persist than small ones. Redundant populations increase the species' chances of surviving catastrophic events.

Representation refers to the breadth of genetic diversity necessary to conserve long-term adaptive capability. Slickspot peppergrass populations with higher resiliency, representation, and redundancy levels would meet the following criteria:

Resiliency

Populations with the following resiliency characteristics could withstand stochastic events such as drought and ground disturbance associated with localized off highway vehicle use, livestock use, or recreational activities:

- Population contains at least 1,000 or more above ground plants in years of average or above average spring precipitation.
- Population located within relatively intact sagebrush steppe habitat that supports a diversity of insect pollinators needed for successful reproduction.
- Population and associated slick spot microsites have no or minimal exposure to ground disturbance.
- Population and associated insect pollinators have no or minimal exposure to pesticides or herbicides.

Representation

Populations with the following representation characteristics would include the range of genetic variability as well as special habitats used by the species (such populations would capture adaptive capacity of the species, which enables the species to respond to future change):

- Several larger populations are located within the expected range of slickspot peppergrass insect pollinator travel distance (0.6 mile or less) of one another.
- Populations and connectivity corridors and islands between populations support diverse flowering shrubs and forbs with overlapping bloom times capable of supporting insect pollinator foraging throughout the seasons, provide nesting and egg-laying sites, and provide sheltered, undisturbed places for pollinator hibernation and overwintering.
- Populations and connectivity corridors and islands contain diverse perennial bunchgrasses, shrubs, and forbs as well as biological soil crusts.
    - Perennial plants contribute to habitat resistance to nonnative invasive annual grass invasion in low ecological resistance and resilience sagebrush steppe habitats found across the range of slickspot peppergrass.
- Populations at the high and low elevation extent of the species maintain special habitats

Redundancy

High redundancy levels secure current and future viability of slickspot peppergrass populations rangewide. Species with higher redundancy have a sufficient number of populations for the species to withstand catastrophic events as described by the characteristic below:

- At least six groupings spread across the range of the species that contain two or more representative, larger populations within intact sagebrush steppe habitat.
    - Redundancy provides for species security in the face of catastrophic events such as wildfire.

3. Factors Affecting the Species

A detailed discussion of the threats to slickspot peppergrass is in the final listing rule published in the Federal Register on October 8, 2009 (74 FR 52014), with updated information associated with threats in the final listing reconsideration rule published August 17, 2016 (81 FR 55058). As identified in these final rules, the two primary threat factors affecting the habitat and survival of slickspot peppergrass in southwest Idaho are increased frequency and intensity of wildfire and introduction and spread of invasive nonnative plants (primarily nonnative annual grasses such as cheatgrass). The modified wildfire regime and increased invasive nonnative plants are further exacerbated by climate change. Development and associated infrastructure has also directly affected slickspot peppergrass through destruction of populations, loss of slick spot microsites, and fragmentation. Ten populations have been extirpated due to development. An additional concern is the widespread occurrence of seed predation by Owyhee harvester ants.

Several other activities were also identified in the 2009 listing rule as also having the potential to impact slickspot peppergrass. These activities include livestock use, wildfire management activities, post-fire stabilization and restoration activities, recreation and off highway vehicle use, and military training; they were not considered to result in significant impacts that would lead to slickspot peppergrass becoming endangered in the foreseeable future, primarily due to implementation of conservation measures designed to avoid or reduce impacts to slickspot peppergrass associated with these lesser activities. Because livestock use occurs within the majority of slickspot peppergrass populations and is considered as a potential tool for the reduction of fine fuels within the Great Basin to reduce the risk of catastrophic wildfire, this topic is discussed separately within the SSA. Wildfire management activities, post-fire stabilization and restoration activities, recreation and off highway vehicle use, and military training will be briefly discussed within the analysis of the three higher significance threats to the species (wildfire, invasive nonnative plants, and development). Additional information on these secondary threats is also available in the 2009 (74 FR 52014) and 2014 (81 FR 55058) listing rules.

3.1 Primary Threat: Increased Frequency and Intensity of Wildfire

Along with the introduction and spread of invasive nonnative plants, the altered wildfire regime is one of the two primary causes of reduced quality of habitat for slickspot peppergrass. Across the intermountain west, increased frequency, severity, intensity, and extent of wildfire has converted vast areas of former sagebrush steppe ecosystem to nonnative annual grasslands. Invasive nonnative annual grasses, such as cheatgrass and medusahead, have contributed to increases in the amount and continuity of fine fuels across the landscape. As a result, the wildfire frequency interval of sagebrush steppe habitat has been drastically shortened from a historical range of approximately 60 to over 300 years (depending on the species of sagebrush and other site specific characteristics) to less than 5 years in many areas of the sagebrush steppe ecosystem (Billings 1990, pp. 307–308; Whisenant 1990, p. 4; USGS 1999, *in litt.,* pp. 1–9; West and Young 2000, p. 262; Bukowski and Baker 2013, p. 557). Not only are wildfires burning far more frequently, but these wildfires tend to be larger and burn more uniformly than those that occurred historically, resulting in fewer patches of unburned vegetation, which affects the post-fire recovery of native sagebrush steppe vegetation (Whisenant 1990, p. 4). However, because estimates of increased fire frequency are critically dependent on the spatial area and period over which authors use for their computations, each estimate of fire frequency in sagebrush steppe provides a perspective on the role of fire in the sagebrush ecosystem that must be interpreted using the appropriate scale (Miller *et al.* 2011, p. 165).

Characteristics of individual fire events as well as the collective fire regime are important drivers of structure, composition, and abundance of vegetation within sagebrush communities. At broader spatial scales, fire events and regime are dominant determinants of habitat configuration within the landscape. Individual fires are described by severity (the level of biological and physical effect of fire on all plant layers, soils, and animals), intensity (the amount of energy released during a fire), season, extent or size, and complexity (patchiness of burned and unburned areas within the fire boundary) (Miller *et al.* 2011, p. 164). In contrast, fire regime is a function of the mean and range of the interval (usually in years) between fire events for a defined area. The fire regime for a specific area is influenced by climate, regional location, fuel characteristics (biomass and structure), and recovery time following disturbance, topography, season and frequency of ignition, and vegetation composition (Miller *et al.* 2011, p. 165).

Increased frequency and intensity of wildfire and the introduction and spread of invasive nonnative plant species, especially invasive nonnative annual grasses, were cited in the 2009 final listing rule and the 2016 reinstatement rule as the primary causes for the decline of slickspot peppergrass. Invasion of native sagebrush steppe habitat with nonnative annual grasses, such as cheatgrass and medusahead within the range of slickspot peppergrass has provided continuous fine fuels that contribute to the increased frequency and extent of wildfires. Frequent wildfires ultimately result in the conversion of the sagebrush steppe habitat to nonnative annual grassland monocultures, with consequent losses of native species diversity and natural ecological function. This creates a positive feedback loop between invasive nonnative annual grasses and wildfire, which makes it difficult to independently separate out effects of each of these two primary threats to slickspot peppergrass.

In southwest Idaho, increased frequency, size, and duration of wildfire has converted vast areas of former sagebrush steppe ecosystem to nonnative annual grasslands (USGS 1999, *in litt*., pp. 1–9), resulting in the loss or reduction in cover of sagebrush, native grasses, and native forbs available for insect pollinator foraging and shelter. For example, although some native shrubs such as rabbitbrush readily resprout after burning, sagebrush depends on sources of viable sagebrush seed for re-establishment following wildfire; these seed sources may be too distant for recolonization of a site following a landscape-scale, intense wildfire.

Frequent wildfires also promote soil erosion (Sankey et al. 2009, p. 81) and deposition and sedimentation (Bunting *et al.* 2003, p. 82) in arid environments such as the sagebrush steppe ecosystem, which can affect slickspot peppergrass and its habitat. Short-term reductions in vegetative cover following disturbance such as wildfire make soils within the range of slickspot peppergrass more susceptible to erosion, which could reduce productivity over the short and long term, depending on the degree of soil loss. Highly erodible soils dominated by shallow-rooted annual vegetation, are most vulnerable to wildfire-facilitated erosion. Wind erosion can result in loss of topsoil from burned sagebrush steppe, the majority of which occurs as a pulse in the first few months following a wildfire (Hasselquist *et al.* 2011, p. 3654). Post-wildfire wind erosion can reduce critical organic matter, nutrients, and hydrological permeability of eroded sites

(Hasselquist *et al.* 2011 p. 3657, Ravi *et al.* 2011, pp. 13, 16), which may reduce the ability of burned sites to support vegetation important for slickspot peppergrass and its insect pollinators. Conversely, the effects of the partial loss of slick spot upper silt layers or of surrounding matrix soils due to post-fire wind or water erosion on slickspot peppergrass are unknown.

Deposition of wind- or water-borne sediment following wildfire may also occur within both burned and unburned areas that support slickspot peppergrass following wildfire events. Increased deposition and sedimentation can result in a silt layer that is too thick for optimal slickspot peppergrass emergence (Meyer and Allen 2005, pp. 6–7). Deposition of post-fire sediment in unburned areas can also increase nutrient levels in sagebrush steppe habitats (Hasselquist *et al.* 2011 p. 3655), potentially increasing the risk of invasive nonnative plant spread into slick spots microsites where nutrient-rich sediment deposition occurs.

The majority of areas that currently contain slickspot peppergrass are at high risk of large catastrophic wildfires. Ecological resistance and resilience concepts are being used to reduce impacts of invasive annual grasses and altered fire regimes on the sagebrush ecosystem and the greater sage-grouse (*Centrocercus urophasianus*) (Chambers *et al.* 2014a, entire). Resilient ecosystems have the capacity to ***regain*** their fundamental structure, processes, and functioning when altered by stressors like drought and disturbances like inappropriate livestock grazing and altered fire regimes (Allen *et al.* 2005, pp. 341, 342). Species resiliency is closely linked to ecosystem resilience. Resistant ecosystems have the capacity to ***retain*** their fundamental structure, processes, and functioning when exposed to stresses, disturbances, or invasive species (Folke *et al.* 2004, p. 558). Resistance to invasion by nonnative plants is increasingly important in sagebrush ecosystems; it is a function of the abiotic and biotic attributes and ecological processes of an ecosystem that limit the population growth of an invading species (D'Antonio and Thomsen 2004, p.1572**)**.

The risks of increased frequency of wildfire and nonnative annual grass invasion were analyzed in an ecological Resistance and Resilience matrix developed by the Western Association of Fish and Wildlife Agencies (WAFWA), including within the range of slickspot peppergrass. This WAFWA analysis classified different ecological soil and moisture regimes into categories (low, moderate, and high) of ecological resilience to wildfire disturbance and resistance to invasion by annual grasses (Chambers *et al.* 2014a, entire). Of the analyzed ecological resistance and resilience areas occupied by slickspot peppergrass*,* 99 percent occur within Warm and Dry (Mesic/Aridic) Ecological Type (Figure 16) areas classified as having low ecological resistance and resilience (Chambers *et al.* 2014a, p. 17). Low ecological resistance and resilience areas tend to be prone to invasion by and subsequent persistence of cheatgrass; thus, these areas are at a higher risk for large catastrophic wildfires. The low ecological resistance and resilience of the vast majority (99 percent) of the range of slickspot peppergrass represents a challenge to wildfire management, particularly due to increased risk for large, catastrophic wildfires within the range of slickspot peppergrass.

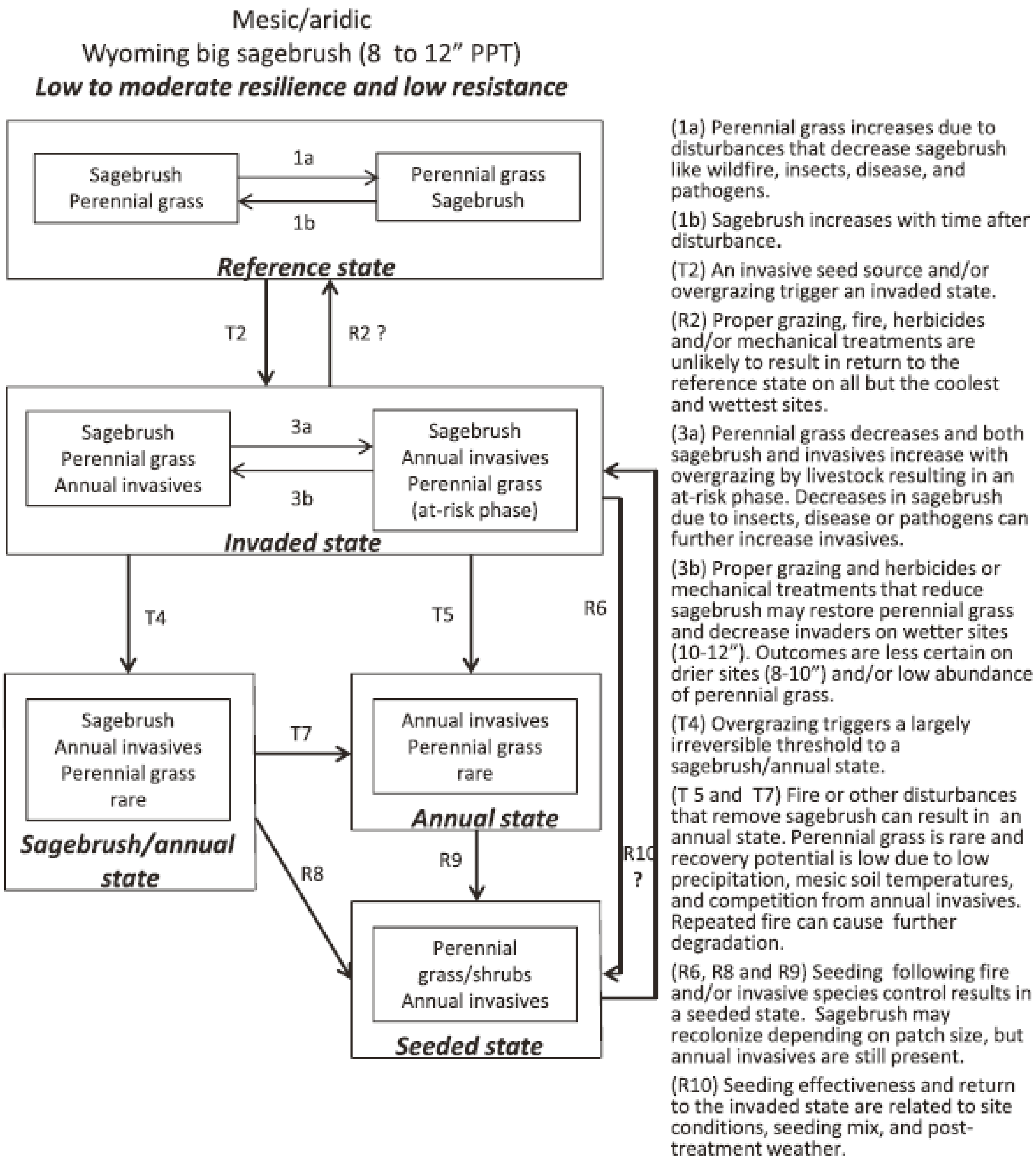


Figure 16. State and transition model for a mesic/aridic Wyoming big sagebrush ecological type with low to moderate ecological resilience and low ecological resistance (from Chambers *et al.* 2014b, p. 450). This model reflects habitat condition across the range of slickspot peppergrass.

Wildfire can modify slick spot microsite soils, which may influence the survival of slickspot peppergrass plants. The upper soil layers of burned slicks spots contain less moisture during the spring months relative to unburned slick spot soils (Nichol-Driskill 2011, p. 25); thus, burned slick spots have less soil moisture available for germinating seeds and emerging slickspot peppergrass seedling survival. Burned slick spots have been documented to contain greater ground cover of annual and perennial vegetation in summer than unburned slick spots (Nichol-Driskill 2011, p. 25). Wildfire-related vegetation within slick spots may outcompete slickspot peppergrass for resources such as water and nutrients, reducing slickspot peppergrass vigor and survival.

Analysis of 10 years of rangewide monitoring data has shown that slickspot peppergrass abundance is significantly reduced in the year following burns (Bond 2017, p. 12). Additional analysis of wildfire history and slickspot peppergrass abundance using 10-year HIP monitoring data set is currently being conducted. Sullivan and Nations (2009, pp. 114–118, 137) found a consistent, statistically significant, negative correlation between wildfire and the abundance of slickspot peppergrass across its range in their analysis of five years of HIP monitoring data. They found that slickspot peppergrass "abundance was lower within those slick spot [sic] that had previously burned'' (Sullivan and Nations 2009, p. 137), and the relationship between slickspot peppergrass abundance and fire is reported as ''relatively large and statistically significant,'' regardless of the age of the fire or the number of past fires (Sullivan and Nations 2009, p. 118). The nature of this relationship was not affected by the number of fires that may have occurred in the past; whether only one fire had occurred or several, the association with decreased abundance of slickspot peppergrass was similar (Sullivan and Nations 2009, p. 118).

More than 50 percent of known slickspot peppergrass EOs have already been affected by wildfire. While some EOs may persist for a time in unburned habitat ''islands'' within the mosaic of burned and unburned areas created by wildfire, the resulting habitat fragmentation will subject any such EOs to a high degree of vulnerability, such that they may have reduced viability over the long term. Wildfire in combination with other activities can lead to reduced slickspot peppergrass population viability. Severe wildfires coupled with other disturbance such as increased off highway vehicle use facilitated by loss of shrubs or improper levels of livestock grazing on perennial native plants can lead to a type conversion of native sagebrush steppe to annual grassland (Chambers *et al.* 2014a, p. 11). In these disturbed sites, successional habitat changes result in grasslands dominated by invasive nonnative grasses, rather than slick spot microsites surrounded by sagebrush and native grass and forb species needed by slickspot peppergrass. Therefore, although low numbers individual slickspot peppergrass plants (often less than 50 plants) may continue to be found in burned areas, remnant populations or portions of populations in burned areas would be vulnerable to local extirpation.

Even though slickspot peppergrass occurs in naturally patchy microsite habitats, increased habitat fragmentation produced by wildfires and subsequent proliferation of invasive nonnative annual grasses may result in the separation of slickspot peppergrass populations beyond the distance that its insect pollinators are capable of traveling. Genetic exchange in slickspot peppergrass is achieved through either seed dispersal or insect-mediated pollination, and plants that receive pollen from more distant sources demonstrate greater reproductive success in terms of seed production. As all indications are that seeds are dispersed over only a very small distance and insect pollinators are limited in their dispersal capabilities, wildfire-related habitat fragmentation and isolation of populations poses a threat to slickspot peppergrass in terms of decreased resiliency, representation, and redundancy through decreased reproductive success (lower seed set), reduced genetic variability, and increased local extirpation risk.

3.2 Primary Threat: Introduction and Spread of Invasive Nonnative Plants

Executive Order 13112 defines an invasive species as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health" (EO 13112). Invasive nonnative plants within the range of slickspot peppergrass include both invasive nonnative annual grasses and nonnative perennial plants such as noxious weeds.

Invasive, nonnative annual grasses can alter various attributes of ecosystems including geomorphology, wildfire regime, hydrology, microclimate, nutrient cycle, and productivity (for a summary, see Dukes and Mooney 2003, entire). Additionally, invasive nonnative annual grasses can negatively affect native plants, including rare plants such as slickspot peppergrass, through competitive exclusion, niche displacement, hybridization, and competition for insect pollinators. Examples of these negative effects are widespread among different taxa, locations, and ecosystems (D'Antonio and Vitousek 1992, pp. 63–87; Olson 1999, p. 5; Mooney and Cleland 2001, p. 1).

Sagebrush steppe habitats in the Great Basin have been modified by a series of changes in vegetation and structure, beginning with the arrival of Euro-Americans in the mid-1800s when new land uses and management activities such as large-scale livestock grazing, sagebrush removal, mining, road building, and fire suppression were introduced (Morris and Rowe 2014, pp. 1147-1148, 1152; Romme *et al.* 2009, p. 218; Pyke *et al.* 2016, p. 314). Dispersed recreational use, off highway vehicle use, and utility easements, such as pipelines and electrical transmission lines, have further fragmented sagebrush steppe habitat. Within Great Basin sagebrush steppe habitats, a decrease in native perennial bunchgrasses and forbs across much of the area due to improper historic livestock grazing provided an opportunity for spread of introduced invasive annual grasses such as cheatgrass (Miller and Eddleman 2001, pp. 19-20; Miller *et al.* 2011, p. 160; Pyke *et al.* 2016, pp. 316-317), particularly in areas of low ecological resistance and resilience. Introduced from Eurasia in the late 1800s, cheatgrass spread into low- to mid-elevation ecosystems with understories depleted by improper grazing or were disturbed through anthropogenic development (Knapp 1996, pp. 4-7; Mealor *et al.* 2013, pp. 8-9; Pyke *et al.* 2016, pp. 314-317). Warming following the end of the Little Ice Age, when winter temperatures in North America were about 1° C cooler during a 19th century peak cooling period (Mann 2000, p. 4), has also likely contributed to the current extent of cheatgrass and medusahead in lower elevation Idaho sagebrush steppe habitats. Additional information on effects of climate change on slickspot peppergrass and its sagebrush steppe habitat is provided in the "Additional Threat: Climate Change" section below.

Invasive nonnative annual grasses increased the amount and continuity of fine fuels in lower elevation sagebrush habitats and initiated annual grass/wildfire cycles characterized by shortened wildfire return intervals and larger, more contiguous wildfires (Whisenant 1990, p. 4; D'Antonio and Vitousek 1992, pp. 73, 75; Brooks and Pyke 2001, p. 5; Brooks *et al.* 2004, p. 678; Balch *et al.* 2013, pp. 177–179). Native and nonnative perennial bunchgrasses are less flammable than invasive nonnative annual grasses, because perennial bunchgrasses have more dense, moist vegetation with open spaces of bare soil (inclusive of biological soil crusts in intact sagebrush steppe habitats) between their clumps, which makes them less flammable than invasive nonnative annual grasses. Invasive nonnative annual grasses have a finer growth form that facilitates drier, more continuous fuels (IDFG *in litt.* p. 4). Once established, deep-rooted perennial bunchgrasses can successfully compete with invasive nonnative annual grasses such as cheatgrass (Ott *et al.* In press, pp. 7, 12; Nafus *et al.* 2015, pp. 212-213; Pyke and Archer 1991, p. 552; Lesica and DeLuca 1998, p. 408).

Cheatgrass is a successful invader of the intermountain west due to a variety of factors:

- Cheatgrass easily establishes on sites where soil and vegetation have been disturbed
- Cheatgrass is adapted to a broad range of soil textures
- Cheatgrass has long, sharp awns allow for seed transport by animals as well as provide defense of the plant from herbivory
- Cheatgrass fills the niche of a dominant cool-season grass, especially in areas where native cool season grasses are lacking
- Cheatgrass is highly adaptable due to its ability to alter its form and the way it functions based on changing environmental conditions (e.g., "phenotypic plasticity").

Cheatgrass competes easily with native sagebrush steppe vegetation for moisture, nutrients, and sunlight due to its winter and early spring growth habit and its extensive and rapid-growing shoot and root system (Mealor *et al.* 2013, p. 10). Germination of cheatgrass occurs at a much quicker rate than most perennial plants. Development of extensive root systems at cold temperatures gives cheatgrass an advantage of exploiting moisture early while most native perennial plants are still dormant. Where cheatgrass is present, it can use a large portion of soil moisture, making subsequent establishment of other desirable plant species more difficult (Mealor *et al.* 2013, pp. 9-10).

As of 2009, cheatgrass and other invasive nonnative annual grasses dominated at least six percent (over 250,000 square miles) of the central Great Basin (Balch *et al.* 2013, p. 181) and have the potential to spread across many of the remaining low- to mid-elevation sagebrush ecosystems in the western part of the sagebrush biome, including within the range of slickspot peppergrass. Disturbance, such as improper livestock management, that reduces site ecological resistance to cheatgrass can continue to exacerbate cheatgrass dominance in sagebrush communities (Reisner *et al.* 2013, pp. 1044, 1046; Condon and Pyke 2018; Pyke et al. 2016, pp. 319-321). Conversion of sagebrush steppe habitat to invasive nonnative plants, particularly cheatgrass-dominated annual grasslands over the past several decades has resulted in habitat loss, fragmentation, and degradation for slickspot peppergrass and its insect pollinators.

Invasive nonnative plants are one of the primary causes of reduced habitat suitability for slickspot peppergrass. Invasive nonnative plants can impact slickspot peppergrass through both perpetuation of the wildfire/nonnative plant cycle as well as through direct competition with individual slickspot peppergrass plants. Recent analyses have revealed a significant, negative association between invasive nonnative plant cover and the abundance or density of slickspot peppergrass, to the point that slickspot peppergrass plants may be excluded from slick spots (Sullivan and Nations 2009, pp. 109–112, Bond 2017, p. 12). Invasive nonnative plants may impact slick spot microsite hydrology and increase levels of organic matter in slick spots, making them more vulnerable to increased plant invasion (Kinter *et al.* 2014, p. 13). Some slick spots also appear to be disappearing due to encroachment by invasive nonnative plants. Although the specific mechanisms are not well understood, invasive nonnative plants, such as cheatgrass, are strong competitors in this arid environment for limited resources such as moisture (Pyke and Archer 1991, p. 4; Lesica and DeLuca 1998, p. 4), which tends to be concentrated in slick spot microsites (Moseley 1994, p. 8) at least in the subsurface soils (Fisher *et al.* 1996, pp. 13–16).

Ground disturbance generated by land management actions can create openings available for establishment of invasive nonnative plants, including activities required to address the primary threats of wildfire and invasive nonnative plants. For example, ground disturbance associated with wildfire control (such as the establishment of fire lines and firefighting staging areas as well as using wildfire suppression vehicles off of established roads) can impact existing slickspot peppergrass populations through introduction and spread of invasive nonnative plants (ILPG 1999, *in litt*., p. 2; Zouhar *et al*. 2008, p. 273) and damage to slick spot microsites (ILPG 1999, *in litt*., p. 2). Disturbance during periods when slick spot soils are saturated can bury slickspot peppergrass seeds too deep for successful emergence, injure or kill slickspot peppergrass seedlings, and provide a niche for invasive nonnative plants to spread (ILPG 1999, *in litt*., entire; Meyer *et al.* 2006, pp. 898, 901; Meyer *et al*. 2005, pp. 21-22; Meyer and Allen 2005 pp. 8-9).

Restoration of the sagebrush steppe ecosystem is considered one of the greatest restoration challenges in the Great Basin (Bunting *et al*. 2003, pp. 82-84). Maintaining or restoring functional sagebrush steppe vegetation communities which once occurred throughout the Great Basin is an essential biological and physical requirement of slickspot peppergrass, and habitat restoration within and around higher viability populations will likely be essential to the recovery of this species. Native plant species are the foundation of functional sagebrush ecosystems and provide essential habitat for sagebrush obligate species such as slickspot peppergrass. Native plants possess traits that make them uniquely adapted to local conditions; therefore, restoration of the landscape can help to reverse the trend of species loss. A relatively intact Wyoming big sagebrush vegetation community (represented by perennial bunchgrasses, shrubs, and forbs as well as biological soil crusts) provides greater ecological resistance to invasive nonnative plants and resilience to disturbance such as wildfire by buffering slick spots and slickspot peppergrass from wildfire, slowing the invasion of slick spots by invasive nonnative plant species, and providing habitat requirements for insect pollinators. About 20 percent cover of perennial native grasses and forbs is needed in Wyoming big sagebrush sites to prevent significant increases in cheatgrass and other exotic annuals after management treatments (sagebrush mowing and prescribed fire) (Chambers *et al.* 2014b, p. 449). Tradeoffs associated with use of highly competitive nonnative plant materials to address the primary threats of wildfire and invasive nonnative plant spread are described in the “Additional Threat: Highly Competitive Nonnative Seeded Species” section below.

Herbicide treatments are used as another method to reduce cheatgrass cover during sagebrush steppe habitat restoration efforts in low ecological resilience and resilience sites. Slickspot peppergrass contact with herbicides may result in injury or mortality of individual plants. Effects of herbicide treatments on slickspot peppergrass populations would depend on the toxicity of both the active ingredients and any adjuvants on non-target plants, contact between non-target plants and the herbicide, and persistence of the herbicide in the environment. It is expected that herbicides known to kill broadleaf plants (especially mustards) would injure or kill exposed slickspot peppergrass plants. For example, an on-the-ground study examining the effects of Oust

© herbicide showed reduced slickspot peppergrass plant numbers over the long-term (Scholten and Bunting 2001, pp. 7-8).

Herbicides typically used within the range of slickspot peppergrass to treat invasive nonnative annual grasses such as cheatgrass and medusahead have included glyphosate and imazapic. Glyphosate is a contact herbicide that kills both grasses and broadleaf plants, with a typical suggested half-life of 47 days. Effects of slickspot peppergrass plant or seed exposure to glyphosate has not been determined through on-the-ground testing or in a laboratory setting to date. Imazapic is a pre-and post-emergent herbicide that kills broadleaf plants and grasses. Imazapic is moderately persistent in soil, with an average half -life in soil of about 120 days. Recent laboratory trials have shown that exposure to imazapic is lethal to slickspot peppergrass seedlings (DeGraaff and Robertson 2019, p. 5). Because the effects of imazapic-treated soils were low on a forb species with a relatively thick seed coat (*Astragalus filipes* (basalt milkvetch); DeGraaff and Johns 2014, p. 64), it has been suggested that potential effects of imazapic on slickspot peppergrass seeds may also be low. It is also possible that the persistent seed bank may buffer slickspot peppergrass from effects of exposure during a single treatment of a non-persistent herbicide in populations where chemical treatment of invasive nonnative annual grasses may occur. The full effects of exposure to herbicides commonly used for invasive nonnative plant control in southern Idaho as well as the concentration and timing of herbicide applications on slickspot peppergrass plants have yet to be determined.

Control of cheatgrass spread and subsequent increases in wildfire frequency and extent once cheatgrass is established on a large scale is economically and biologically challenging (Pellant 1996, pp. 13–14; Menakis *et al.* 2003, p. 287; Pyke 2007, entire; Pyke 2011, pp. 539, 542-544; Pyke *et al.* 2017, pp. 5, 29; Weltz *et al.* 2014, p. 44A; Mayer *et al.* 2018, pp. 7-10). Control of invasive nonnative plants poses management challenges, and future land management decisions will determine the degree to which nonnative plants may affect slickspot peppergrass.

Invasive nonnative annual grasses and noxious weeds may compete with slickspot peppergrass for moisture and nutrients, and may cause changes in slick spot hydrology. Invasive nonnative annual grasses, primarily cheatgrass and medusahead, pose a serious and significant threat to slickspot peppergrass, particularly when the synergistic effects of nonnative annual grasses and wildfire are considered.

Sagebrush steppe plant communities, especially big sagebrush, perennial bunchgrasses, forbs, and biological soil crusts, represent a critical conservation component for higher viability slickspot peppergrass populations. Because slickspot peppergrass relies on a diverse pollinator assemblage to facilitate genetic dispersal and seed set, the species benefits from contiguous, intact sagebrush steppe habitat within populations that maintains pollinator assemblages and enables pollinators to forage among subpopulations of slickspot peppergrass. However, where native plants have been replaced by invasive nonnative annual grasses and noxious weeds over vast acreages, native sagebrush steppe communities have not returned on their own, and are often difficult to actively restore. Therefore, habitat fragmentation, barriers to insect pollination, and direct competition with and loss of native sagebrush steppe vegetation, including slickspot peppergrass, due to invasive nonnative annual grass introduction and spread poses a threat to slickspot peppergrass in terms of decreased resiliency, representation, and redundancy through decreased reproductive success (lower seed set), reduced genetic variability, and increased local extirpation risk.

3.3 Additional Threat: Highly Competitive Nonnative Seeded Species

The invasive nonnative plants section of the 2009 listing rule (74 FR 52033-52035) included a subsection that described the effects of highly competitive nonnative seeded species on slickspot peppergrass. Consistent with USFWS findings for greater sage-grouse within the sagebrush steppe landscape, the effects of invasive nonnative unseeded species (especially annual invasive nonnative grasses such as cheatgrass and medusahead) have been identified by Idaho Fish and Wildlife Office and the State of Idaho as the appropriate primary focus of the rangewide invasive nonnative plant threat within this SSA. Highly competitive nonnative seeded species are typically not categorized by land management agencies as invasive plants as these plant materials maybe be more or less competitive based on local ecological site characteristics and have historically been and are currently readily seeded across the West, including within the range of slickspot peppergrass. Due to a lack of funding and readily available native plant materials, highly competitive nonnative plant materials are used for restoration of sagebrush steppe ecosystems to reduce the primary threats of wildfire and invasive nonnative plants at landscape scales. Diversity of deep-rooted plants provides increased ecological resistance to invasive annual grass establishment following disturbance; thereby increasing the functionality of the landscape relative to an annual grass dominated ecological state. While landowners and agency land managers within the range of slickspot peppergrass have discretion to determine the location and composition mix of highly competitive nonnative species seeded or planted on their lands relative to slickspot peppergrass populations, they have essentially no control over the location and extent of annual invasive nonnative grasses that thrive following random catastrophic wildfires. Therefore, within this SSA, highly competitive nonnative seeded species are considered separately from invasive nonnative unseeded species, which includes annual invasive nonnative grasses and perennial noxious weeds.

Both native and nonnative deep-rooted perennial bunchgrasses can play key roles in the ecological resilience of habitat to disturbances (such as wildfire and improper livestock grazing) and of ecological resistance to invasive nonnative annual grass establishment. Established perennial plants with well-developed root systems (Figure 17) can effectively compete with invasive nonnative annual grasses for water and nutrients. Both established native and nonnative deep-rooted perennial grasses can limit the spread of invasive nonnative annual grasses such as cheatgrass (Davies and Johnson 2017, p. 748; Clements *et al.* 2017, pp. 179-180, Ott *et al.* In press, pp. 6, 10). Seeded deep-rooted nonnative perennial species, such as crested wheatgrass and forage kochia, have been extensively used for post-fire soil stabilization efforts in the Great Basin, including within the range of slickspot peppergrass, due to their ability to decrease soil erosion risk, exclude cheatgrass at a lower cost than native species, and their relative ease of establishment compared with native perennial bunchgrasses (Davies *et al.* 2013, p. 472).

Highly competitive nonnative perennial plant species seeded to reduce the presence of unseeded invasive nonnative annual grasses also have the potential to directly compete with slickspot peppergrass, if established within slickspot peppergrass populations. Nonnative perennial bunchgrass, such as crested wheatgrass, are strong competitors for limited resources such as moisture, and can also slow growth or contribute to reductions or loss of desirable plant species such as native plants (Ott *et al.* In press, pp. 7, 12; Nafus *et al.* 2015, pp. 212-213; Pyke and Archer 1991, p. 552; Lesica and DeLuca 1998, p. 408), including slickspot peppergrass. Some native species have been observed to establish and persist within crested wheatgrass seedings;

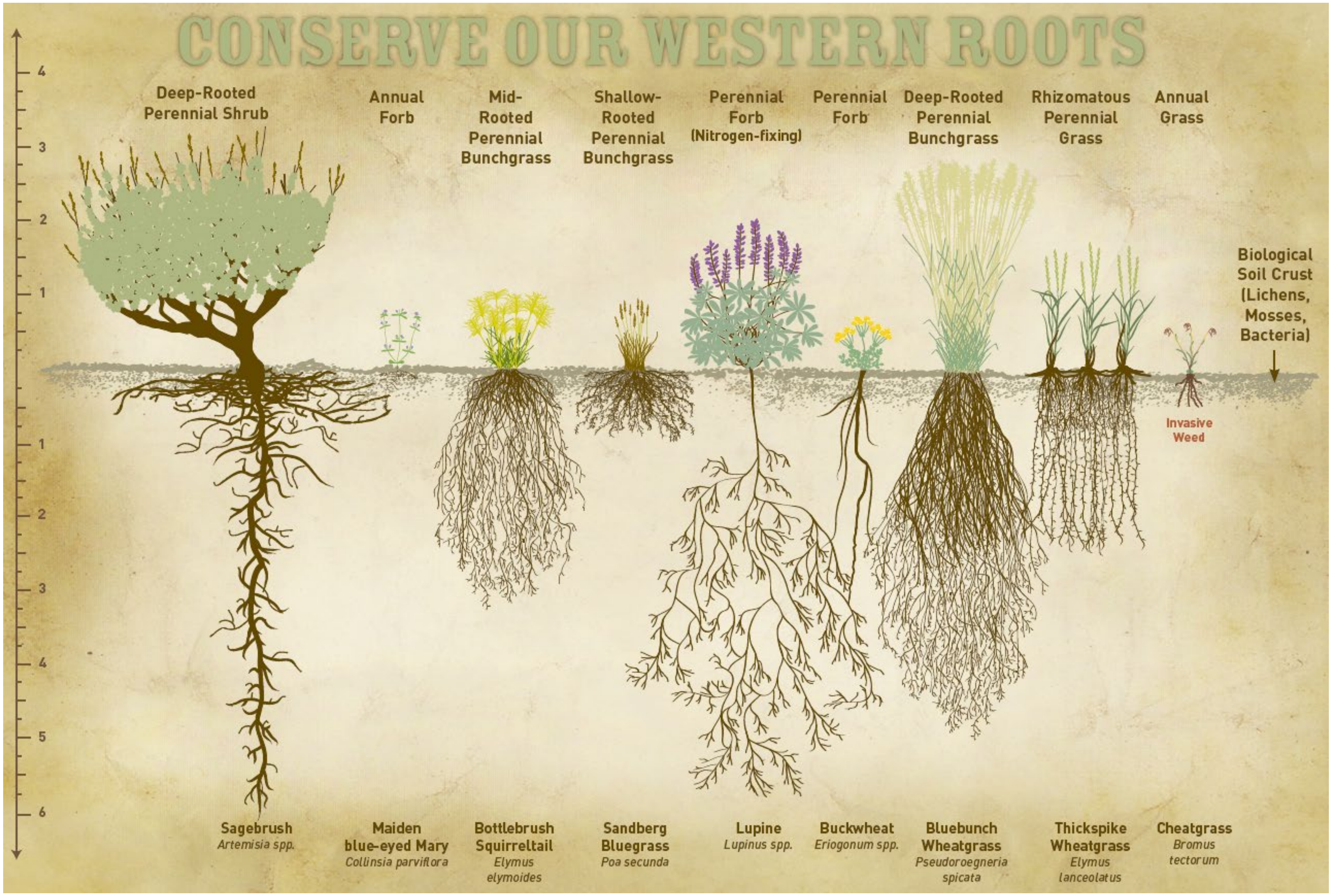


Figure 17. Root extent of deep-rooted, mid-rooted, and shallow-rooted native perennial plants relative to cheatgrass (Conserve Our Western Roots postcard available online by the Sagebrush Initiative at: https://www.sagegrouseinitiative.com/roots).

although depending on the crested wheatgrass-native seed mix used, establishment of native seeded species may not be evident until 30 years or more after seeding (R. Luke pers. comm. 2019). As moisture tends to be concentrated in slick spot microsites in the arid environment of southwest Idaho (Moseley 1994, p. 8), highly competitive seeded nonnative plants may compete with slickspot peppergrass for moisture or other resources. For example, a 35-year study near Malta, Idaho documented robust crested wheatgrass plant re-establishment within slick spot microsites during wet cycles subsequent to die back of this highly competitive nonnative perennial grass species within slick spots during extended drought conditions (Sharp *et al.* 1992, entire). In addition, forage kochia growing in slick spot microsites has been observed to displace slickspot peppergrass (Debolt *in litt*. 2002, entire; Gray and Muir 2013, p. 200; Colket 2009, p. 22; Gray 2011, pp. 67-68; Quinney *et al.* 2002, *in litt.* p. 3). Thus, seeding highly competitive nonnative plants within slickspot peppergrass EOs and subEOs may result in unintended effects.

Plants used in sagebrush steppe habitat restoration are typically selected based on their ability to compete with cheatgrass and to break the wildfire cheatgrass cycle, including within the range of slickspot peppergrass. While seedlings of native, perennial plant species are generally poor competitors with cheatgrass, mature native, perennial grasses and forbs, especially those with similar growth forms and phenology, can be highly effective competitors with cheatgrass (Booth et al. 2003, pp. 44, 46; Chambers et al. 2007, p. 142; Blank and Morgan 2012, pp. 3-4; Ott *et al.* In press, pp. 6, 10). The National Seed Strategy states that native plant communities are key to ecosystem integrity and resilience, and provide essential habitat and food sources of wildlife. Locally sourced plant materials in the Great Basin typically outperform plant materials from nonlocal populations, particularly for reproductive output. Great Basin plant species contain large amounts of intraspecific diversity in a wide range of phenotypic traits, and differences in these phenotypic traits are often associated with their heterogeneous environments of origin (Baughman *et al.* 2019, p. 10), which may be why locally sourced plant materials are observed to have greater success than plant materials from other areas.

The National Seed Strategy also states that nonnative species and cultivars that are transitional and noninvasive may be used to achieve site stabilization, wildfire breaks, or invasive plant control, provided that they are replaced by native species in subsequent ecological restoration or during natural successional processes (National Seed Strategy 2015, p. 110). Until restoration of the sagebrush steppe native plant community is mastered through science and adequate resources, select native cultivars and highly competitive nonnative plant species are necessary for sustaining soils and addressing the primary threats of wildfire and invasive nonnative annual grasses within the range of slickspot peppergrass.

Widespread use of highly competitive nonnative species in some circumstances represents a tradeoff between lowering risks associated with the wildfire-cheatgrass cycle and achieving diverse ecosystem and habitat management objectives for sagebrush habitats and the species that depend upon them, including slickspot peppergrass. While extensively used in degraded habitats due to its ability to compete with invasive nonnative annual grasses, crested wheatgrass can be highly competitive with native sagebrush and perennial grasses, and may in some cases prevent their establishment (Asay *et al.* 2001, pp. 48-50; Hull and Klomp 1966, p. 224, Knutson *et al.* 2014, p. 1421). Although not considered to be invasive in the Great Basin by land management agencies (Ogle 2002, p. 2), crested wheatgrass is described as an invasive species in the Great

Plains and Canada (Vaness and Wilson 2007, p. 1024; Zhou and Guo 2007, p. 2; Frid and Wilmshurst 2009, p. 325; CABI 2019, entire).

Efforts to increase plant diversity in Great Basin crested wheatgrass seedings can be challenging. Attempts to reintroduce native species into crested wheatgrass monocultures within the Great Basin suggest costly and time intensive repeated treatments to control both crested wheatgrass plants and seed in the soil seed bank (McAdoo *et al.* 2017, p. 60; Davies *et al.* 2013, p. 476; Fansler and Mangold 2011, pp. 18-21; Hulet *et al.* 2010, pp. 457-458). Efforts to convert crested wheatgrass monocultures into more diverse habitat are difficult because this species dominates the soil seed bank (Marlette and Anderson 1986, p. 173), limits the growth and establishment of native plants (Gunnell *et al.* 2010, pp. 445-446; Henderson and Naeth 2005, pp. 643-645; Heidinga and Wilson 2002, p. 254), and rapidly recovers from mechanical and chemical control treatments (Davies *et al.* 2013, pp. 474, 476; Fansler and Mangold 2011, pp. 18-21; Hulet *et al.* 2010, p. 453). Short-term studies and a longer-term 13-year study suggest that, even if seeded at low rates in a seed mix, crested wheatgrass may subsequently become the most abundant bunchgrass in a mixed bunchgrass community (Nafus *et al.* 2105, pp. 212-214; Bakker and Wilson 2004, pp. 1058, 1063). Although not as widespread as unseeded invasive nonnative plants within slickspot peppergrass EOs, seeded nonnative plants such as forage kochia have been observed to compete with slickspot peppergrass at some HIP transects (Colket 2009, pp. 16, 130; Kinter *et al.* 2012, pp. 7, 13; Kinter *et al.* 2013, p. 14; Kinter *et al.* 2014, p. 13). Slickspot peppergrass populations have the potential to benefit from surrounding landscape level herbicide and nonnative bunchgrass seeding treatments designed to reduce the primary threats of increased fire frequency and intensity and spread of invasive nonnative annual grasses within the larger landscape, provided that they are not outcompeted by seeded highly competitive nonnative species at the local level.

Highly competitive seeded nonnative species are well established within the range of slickspot peppergrass, particularly in the disjunct Jarbidge geographic area, where large expanses of Federal lands were seeded with crested wheatgrass and intermediate wheatgrass. Past forage kochia fuel breaks and seedings are also found within the range of slickspot peppergrass, including within or adjacent to some EOs. Highly competitive seeded nonnative perennial plants also compete with other native plants (Nafus *et al.* 2015, pp. 213-214; Davies *et al.* 2013, p. 472; Hulet *et al.* 2010, pp. 457-458), and may reduce the availability of native forbs for use by insect pollinators that are essential to successful seed production by slickspot peppergrass. Highly competitive nonnative plants, including crested wheatgrass and forage kochia, have also been documented to expand outside of seeded areas in southern Idaho (Hull and Klomp, 1967, p. 226; Hull and Klomp 1966, p. 11; Hull 1972, p. 134; Colket 2009, p. 22; Gray and Muir 2013, p. 200; USFWS 2014, pp. i-iii; Ott *et al.* 2017, pp. 5, 8); this spread typically occurs into disturbed areas. Expansion of crested wheatgrass outside of seeded areas within the range of slickspot peppergrass has not been described to date, and no studies are known.

Highly competitive nonnative plants may compete with slickspot peppergrass for moisture and nutrients, and may cause changes in slick spot hydrology. While highly competitive nonnative plant species established within slickspot peppergrass populations can compete with slickspot peppergrass, posing a challenge to population viability, strategically located highly competitive seeded nonnatives may benefit slickspot peppergrass by reducing the threat of wildfire at a large landscape scale. Specific objectives that balance the desirability of breaking the wildfire cheatgrass cycle at the landscape scale with competition-related effects on slickspot peppergrass population viability at a more local EO or subEO scale have yet to be developed for future highly competitive nonnative plant species seeding.

Sagebrush steppe plant communities, especially big sagebrush, perennial bunchgrasses, forbs, and biological soil crusts, represent a critical conservation component for higher viability slickspot peppergrass populations. Because slickspot peppergrass relies on a diverse pollinator assemblage to facilitate genetic dispersal and seed set, the species benefits from contiguous, intact sagebrush steppe habitats within populations that maintain pollinator assemblages and enables pollinators to forage among subpopulations of slickspot peppergrass. However, where native plants have been replaced by highly competitive nonnative seeded species, native sagebrush steppe communities have not returned on their own, and are often difficult to actively restore. Therefore, habitat fragmentation, barriers to insect pollination, and direct competition with and loss of native sagebrush steppe vegetation, including slickspot peppergrass, associated with establishment of highly competitive nonnative seeded species within and adjacent to slickspot peppergrass populations poses a threat to slickspot peppergrass in terms of decreased resiliency, representation, and redundancy through decreased reproductive success (lower seed set), reduced genetic variability, and increased local extirpation risk.

Restoration of habitat for the recovery of slickspot peppergrass will likely require long-term and intensive adaptive management. Landscape-scale techniques to restore highly degraded sagebrush steppe habitats are being developed, although it likely is not logistically or economically feasible to restore all slickspot peppergrass populations exclusively with native plants. However, efforts to restore crested wheatgrass-dominated rangelands to their full complement of native plant species or even native plant functional groups have a high probability of failure (Davies *et al.* 2013, p. 472). Replacement of highly competitive nonnative plants with native species through assisted succession within and adjacent to slickspot peppergrass populations poses management challenges, and future land management decisions will determine the degree to which highly competitive seeded nonnative plants may impact or benefit slickspot peppergrass resiliency, representation, and redundancy.

3.4 Additional Threat: Development

In the Service's 2009 listing rule, residential, commercial, and agricultural development was identified as a secondary threat to slickspot peppergrass in the Foothills and Snake River Plain geographic areas (74 FR 52036-52037). More recently, residential and commercial development, inclusive of infrastructure, was identified as one of the most extreme and widespread disturbances documented to impact the species within the Foothills and Snake River Plain geographic areas (Miller and Kinter 2018, p. 38). Development can affect slickspot peppergrass through direct destruction of populations and loss of slick spot microsites. Development can also have indirect impacts by contributing to nonnative plant invasions, particularly along associated utility lines and roads, which act as corridors for nonnative plant invasions (Forman and Alexander 1998, p. 210; Gelbard and Belnap 2003, pp. 424-425, 430-431; Bradley and Mustard 2006, p. 1142); increased human-caused ignition of wildfires, presumably by increasing the area of the urban-wildland interface (e.g., Keeley *et al.* 1999, p. 1829; Romero-Calcerrada *et al.* 2008, pp. 341, 351; Syphard *et al*. 2008, pp. 610-611); increased off road vehicle use; and increased habitat fragmentation, which can pose problems for slickspot peppergrass by creating barriers in the landscape to pollinators that prevent effective genetic exchange within or among populations (Robertson *et al.* 2004, pp. 2-4).

Development can affect slickspot peppergrass and slick spot habitat, whether directly or indirectly, through habitat conversion (resulting in direct loss of individuals and permanent loss of habitat), or through habitat degradation and fragmentation as a result of increased nonnative plant invasions, increased off highway vehicle use, increased wildfire, and changes to insect pollinator populations (ILPG 1999, *in litt.* pp. 1–3; InterFire undated article; Robertson and White 2007, pp. 7, 13). The most direct impact of development is the outright loss of slickspot peppergrass populations due to habitat conversion, such as when habitat occupied by slickspot peppergrass is converted to a residential development or an agricultural field, resulting in the permanent loss of the plant population and its habitat. Because the Endangered Species Act provides limited protection to listed plant species on non-Federal lands with no Federal nexus, slickspot peppergrass conservation on private lands is challenging.

Slickspot peppergrass populations and habitat on private lands are particularly vulnerable to urban development (IDFG *in litt.* 2018, p. 3). Narducci *et al.* (2017, p. 6) project that 20,000 to 44,000 acres of sagebrush steppe will be lost to urbanization across Ada and Canyon County over about the next 80 years. Given that the population of Idaho continues to grow (U.S. Census Bureau 2017, p. 3), the long-term trend of habitat fragmentation and loss seems certain to continue. With the current increase in population in southern Idaho, additional rangelands are being lost to development, and slickspot peppergrass populations located on private lands or on public lands near these developments are at risk for damage or loss. Development also increases recreational use on adjacent public lands, including within slickspot peppergrass populations. With the growth of human populations in southern Idaho, the risk of fragmentation of adjacent public lands has increased due to inadvertent wildfire ignitions, introduction and spread of invasive nonnative plants, and ground disturbance associated with increased recreational use.

Development increases the risk of wildfire to slickspot peppergrass due to construction-related wildfire ignition resulting from construction equipment and increased public use of roadways and trails. Increases in human habitation and activity in the rangelands of southern Idaho have contributed to the increase in wildfire starts in recent years. The potential for fire ignition from vehicle sparks or other sources is further increased in areas with a large amount of fine fuels associated with invasive nonnative annual grasses.

Increased development places additional off-site demands on adjacent or nearby public lands, especially from a recreational perspective. Demand for easily accessible recreation areas, including OHV use areas, continues to increase as the human population increases. Off highway vehicle, equestrian, bicycle, and foot traffic can impact slickspot peppergrass via direct mortality (e.g., crushing, trampling) and indirect population decline from habitat loss (such as from mechanical damage to slick spot microsites or biological soil crust). Recreational activity associated with development may also have an indirect effect on slickspot peppergrass through spread of invasive nonnative annual grasses (e.g., cheatgrass seed dispersal, soil disturbance) or wildfire ignition through disposal of cigarettes, firearm discharge, fireworks, contact between hot vehicle undercarriage and dry fuels, or other careless or intentional ignition sources. Development may also have indirect effects on slickspot peppergrass by negatively impacting insect populations that the species depends on for pollination and genetic exchange. Slickspot peppergrass is primarily an outcrossing species and depends upon a diversity of insect pollinators for successful fruit production (Robertson and Klemash 2003, p. 336-342, Robertson and Leavitt 2011, p. 383-388) and to maintain genetic variability by genetic exchange within and among populations. Changes in native habitat caused by residential, commercial, or agricultural development, or conversion of the native plant community to nonnative species, may impact insect pollinator populations by removing specific food sources or habitats required for breeding or nesting (Kearns and Inouye 1997, p. 298; McIntyre and Hostetler 2001, p. 215; Zanette *et al.* 2005, pp. 117-118). As all indications are that most seeds are dispersed over a short distance and insect pollinators are limited in their dispersal capabilities, development-related habitat fragmentation and isolation of populations reduces slickspot peppergrass resiliency, representation, and redundancy through decreased reproductive success (lower seed set), reduced genetic variability, and greater local extinction risk.

3.5 Additional Threat: Owyhee Harvester Ants

While effects of herbivory on slickspot peppergrass by mammals and most insects has not been identified as a significant stressor (IDFG *in litt*. 2018, p. 6), in recent years, concern has emerged over potential detrimental effects of seed predation by Owyhee harvester ants. Owyhee harvester ants are a native species that thrive in open grassy areas throughout southwest Idaho, including areas occupied by slickspot peppergrass where shrubs have been lost. These ants consume the seeds of small-seeded species (including slickspot peppergrass) preferentially over large-seeded species such as cheatgrass (Schmasow and Robertson 2016, p. 955). Studies have shown that Owyhee harvester ants can remove up to 90 percent of slickspot peppergrass fruits and seeds from individual plants, either directly from the plant or by scavenging seeds that drop to the ground (White and Robertson 2009b, p. 511; Robertson and Crossman 2012, pp. 14-15; Jeffries 2016, entire). The extent to which seed predation by harvester ants impacts slickspot peppergrass seed recruitment within slick spots and populations is currently under investigation. Slick spots with low numbers of flowering slickspot peppergrass plants are likely to suffer high levels of seed loss in a given year (based on the results of White and Robertson 2009b, Robertson and Crossman 2012, and Jeffries 2016), whereas slick spots with large numbers of plants may overwhelm the ants' capacity to consume seeds (Robertson 2018, personal communication).

Harvester ant colonies are present within many, if not most, slickspot peppergrass populations. In a five-year survey of 16 slickspot peppergrass populations in the Snake River Plain and adjacent foothills, Robertson (2015, p. 6) found harvester ant colonies at each site. Colonies ranged in density from 0.37-199 colonies per acre. Colony density was inversely related to the amount of sagebrush and positively related to the amount of grasses (excluding cheatgrass) at each site. Throughout the Great Basin, increased frequency and intensity of wildfire has caused sagebrush stands to be replaced by grasslands, which may allow harvester ants to colonize areas that historically were unsuitable for nesting by increasing the carrying capacities of those burned sites (Robertson 2015, p. 13). Thus, increased density of Owyhee harvester ant colonies may be linked to the increased frequency and intensity of wildfire within the range of slickspot peppergrass over the past several decades.

Owyhee harvester ant colony expansion into areas adjacent to and within occupied slick spots, and the associated increase in seed predation, has the potential to significantly affect slickspot peppergrass recruitment and the replenishment of the seed bank, which could in turn affect the long-term viability of slickspot peppergrass. Owyhee harvester ant research within slickspot peppergrass habitat is ongoing and the current understanding of how pervasive harvester ant colonies have become within the range of slickspot peppergrass, and their overall significance on the long-term viability of the species, continues to expand. Seed predation by Owyhee harvester ants poses a threat to slickspot peppergrass in terms of decreased resiliency through reduced replenishment of the persistent seed bank, which may contribute to the risk of local extinction for some smaller populations.

The relationship between Owyhee harvester ant colony presence and long-term slickspot peppergrass numbers in good to poor viability populations rangewide is not clearly understood. Slickspot peppergrass populations have the potential to be impacted by increased Owyhee harvester ant presence, especially in areas of low shrub cover or if shrubs are removed by factors such as wildfire or development. The shift from sagebrush cover to grassland following wildfire may allow Owyhee harvester ants to colonize historically unsuitable areas by increasing the carrying capacity of these sites (Robertson 2015, p. 13). Increased harvester ant presence could significantly impact the ability of slickspot peppergrass to replenish its seed bank as Owyhee harvester ants have been shown to remove the majority of slickspot peppergrass seeds at experimental sites. The reduction in native forb cover, which likely served as an alternative source of available seeds for Owyhee harvester ant foraging, may further increase seed predation pressures on slickspot peppergrass (C. Baun pers. comm. 2019).

Implementation of actions to address Owyhee harvester ant slickspot peppergrass seed predation within and adjacent to select slickspot peppergrass populations may maintain or improve resiliency over the short-term. Addressing Owyhee harvester ant presence may serve to increase individual slickspot peppergrass population resiliency to stochastic events as buffering effects of robust seed banks could be realized. Because density of Owyhee harvester ant colonies is inversely related to sagebrush cover, and positively related to the amount of non-cheatgrass grasses at a site (Robertson 2015, p. 9, Fig. 3), harvester ant presence in priority EOs and subEOs could be addressed through protection of existing sagebrush cover as well as restoration of shrubs in populations dominated by grasslands. Prioritization of slickspot peppergrass populations for Owyhee harvester ant reduction measures has not occurred. Research and monitoring are expected to further increase knowledge of this emerging threat and identify management options.

3.6 Additional Threat: Improper Livestock Grazing

Livestock use is widespread across the range of slickspot peppergrass. Livestock use in areas that contain slickspot peppergrass can result in both positive and negative effects on the species, depending on factors such as intensity, timing, and duration of use. Livestock grazing may be used as a tool to ameliorate the primary threats of wildfire and invasive annual grasses on slickspot peppergrass. Domestic cattle are not known to feed on slickspot peppergrass, and domestic sheep have been observed uprooting but not consuming plants (D. Quinney and J. Weaver pers. comm. 1998). Although direct herbivory of slickspot peppergrass by livestock has not been documented to occur, livestock grazing can impact slickspot peppergrass through trampling and interactions with the nonnative invasive plant cycle.

Improper season of use, duration, stocking rates, or location of livestock grazing can be detrimental to slickspot peppergrass. Statistically significant reductions in slickspot peppergrass plant numbers were associated with a density of 10 or more cattle hoof prints per $meter^2$ (1.2 $yard^2$) within slick spot microsites regardless of hoof print depth using an 11-year data set (Bond 2017, p. 21). Livestock grazing can result in plants being crushed, severed, or bruised by hoofs (Vallentine 2001, p.155). Laylock and Hamiss (1972, as described in Vallentine 2001, p. 155) found that because forbs were succulent and easily broken, forbs suffered disproportional livestock trampling losses when compared to grasses. Previous studies failed to show a correlation between cattle hoof prints and plant numbers. As these studies examined a treatment-generated hoof print density of 10 percent hoof print cover per slick spot over a 2-year time period (Young 2007, entire; Nichol-Driskill 2011, entire), a potential threshold hoof print density that could impact the plant and its habitat was not established through these studies.

Improper livestock grazing can impact the resiliency of slickspot peppergrass populations because concentrations of livestock in areas (such as water troughs, supplement sites, or along fences) that coincide with actively growing and flowering slickspot peppergrass plants may result in direct loss of individual plants and their contribution to the seed bank due to trampling injury or mortality from crushing plants. Ground disturbance associated with improperly timed livestock presence when slick spot soils are wet also has the potential to affect the seed bank for slickspot peppergrass as trampling may push seeds below the depth which seedlings can successfully reach the soil surface (i.e., below 1.5 in.) (Meyer and Allen 2005, pp. 9–10; Meyer *et al.* 2006, pp. 891, 901–902). Improperly timed livestock presence may also result in trampling of water-saturated slick spot soils, potentially altering the structure and the functionality of slick spots (Rengasamy *et al.* 1984, p. 63; Seronko 2004, *in litt*., p. 2) or trampling of seedlings. Meyer and Allen (2005, p. 3) observed heterogeneous silt thickness within individual slick spots, with pockets of deep silt within slick spots otherwise suitable for slickspot peppergrass presence that likely reflected silting in following a past livestock trampling episode. As silt thickness heterogeneity was not visible upon casual inspection of the slick spot surface, soil sampling is the only way to detect these silt pockets. In these slick spots, a considerable proportion of the slick spot surface is likely unsuitable for the plant due to these deep silt pockets.

The Service is aware of three incidents where localized livestock trampling events have been suggested as the likely cause of reduced slickspot peppergrass numbers at sites where the plants were formerly abundant, while reduced plant numbers were not observed at similar nearby sites within the same year (Robertson 2003b, p. 8; Meyer *et al*. 2005, p. 22; Colket 2006, pp. 10-11). It is unknown how reducing the number of seeds that replenish the seed bank associated with these localized reductions in plant numbers may affect the longer term status of slickspot peppergrass at these sites.

Improper livestock grazing increases the risk of reducing native forb and grass cover through trampling and herbivory, which could impact slickspot peppergrass and its habitat. Native perennial and annual forbs essential for slickspot peppergrass insect pollinators may be consumed during the growth and flowering period, especially with spring livestock grazing, reducing native forb cover and preclude the recovery of historic forb cover levels (Kimball and Shiffman 2003, pp. 1683, 1687-1688). When managed at higher stocking rates or more frequent grazing periods, grazing prior to seed set has the potential for loss of desirable perennial native bunchgrasses (NRCS 2009, p. 9). Annual spring grazing during the critical growth period for native grasses and forbs can affect plant vigor and overall health. While low to moderate grazing has little effect on native bunchgrass species growth for most of the year, native bunchgrasses may be reduced or lost with severe annual grazing pressure during their spring (March 20 – June 25) critical growth period (NRCS 2009, pp. 1, 5-6). Over time, annual spring grazing without rest or deferment scheduled into the grazing management rotations, range condition can decline, including within areas that contain slickspot peppergrass populations. Conservation measures to reduce potential effects of improper livestock grazing on slickspot peppergrass have been implemented on BLM, Mountain Home Air Force Base, and State lands.

Livestock forage utilization levels may not correlate with livestock hoof print cover generated when slick spot soils are saturated. Less than 10 percent forage utilization was observed in areas in the vicinity of slick spots with deep hoof prints (greater than 1 inch depth) over 50 to 80 percent of their surface areas on the Orchard Combat Training Center in early May (Rosentreter *in litt.* 2003, p. 2). Similarly, livestock hoof prints were observed within 79 percent of slick spot microsites on monitoring transects on the Juniper Butte Range despite livestock utilization levels below 50 percent in two of three pastures (USFWS 2018, p. 17, 25-26; Blake 2015, p. 20). Minimizing livestock congregation or movement within EOs when soils are saturated may be more important for reducing potential impacts to slickspot peppergrass and its habitat than use of livestock forage utilization levels.

Improper livestock grazing has also been associated with the introduction and spread of nonnative plants. Areas with a history of livestock grazing often support a wide variety of nonnative species, especially in areas where nonnatives have been introduced to increase the forage value of rangelands or pastures (Zouhar *et al*. 2008, pp. 23–24). Both seeded and unseeded nonnative species compete with native plant species, including slickspot peppergrass, and may make future re-establishment and persistence of native shrubs, grasses, and forbs within and adjacent to slickspot peppergrass populations challenging.

Improper livestock grazing activities can contribute to the spread of invasive nonnative plants by the following:

- Reducing native plant biomass and competition within the plant community;
- Disrupting the soil surface (particularly during saturated soil conditions) and creating disturbed areas open for nonnative and native plants to establish;
- Reducing biological soil crust cover through trampling, which decreases ecological resistance to invasion by cheatgrass, and;
- Physically transporting invasive nonnative plant seeds externally or in feces.

Recent studies describe a relationship between improper livestock management and increased cheatgrass cover in native sagebrush steppe habitats. In relatively intact sagebrush steppe habitat that support remnant native bunchgrass communities, improper livestock grazing intensity indirectly promoted an increase in the magnitude of cheatgrass dominance by reducing ecological resistance (Reisner *et al.* 2013, pp. 6, 10). In addition, burned native sagebrush steppe sites that experienced increased livestock grazing pressure showed increased cheatgrass cover, indicating an interaction between fire and grazing that decreases site resistance to cheatgrass invasion (Condon and Pyke 2018, Figure 4a, p. 10). Historic annual spring grazing perpetuated cheatgrass domination through the loss of native perennial bunchgrass in sagebrush steppe habitats of southern Idaho and across the Great Basin (Hironaka *et al.* 1983, pp. 25, 27-28; West 1988, p. 216).

Proper season of use, duration, stocking rates, or location of livestock grazing has the potential to benefit slickspot peppergrass. Benefits of livestock grazing on landscapes within the range of slickspot peppergrass include herbivory of invasive nonnative plants and lowered risk of wildfire through the reduction of fine fuels (Pellant 1996, p. 6; Frost and Launchbaugh 2003, p. 43). Properly timed and located targeted grazing and prescriptive grazing, as well as outcome-based livestock grazing management within cheatgrass-dominated sites may be the first step in breaking the cheatgrass–wildfire cycle. Livestock grazing reduces the availability of fine fuels, which reduces the risk of wildfire ignition (Romero-Calcerrada *et al*. 2008, p. 351) and spread. Long-term moderate levels of livestock grazing appear to have limited effects on native sagebrush communities and may contribute to the persistence of sagebrush communities because ungrazed bunchgrasses may be more susceptible to fire-induced mortality than bunchgrasses that are moderately grazed (Davies *et al.* 2017, pp. 278, 279).

Properly managed livestock may be beneficial in cheatgrass-dominated areas that lack perennial native bunchgrasses and forbs where large fires could spread to burn slickspot peppergrass populations. Seasonality of grazing can influence the degree to which grazing may be detrimental or beneficial to slickspot peppergrass. Spring and fall grazing can effectively reduce fuel loading of cheatgrass (Mosley and Roselle 2006, entire; Foster *et al.* 2015, entire; Diamond *et al.* 2009, entire). For example, removal of 90 percent removal of biomass through intensive spring grazing resulted in substantial reduction in cheatgrass cover and subsequent reduced vulnerability to wildfire (Diamond et al. 2009, pp. 948-950). Application of livestock grazing across entire landscapes at rates necessary to reduce fuel loads and affect fire behavior could have negative effects on livestock production and land management habitat goals; thus, use of livestock to accomplish fine fuel objectives hold promise but would require detailed planning that includes clearly defined goals for fuel modification and appropriate monitoring to assess effectiveness (Launchbaugh *et al.* 2008, p. 32).

Livestock grazing can also facilitate re-establishment of shrubs within highly competitive nonnative grass seedings. For example, livestock grazing practices can enhance sagebrush reestablishment, particularly with prolonged spring grazing during drought (Busso and Richards 1995, as cited in Gunnell *et al.* 2011, p. 13). Over-utilization of crested wheatgrass through high intensity, long duration grazing reduces grass productivity and reduces seedling survival, which could benefit other established plant species, including sagebrush (Angell 1995, pp. 163-164); Salihi and Norton 1987, p. 148). Short duration high intensity livestock grazing could be used in some areas to create niches for sagebrush recruitment to increase diversity in areas dominated by highly competitive nonnative perennial bunchgrasses.

Effectiveness of livestock grazing to reduce wildfire risk in the vicinity of slickspot peppergrass populations is associated with the level of shrub cover within and adjacent to EOs. Fire behavior in sagebrush vegetation is driven by sagebrush cover and height, with herbaceous understory playing a lesser role. Use of livestock as a fine fuels management technique would be most effective on uniform grasslands and becomes less effective as the amount and size of the shrub component in the plant community increases (Launchbaugh et al. 2008, pp. 30-31). For slickspot peppergrass conservation, use of livestock grazing as an effective wildfire control technique would be most effective in annual grassland areas with limited or absent sagebrush cover.

While spring grazing has also been identified as a potential tool for seed bed preparation or other treatments, fall grazing is expected to have lower risk of grazing-related impacts to slickspot peppergrass and its habitat than spring grazing as the risk of saturated soils is greater in spring, and actively growing and flowering native plants, including slickspot peppergrass, could be exposed to potential livestock trampling in spring. Managed winter grazing, particularly within EOs and subEOs, may also represent an available tool for fine fuels management following years of above average herbaceous production in big sagebrush sites with an understory of intact native grasses and forbs (Davies *et al.* 2016, p. 183). Fall grazing may be appropriate for sagebrush steppe sites with a cheatgrass-dominated understory (Foster *et al.* 2015, entire). Fall or winter grazing is assumed to be less likely to damage areas with native bunchgrass and perennial forbs than grazing during the growing season when defoliation can place grazed plants at a competitive disadvantage with non-defoliated plants (Davies *et al.* 2016, p. 180; Foster *et al.* 2015, p. 3; NRCS 2009, pp. 5-6), and represents an option for implementing vegetation and fine fuel treatments using livestock both within and outside of slickspot peppergrass populations.

Livestock grazing has been identified as a potential tool to address the primary threats of wildfire and invasive nonnative plants on slickspot peppergrass at landscape scales, but may have localized detrimental impacts if not managed appropriately. The effectiveness of cattle grazing for widespread control of cheatgrass is uncertain. Control of cheatgrass through livestock grazing may be challenging due to the high grazing tolerance of this species (Pyke *et al.* 2016, pp. 318-319). Timing of cheatgrass germination and development is variable, and the species has a high ability to spread (Hempy-Mayer and Pyke 2008, p. 121; Mayer 2004, p. 32). Cheatgrass seed banks in the soil may not be directly impacted by grazing intensities, and livestock grazing on cheatgrass can also increase the amount of cheatgrass seed set in the following year (Clements *et al*. 2008, p. 1). Optimal livestock intensity, timing, and location for reducing cheatgrass cover while avoiding or minimizing potential trampling impacts to slickspot peppergrass populations when slick spot soils are saturated or when plants are actively growing and flowering has yet to be determined.

3.7 Additional Threat: Climate Change

Warmer temperature regimes and changes in precipitation associated with global climate change represent another risk factor for slickspot peppergrass. Consequences of climate change, if current projections occur, are likely to exacerbate existing primary threats (modified wildfire regime and invasive nonnative plants, particularly cheatgrass) to slickspot peppergrass conservation. Researchers confirmed “experimentally that, in an intact ecosystem, elevated carbon dioxide may enhance the invasive success of *Bromus* spp. in arid ecosystems,’’ and suggest that this enhanced success will then expose these arid areas to accelerated wildfire cycles (Smith *et al.* 2000, p. 81). Chambers and Pellant (2008, p. 32) also suggest that higher carbon dioxide levels are likely increasing cheatgrass fuel loads due to increased productivity, with a resulting increase in wildfire frequency and extent. Furthermore, current climate change models predict future climatic conditions within the range of slickspot peppergrass will favor further invasion by cheatgrass (Smith *et al.* 1987, pp. 142-143; Smith *et al.* 2000, p. 81; Brown *et al.* 2004, p. 384; Neilson *et al.* 2005, pp. 150, 156; Chambers and Pellant 2008, pp. 31-32). These and other models (Littell *et al.* 2009, p. 1019; Abatzoglou and Kolden 2013, p. K; Westerling *et al.* 2014, p. 91; McKenzie and Littell 2017, p. 29) also project that wildfire frequency will continue to increase, and the extent and severity of wildfires may increase as well. Thus, the projected consequences of climate change are acting to exacerbate the primary threats of frequent wildfire and invasive nonnative plant species on slickspot peppergrass throughout its range.

The Intergovernmental Panel on Climate Change (IPCC) projects changes to the global climate system in the 21st century will likely be greater than those observed in the 20th century (IPCC 2007, p. 45; IPCC 2014a, pp. 10, 60). Increases in global mean surface temperatures are evident now and are expected to increase over time. The Pacific Northwest region has warmed substantially (nearly 2° F) since 1900, and current climate change projections are that precipitation will increase in the winter but decrease in the summer months (May *et al*. 2018, pp. 1041-1043). According to climate change models, the temperature within the Snake River Plain has been increasing and is expected to continue to increase at least through the middle of the 21st century, with the largest portion of the precipitation within the Snake River Plain to shift to December and January (Klos *et al.* 2014, p. 11; Klos *et al.* 2012, p. 1). Precipitation patterns within the Snake River Plain have been shifting to increased winter rain and less snow, increased intensity for spring rain events, and decreased summer precipitation than was received historically (Nayak *et al.* 2010, pp. 9-10, 15; Klos *et al.* 2012, pp. 2-4, Klos *et al*. 2015, pp. 244-245, 248-249). Evidence of changes in plant phenology also appear to be related to climate change, with lilacs bloom dates in Idaho documented to be 8.1 days earlier per decade from 1975 through 1993 (Klos *et al*. 2015, p. 249); these observed changes may also be occurring for other plant species, and have the potential to affect phenology of slickspot peppergrass as well as resource availability for its insect pollinators.

Climate change is predicted to serve as a catalyst to the wildfire-cheatgrass cycle in the deserts of the western United States (Abatzoglou and Kolden 2011, p. 476). If this prediction is realized, it is expected that slickspot peppergrass survival and reproduction would be reduced through accelerated habitat fragmentation or loss for the species and its insect pollinators. Cheatgrass capitalizes on conditions associated with a changing climate in the Great Basin, including increased fall/winter precipitation, earlier snowpack melt, and decreased water availability in summer. Warmer, drier summer conditions are linked to larger and more frequent wildfires throughout the Great Basin, including within the range of slickspot peppergrass. Increased temperatures and carbon levels are likely contributing to current cheatgrass domination within low ecological resistance and resilience areas present throughout the Snake River Plain and are expected to result in future increases in cheatgrass and associated wildfire frequencies across the range of slickspot peppergrass.

Changes in precipitation and temperature regimes can reduce resiliency of individual populations as well as to reduce representation and rangewide redundancy of slickspot peppergrass populations directly through reduced survival of plants. Using data collected from numerous field studies, Meyer *et al.* (2006, p. 896) found that slickspot peppergrass biennial persistence is reliant on high summer and low early winter rainfall. Meyer *et al.* (2006, p. 896) determined that while a constant percentage of the seed bank germinates each year, the proportion that survives to emergence is reliant on levels of precipitation in February and March. The survivorship of slickspot peppergrass rosettes to flower the following spring is favored by greater summer precipitation (Meyer *et al.* 2005, p. 15; CH2MHill 2007, p. 14; Sullivan and Nations 2009, pp. 33, 41), and increased winter precipitation appears to decrease survivorship (Meyer *et al.* 2005, pp. 15-16; Sullivan and Nations 2009, pp. 39, 43-44). Precipitation trends shifting as a result of climate change could negatively affect slickspot peppergrass by decreasing the number of first year biennials that survive over the winter and into the following spring to successfully flower and fruit. Numbers and vigor of annual slickspot peppergrass flowering plants could also be negatively affected if growing season precipitation (February through May) decreases, as predicted. Reduced numbers of plants that survive to successfully flower would result in fewer viable seeds for replenishment of the seed bank, affecting resiliency of populations.

Effects of future climate change are expected to have serious implications for slickspot peppergrass resiliency, representation, and redundancy as historic precipitation and temperature patterns will continue to be modified within the range of slickspot peppergrass. There is a high degree of confidence that a large fraction of species face increased extinction risk due to climate change during and beyond the 21st century, especially as climate change interacts with other stressors (IPCC 2014b, pp. 14-15, 60, 67). Most plant species (such as slickspot peppergrass) cannot naturally shift their geographical ranges sufficiently fast to keep up with predicted high projected rates of climate change in most landscapes.

Shifts in precipitation trends as a result of climate change could negatively affect slickspot peppergrass resiliency, representation, and redundancy by decreasing the number of germinating seeds that survive to the rosette stage as well as by decreasing the number of first year biennials that survive over the winter and into the following spring to successfully flower and fruit. Numbers and vigor of annual slickspot peppergrass flowering plants could also be negatively affected as growing season precipitation (February through May) shifts.

Warmer temperature regimes associated with global climate change represent another substantial risk factor for slickspot peppergrass. Climate change models predict future climatic conditions within the range of slickspot peppergrass will favor further invasion by cheatgrass (Smith *et al.* 1987, pp. 142-143; Smith *et al.* 2000, p. 81; Brown *et al.* 2004, p. 384; Neilson *et al.* 2005, pp. 150, 156; Chambers and Pellant 2008, pp. 31-32). These and other models (Littell *et al.* 2009, p. 1019; Abatzoglou and Kolden 2013, p. K; Westerling *et al.* 2014, p. 91; McKenzie and Littell 2017, p. 29) also project that wildfire frequency will continue to increase, and the extent and severity of wildfires may increase as well. Thus, the projected consequences of climate change could act to further exacerbate the primary threats of frequent wildfire and invasive nonnative annual grasses on slickspot peppergrass throughout its range. With increased wildfires and spread of invasive nonnative annual grasses, the risk of slick spot microsites being burned over and invaded by cheatgrass could be increased, reducing their suitability for slickspot peppergrass. Climate change accelerating increased wildfire frequency and intensity and associated invasive nonnative annual grass spread, the number and distribution of populations with good to fair viability may be reduced, resulting in reduced future representation and redundancy of populations from current levels. In addition, populations with fair to poor viability may be lost or reduced to levels that they would effectively be extirpated. Effects of accelerated wildfire and invasive nonnative annual grass spread associated with climate change are anticipated to be most pronounced for populations located in the New Plymouth area, where populations are found on smaller acreages, are currently surrounded by degraded landscape conditions, and are located at the lowest elevation extent of the species' range.

Climate change is also expected to modify current habitat parameters important to slickspot peppergrass resiliency, representation, and redundancy. Habitat conservation and restoration efforts, which are already challenging due to the low ecological resistance and resilience of habitat within the range of slickspot peppergrass, are also likely to be further complicated by the drier, hotter summer conditions predicted as a result of climatic change. For example, modeling of projected climate change effects in the Great Basin predict a major decline in the area suitable for Wyoming big sagebrush, which is currently the most prevalent big sagebrush species in the Great Basin (Chambers *et al.* 2017, pg. 81). Under both moderate and high greenhouse gas emissions scenarios, Wyoming big sagebrush is predicted to contract in southern Idaho (Figure 18), including within the range of slickspot peppergrass. Reduced ability of southern Idaho rangelands to support Wyoming big sagebrush over time are expected to make post-fire restoration efforts more difficult while increasing the potential for cheatgrass monocultures to further dominate within the range of slickspot peppergrass.

Due to the uncertainty associated with climate change projections, climate change in and of itself was not considered to represent a significant rangewide threat to slickspot peppergrass in the 2009 listing decision. However, current information indicates that climate change has already played an important supporting role in intensifying the most significant threats to the species.

It is possible that climate change has contributed to the downward trend in slickspot peppergrass population numbers observed over the past decade. The severity and scope of the primary threats of changing wildfire regime and invasive nonnative plants to slickspot peppergrass are expected to be magnified as climate change continues, reducing resiliency, representation, and redundancy of slickspot peppergrass populations rangewide.

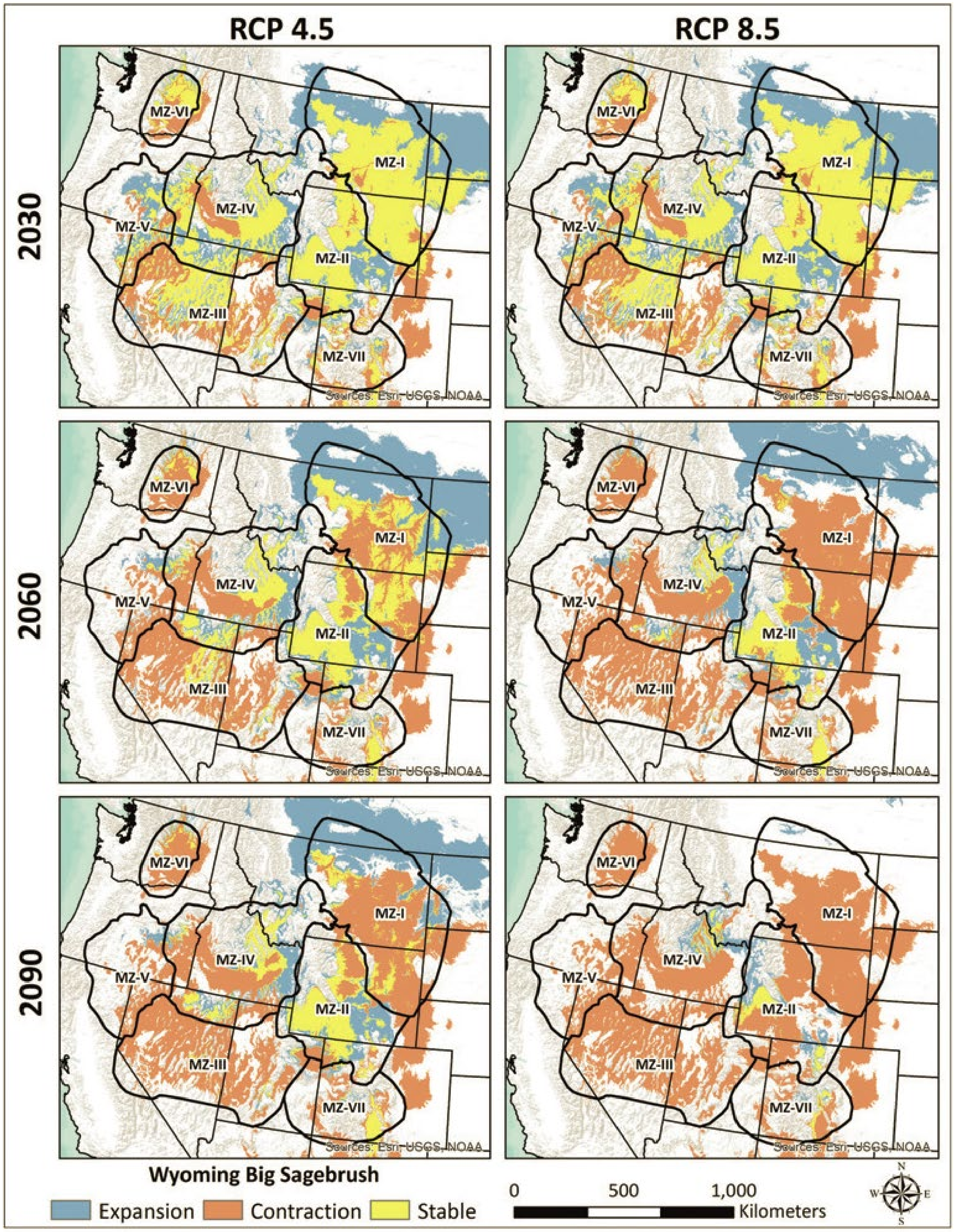


Figure 18. A climate niche model for Wyoming big sagebrush projected for three decades and two greenhouse gas emission scenarios (from Chambers et al. 2017, p. 82). The columns show scenarios with moderate emissions (RCP 4.5) and unabated emission (RCP 8.5). Rows reflect the decade surrounding 2030, 2060, and 2090. The range of slickspot peppergrass is located within Management Zone (MZ)-IV.

4. Analysis of Current Condition

The analysis of current condition includes information about the species' current status and habitat condition relative to threats as well as conservation efforts to avoid or reduce those threats. We also consider the relationship of the current condition of slickspot peppergrass relative to concepts of resiliency, representation and redundancy.

4.1 Conservation Plans

Currently, there are six formalized plans that incorporate specific conservation measures for slickspot peppergrass:

- The Candidate Conservation Agreement for Slickspot Peppergrass between the State of Idaho, BLM, Idaho Army National Guard and nongovernmental cooperators (private landowners who also hold livestock grazing permits on BLM lands) (State of Idaho *et al*. 2003, as updated in 2006);

- The BLM and U.S. Fish and Wildlife Service Conservation Agreement for existing BLM land use plans (USBLM and USFWS 2006, as updated in 2009, 2013, and 2014). Once conservation measures of identical or greater conservation value are incorporated into all applicable BLM land management plans, the term of this Conservation Agreement will be concluded. One applicable BLM land management plan where conservation measures have yet to be incorporated (the Four Rivers Resource Management Plan) remains. Conservation measures with identical or greater conservation value than this Conservation Agreement have been incorporated into two recent BLM land use plans:

    - The 2008 Morley Nelson Snake River Birds of Prey National Conservation Area Resource Management Plan (as contained within Appendix 8 of the 2008 Record of Decision), and

    - The 2015 Jarbidge Approved Resource Management Plan.

- The Idaho Army National Guard's Integrated Natural Resource Management Plan for the Orchard Combat Training Center (National Guard 1991, as updated in 1997, 2004, 2008, and 2013); and

- The Mountain Home Air Force Base's Integrated Natural Resource Management Plan, which includes the Juniper Butte Range (Air Force 2004, as updated in 2012 and 2018).

Detailed descriptions of the six plans and other conservation actions (such as implementation of fuel break projects, establishment of Rangeland Fire Protection Associations, and sagebrush habitat conservation efforts associated with the greater sage-grouse) can be found in Appendix B of this document.

4.2 Increased Frequency and Intensity of Wildfire

Unnaturally high levels of wildfire recurrence is evident within landscapes across the range of slickspot peppergrass, particularly in the Snake River Plain geographic area (Figure 19). Recent assessments document that wildfire has impacted good to poor viability populations of slickspot peppergrass across the range of the species. Of the 105 EOs and subEOs with available disturbance data, about 30 percent of populations (32 EOs) exhibited evidence of wildfire disturbance (Kinter and Miller 2016, raw data). Twenty-nine of these 32 EOs and subEOs (91 percent) experienced severe to extreme levels of wildfire disturbance. The extent of disturbance in affected EOs ranged from 71 to 100 percent of their respective areas, which indicates that these wildfires consumed the majority of native shrubs. Of these 29 EOs and sub EOs, 2 were B-ranked, 9 were C-ranked, 3 were CD-ranked, and 15 were D-ranked. Addressing wildfire in higher ranked EOs and subEOs (e.g., higher viability populations) to (1) reduce risks of wildfire in unburned populations or (2) avoid re-burn of the two B-ranked EOs and nine C-ranked EOs with evidence of wildfire disturbance should increase representation and redundancy and thus the species' ability to persist.

Slickspot peppergrass populations are vulnerable to wildfire on an annual basis. Over a 59 year period from 1957 to 2015, the perimeters of 147 wildfires occurring within the known range of slickspot peppergrass burned approximately 8,348 acres (about 53 percent) of the total slickspot peppergrass EO acreage (Hardy 2016, *in litt.*, entire). Approximately 80 to 90 percent of the remaining slickspot peppergrass habitat not yet impacted by wildfire is predicted to burn within the next 50 years (by about 2065) (81 FR 55058, August 17, 2016). The risk of future wildfires has intensified in recent years due to the expansion of the wildfire season in southwest Idaho (Klos *et al.* 2015, pp. 247, 249). The fire season has expanded from the dry summer months (June through August) to include the spring and fall months during years of abnormally low snowpack, high thunderstorm activity, and drier, warmer spring and fall seasons (Spokesman Review 2015 *in litt.*, p. 2). Thus, the estimated 7,477 acres of slickspot peppergrass EOs and subEOs not yet negatively affected by wildfire are at risk of burning, while previously impacted EOs and subEOs are at a higher risk of re-burn. As previously described, wildfire substantially reduces slickspot peppergrass numbers relative to unburned EOs (Bond 2017, p. 12). The low ecological resistance and resilience of the vast majority (99 percent) of the range of slickspot peppergrass increases the risk for large, catastrophic wildfires to burn slickspot peppergrass populations.

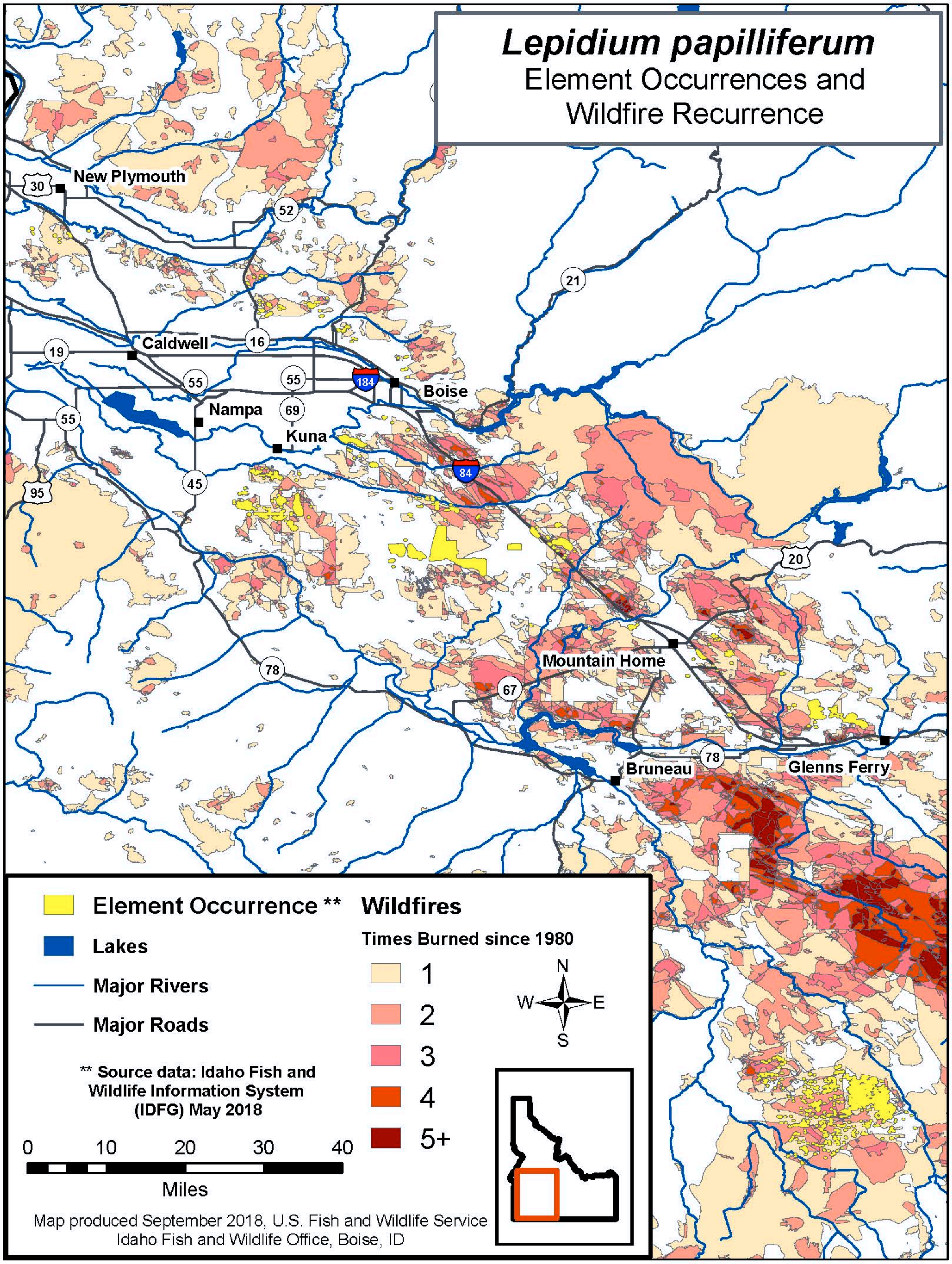


Figure 19. Wildfire recurrence levels in landscapes across the range of slickspot peppergrass.

Because low ecological resistance and resilience habitats are widespread within the range of slickspot peppergrass, implementation and effectiveness of wildfire-related conservation measures on a large scale has been challenging. For example, the State of Idaho's 2006 Candidate Conservation Agreement contains conservation measures for wildfire suppression that identify annual threshold acreages that could burn within individual slickspot peppergrass Management Areas as well as adaptive management triggers for any EOs that have burned. Monitoring data show wildfire suppression triggers for maximum acreages of wildfires within individual Management Areas have often been exceeded, and portions of EOs have been burned despite diligent wildfire suppression efforts by BLM and their firefighter partners (Kinter *et al.* 2014, p. 24; Kinter *et al.* 2012, p. 23; Kinter *et al.* 2010, p. 37; Colket 2009, pp. 65-66).

Some ongoing conservation efforts have been demonstrated to be effective in reducing wildfire frequency and intensity, such as the Idaho Army National Guard's and MHAFB's efforts to control effects of wildfire on lands covered by their respective Integrated Natural Resource Management Plans through rapid wildfire suppression, and represent a positive step toward the conservation of slickspot peppergrass. For example, staging firefighting crews on-site and limiting military training with the potential to ignite fire during periods of high fire danger has limited wildfires in EOs located on the MHAFB's Juniper Butte Range and the Idaho Army National Guard's Orchard Combat Training Center. These military training lands have concentrated fire suppression capacity within relatively small areas compared to the extensive landscapes administered by BLM. Thus, staging firefighters for rapid wildfire response associated with potential wildfire ignitions from military training activities is more ecologically and economically feasible within these smaller military training areas than it is over the extensive landscape areas administered by BLM, particularly during periods with multiple lightning strike ignitions scattered across the landscape.

Implementation of successful wildfire suppression conservation measures on BLM lands across the entire range of slickspot peppergrass represents a significant challenge. However, the Idaho Department of Lands has facilitated the establishment of Rangeland Fire Protection Associations in Idaho sagebrush steppe habitats since 2012. These Rangeland Fire Protection Associations provide ranchers and landowners in rural areas with necessary tools and training to assist agency wildland firefighters with wildfire prevention and respond quickly to wildfire. Rangeland Fire Protection Associations currently assist BLM and other land management partners with rapid fire suppression efforts in sagebrush steppe habitats, including within the range of slickspot peppergrass. About 45 percent of EO acreage rangewide is located within fire protection boundaries of Rangeland Fire Protection Associations or other Mutual Aid boundaries (IDL *in litt.* 2018, p. 1).

Slickspot peppergrass conservation efforts to date have been limited in their ability to effectively reduce long-term habitat degradation and destruction occurring within slickspot peppergrass habitats from effects of a changed wildfire regime. For example, conservation efforts for wildfire suppression identified in some formalized plans focused on priority EOs and subEOs and MAs rather than on surrounding landscapes. In some cases, surrounding landscapes may be the source of wildfires that spread to slickspot peppergrass populations. Upcoming Great Basin conservation efforts intended to address increased frequency and intensity of wildfire in sagebrush steppe habitats are expected to also benefit slickspot peppergrass. BLM is proactively implementing fuel treatments (including construction of fuel breaks) in degraded sagebrush steppe areas, including within the range of slickspot peppergrass, to reduce the potential for landscape level impacts to rangelands due to wildfire. Both the Paradigm Fuel Breaks Project within the BLM's Boise District and the Jarbidge Fuel Breaks Project in the BLM's Jarbidge Field Office are expected to increase both fire suppression success and firefighter safety within the range of slickspot peppergrass. These fuel treatment projects, in conjunction with subsequent proposed habitat restoration efforts, are intended to increase ecological resistance and resilience of degraded sagebrush habitat, and may reduce the risk of wildfire on slickspot peppergrass. In addition, large fuel break projects implemented through interagency and private partnerships within the range of slickspot peppergrass are anticipated to reduce wildfire extent and spread through more effective suppression. Increased fuels treatment and wildfire suppression coordination among State and Federal agencies as well as with recently created Idaho Rangeland Fire Protection Associations are also expected to further reduce wildfire size and intensity.

The Service is not aware of any long-term data regarding suppression effectiveness of fuel breaks in areas of low ecological resistance and resilience, which is where more than 99 percent of slickspot peppergrass occurs. However, anecdotal evidence, sporadic project monitoring, and limited record keeping indicate that fuel treatments do accomplish their intended goals under certain conditions. Systematically collected, comprehensive spatial and temporal data on fuel treatments in general, and fuel breaks specifically, are currently lacking: thus, data are insufficient to allow for a ready and objective analysis of how often and under what conditions linear fuel breaks are effective. As agency-wide fuels treatment databases continue to be compiled and improved, analyses on effectiveness of fuel breaks may become prudent, at least for portions of the Great Basin with consistent record keeping (Shinneman *et al.* 2018, p. 26).

The BLM's Jarbidge and the Paradigm fuel break projects have the potential to reduce the risk of wildfires within portions of the range of slickspot peppergrass. However, these fuel break projects do not address the co-occurring effects of existing invasive nonnative annual grasses, one of two primary threats identified for the species, or the conservation need for sagebrush steppe habitat restoration. Considering all of these factors, it is unlikely that these large fuel break projects on their own will adequately address threats such that future population viability is maintained or improved in this portion of the species range. Although fire suppression, including Rangeland Fire Protection Associations, and fuels management efforts currently in place are a positive conservation step for slickspot peppergrass and its habitat, they are not sufficient at this time to offset effects of current and future extent of invasive nonnative plants or other threats across the range of the species. Effective control of the most significant threats to slickspot peppergrass (wildfire and invasive nonnative plant species, especially invasive nonnative annual grasses) may require efforts that extend beyond the boundaries of slickspot peppergrass populations since these threats are naturally expansive and occur throughout the Great Basin at landscape levels.

As the entire rangewide extent of slickspot peppergrass populations are located in low ecological resistance and resilience areas, populations with good, good to fair, and fair viability within relatively intact sagebrush steppe habitat would likely benefit from being identified as a high priority for protective management. In high priority areas, emphasis on maintaining or improving habitat conditions by minimizing stressors and disturbance could maintain or increase resiliency of individual populations as well as maintain representation of populations and redundancy for the species. Within low ecological resistance and resilience areas, multiple interventions may be required to restore sagebrush habitat that contains slickspot peppergrass populations following disturbance such as wildfire. As habitat restoration would likely not be possible in areas undergoing rapid climate change, favoring or restoring genotypes of native species that are expected to be better adapted to the future range of climatic and site conditions represents one option to increase the success of native restoration and rehabilitation efforts. (Chambers *et al.* 2017, p. 105). Use of either local plant materials or materials from within the same climate-based provisional seed zone would increase the probability successful native plant establishment through use of genetically appropriate seed for slickspot peppergrass ecological restoration projects (National Seed Strategy 2015, p. 7). However, individual slickspot peppergrass populations have not yet been prioritized for protective management.

Large-scale conservation actions will be required to adequately reduce the risk of catastrophic wildfire on slickspot peppergrass. Controlling wildfire and managing invasive nonnative plant species in habitats currently occupied by slickspot peppergrass represents a significant management challenge for recovery efforts. Restoration of low ecological resistance and resilience areas that currently contain slickspot peppergrass into an ecologically functional condition will likely require years of effort, multiple treatments, and high levels of funding. Given past and current management compounded by the expected effects of climate change, restoration of some slickspot peppergrass populations located in highly degraded, low ecological resistance and resilience areas may not be possible. The potential for enhancement, restoration, and connectivity of sagebrush steppe habitats are important considerations for developing appropriate measures for slickspot peppergrass conservation.

4.3 Introduction and Spread of Invasive Nonnative Plants

Highly invasive nonnative annual grass cover occurs within landscapes across the range of slickspot peppergrass, particularly in the Snake River Plain geographic area (Figure 20). Establishment of invasive nonnative annual grasses has typically occurred across the range of slickspot peppergrass by spreading through natural dispersal (unseeded species, especially cheatgrass and medusahead). Unseeded invasive nonnative plant introduction and spread is associated with ground disturbance and loss of native vegetation through wildfire, improper livestock use, off highway vehicle use, and development and associated infrastructure. Disturbance may occur across the range of the species year-round, although risk of mechanical ground disturbance is reduced when the ground is frozen or when soils are dry.

Within the range of slickspot peppergrass, where sagebrush has been lost to wildfire and replaced by nonnatives, sagebrush typically has not returned as a dominant species (IDFG *in litt.* 2018, p. 4). Native perennial bluebunch wheatgrass appears largely extirpated within EOs across the range of the species (Miller and Kinter 2018, p. 9). Nonnative seeds make up much of the seed bank within the range of slickspot peppergrass, and these nonnatives out-compete sagebrush seedlings as well as other shrubs (such as bitterbrush), bunchgrasses, and forbs. The invasive nonnative plant species that have replaced native plants within the range of slickspot peppergrass do not support the same suite of native wildlife species. Some of these, such as several species of lizards, prey on Owyhee harvester ants, which are efficient predators of slickspot peppergrass seeds (Schmasow and Robertson 2016, p. 956).

Among the nonnative species observed within slick spots during HIP monitoring, the most widespread and abundant was cheatgrass (Kinter *et al.* 2014, pp. 13, 43). All transects contained some level of nonnative unseeded plant cover (Kinter *et al*. 2014, Table 4, pp. 28–29), especially cheatgrass).

Recent analyses of 11 years of Habitat Integrity and Population (HIP) monitoring data found that cheatgrass within slick spot microsites was statistically associated with declining slickspot peppergrass numbers; for every 2.7 percent increase in cheatgrass cover within slick spot microsites, there was an estimated 24 percent reduction in the number of slickspot peppergrass plants (Bond 2017, p. 12). Long-term monitoring of HIP transects indicated that nonnative plant cover has increased at a relatively rapid pace. For example, the number of transects with a 5 percent or more increase in nonnative cover since transect establishment increased from 40 transects in 2009 to 61 transects in 2011 (Kinter *et al*. 2012, pp. 12–13, 25-26). Of the 61 HIP transects with a 5 percent or more increase in nonnative cover since establishment, 46 transects (75 percent) primarily had increased annual invasive nonnative grass cover; most of these transects were located in the Snake River Plain geographic area. The 2013 HIP monitoring results (Kinter *et al.* 2014, which represents the most recent HIP data report available) documented greater than three percent canopy cover of seeded or unseeded introduced plants in all slickspot peppergrass Management Areas, particularly in Management Areas 2 (Boise Foothills - BLM), 5 (Boise), 6 (Kuna), and 9 (Mountain Home). All transects contained some level of nonnative plant cover (Kinter *et al*. 2014, Table 4, pp. 28–29).

Similarly, in the recent assessment of all slickspot peppergrass populations, of the 105 EOs and subEOs with available data, all were observed to contain invasive nonnative annual grasses (Kinter and Miller 2016, raw data). About 55 percent (58 EOs and subEOs) of the 105 EOs and subEOs have invasive nonnative plants (which also included highly competitive nonnative seeded species) present over 71 to 100 percent of the EO and subEO areas at severe to extreme levels.

Over recent years, seeding and planting efforts within and adjacent to slickspot peppergrass populations on BLM lands have primarily occurred as part of post-fire emergency stabilization and rehabilitation projects. Emergency stabilization and rehabilitation is a Department of Interior-developed protocol to restore areas damaged by wildfire that is designed to reduce soil erosion, restore burned areas to their pre-fire state, and reduce fuels available to future wildfires (ARS *et al.* 2013, p. 1). Although use of native plants for treatments within EOs were emphasized in these efforts, past emergency stabilization and rehabilitation plantings were, by definition, tied to wildfire locations. Until recently, very few strategically located and timed habitat restoration projects designed to maximize benefits to slickspot peppergrass and its habitat have been implemented. However, BLM and Idaho Army National Guard are currently implementing several habitat restoration projects within or adjacent to B-ranked EOs specifically designed to maximize benefits to priority slickspot peppergrass populations.

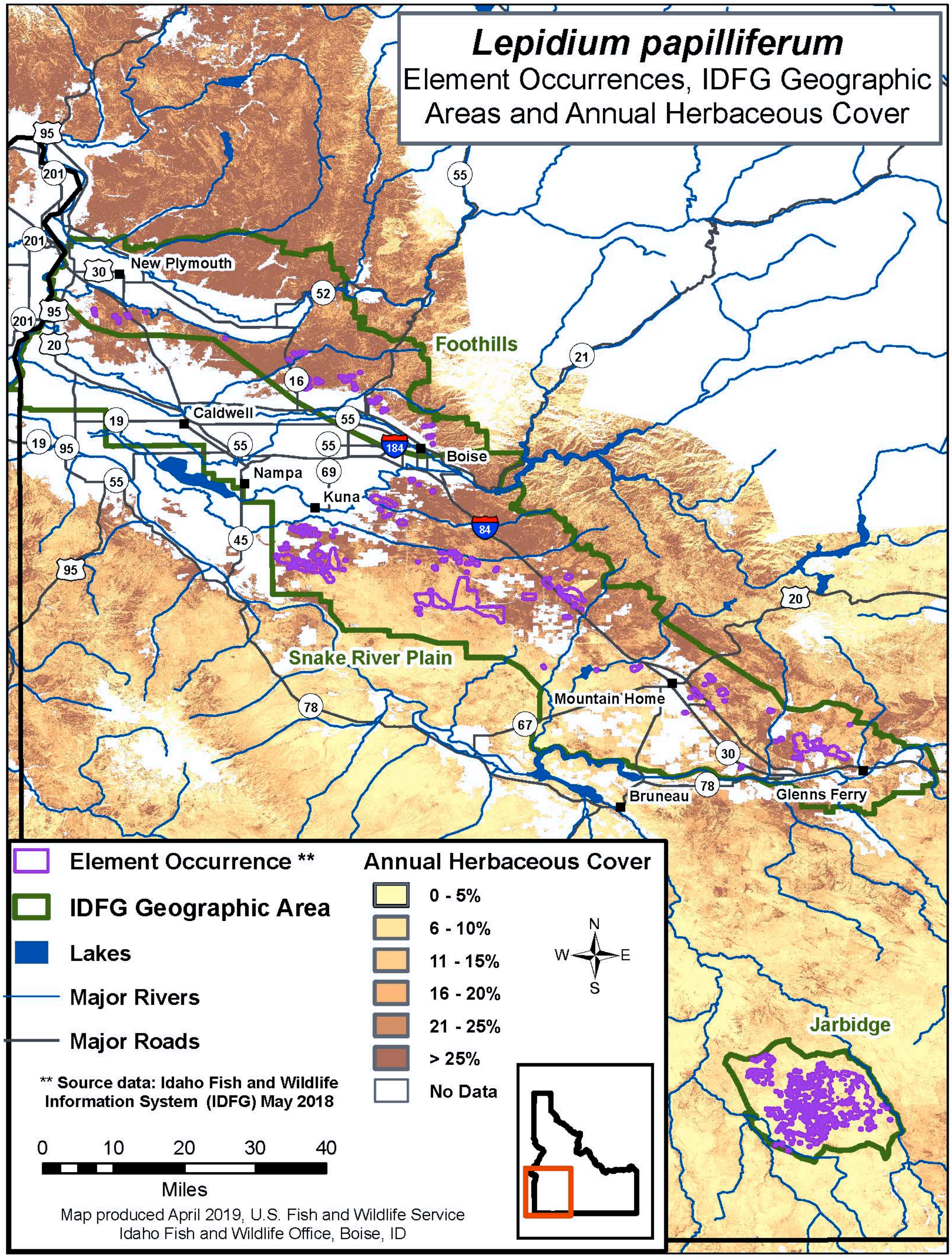


Figure 20. Invasive nonnative annual grass cover across the range of slickspot peppergrass. Cover values may be inflated as native perennial Sandberg's bluegrass may have been incorporated into annual herbaceous cover categories due to its similar phenology to cheatgrass.

A landscape scale conservation effort is currently being proposed to address degraded sagebrush steppe habitat conditions across the West, including those portions of the Snake River Plain and Jarbidge geographic areas that support slickspot peppergrass. These landscape scale habitat improvement proposals, the majority of which will likely be tied to post-fire emergency stabilization and rehabilitation efforts, target invasive nonnative annual grasses such as cheatgrass and medusahead that currently dominate these landscapes. Habitat restoration efforts in degraded sagebrush steppe system are intended to occur at a coarse scale over thousands of acres. In addition, effective landscape scale techniques designed to restore highly degraded sagebrush steppe habitats are currently being developed. At the present time, these coarse scale landscape level restoration efforts in Idaho are anticipated to primarily depend upon herbicide treatments and subsequent seeding of nonnative deep-rooted perennial bunchgrasses such as crested wheatgrass and Siberian wheatgrass that are competitive with invasive nonnative annual grasses, particularly in wetter, higher elevation sites (Knutson *et al.* 2014, p. 1422), and are readily available for use. These nonnative perennial bunchgrasses create a discontinuous fuel distribution and remain green longer into the dry summer fire season than the nonnative annual grasses to be replaced, and is intended to reduce the risk of fire ignition and spread. At a landscape scale, replacement of cheatgrass dominated systems with perennial bunchgrasses is intended to benefit sagebrush steppe obligate species, such as the greater sage-grouse, as cheatgrass cover and fire frequency and intensity across the landscape would be reduced due to the reduction of fine fuels continuity and increased fine fuel moisture. Wildfire risk reduction associated with these large scale plantings of highly competitive nonnative plants have the potential to benefit slickspot peppergrass through disruption of the wildfire-cheatgrass cycle.

Many past conservation efforts were limited in their ability to effectively reduce long-term habitat degradation and destruction occurring within slickspot peppergrass habitats from effects of nonnative plant invasions. Effective control measures for nonnative invasive plants were not known or were not financially or technically feasible. However, new methods for habitat restoration in degraded sagebrush areas with low ecological resistance and resilience, such as use of activated carbon pellets and seed pillows (Davies 2018, p. 323; Davies *et al.* 2018, p. 19; Madsen *et al.* 2016, entire), are currently in development.

The capacity of a plant species to establish and persist following seeding depends on whether or not it is adapted to the environmental conditions on the site. The use of locally adapted and genetically appropriate native seed and plant materials ensures the best genetic fit between a restoration site and the seed source used for the project. However, under many circumstances, using locally adapted seeds and plant materials may not be the most practical solution. Generalized seed zones (also called provisional seed zones) based on climate variables that have been shown to be important to plant establishment and survival, or are based on other broad scale ecological considerations, such as plant communities or soil types, can be used when use of locally sourced seed is not practical (Chambers *et al.* 2017, p. 202). Availability of appropriate native plant materials that are adapted to area climate and soil conditions for use in sagebrush steppe restoration efforts continues to increase (National Seed Strategy: Making Progress 2019, entire).

As described within the 2015-2020 National Seed Strategy, Federal, State, and non-governmental partners are encouraged to work cooperatively to increase the availability of native plant materials for habitat restoration nationwide (National Seed Strategy 2015, pp. 3, 11). Site-appropriate native seeds are also being developed for Great Basin sagebrush steppe habitats, and BLM recently issued west-side native forb and grass seed increase contract award(s) to encourage the agricultural seed industry to produce genetically appropriate native seed by Seed Transfer Zones. Emerging new techniques and increasing awareness of the importance of native plants are promising for increased native sagebrush steppe habitat restoration success for slickspot peppergrass.

Conservation measures to avoid or minimize adverse impacts to slickspot peppergrass are implemented for ongoing post-fire seedings, and projects such as greenstrip fuel breaks are implemented by the BLM, NRCS, and the State of Idaho using conservation measures that avoid or minimize adverse impacts to slickspot peppergrass. BLM, State of Idaho, MHAFB, and Idaho Army National Guard implement measures to avoid or minimize slickspot peppergrass exposure to herbicides. BLM is continuing to develop programmatic National Environmental Policy Act (NEPA) documents that include more areas of southern Idaho to allow for habitat restoration efforts to occur in degraded sagebrush steppe habitats in a more expedited manner, including within the range of slickspot peppergrass. With continued completion of these NEPA documents, large- and small-scale habitat restoration efforts can be implemented in degraded sagebrush steppe habitat areas to benefit sagebrush steppe obligate species, including slickspot peppergrass. Landscape scale sagebrush steppe habitat restoration efforts and post-fire emergency stabilization and rehabilitation projects within the range of slickspot peppergrass have the potential to maintain population representation and redundancy, provided that it also includes strategic, localized use of native and noninvasive nonnative plants associated with slickspot peppergrass populations.

Conservation efforts are being implemented to address, in part, the introduction and spread of invasive nonnative plants within the Great Basin, including within the range of slickspot peppergrass. Multiple agencies; including the BLM, Idaho Department of Lands, Idaho Army National Guard, Mountain Home Air Force Base, and county weed control departments across Idaho; clean their vehicles to avoid the inadvertent spread of invasive nonnative plants associated with their actions. For example, the Idaho Army National Guard requires pressure washing of military vehicles and equipment to avoid introduction of invasive nonnative plants during military training exercises. The National Guard also uses native grasses, forbs, and shrubs for habitat restoration projects within and surrounding EOs to reduce available niches for invasive nonnative annual grasses and noxious weed spread. The Mountain Home Air Force Base annually treats invasive nonnative weeds along roads and building sites.

Conservation measures specifically designed to reduce the risk of invasive nonnative annual grass related-effects on slickspot peppergrass are also being implemented by multiple conservation partners. Prior to the fire season, BLM and State of Idaho Resource Advisors, Rangeland Fire Protection Associations, and fire suppression personnel are trained on conservation measures used to avoid or reduce fire suppression-related ground disturbance within slickspot peppergrass populations, with protection of human life and property taking higher priority than slickspot peppergrass conservation during fire suppression actions. Both Mountain Home Air Force Base and BLM delay spring livestock turn out when slick spot soils are saturated in pastures that contain slickspot peppergrass populations, reducing the extent of disturbed sites available for invasive nonnative annual grass establishment. BLM and State of Idaho permitted grazing in some pastures within the range of slickspot peppergrass have also been changed from spring use to winter use to reduce potential localized impacts to the species and its habitat. BLM, Idaho Army National Guard, Mountain Home Air Force Base, and the State of Idaho also implement conservation measures to avoid or minimize potential effects of OHV use, construction, and maintenance-related ground disturbance in slick spot microsites within the range of slickspot peppergrass. To reduce the risk of potential long-term effects of herbicide exposure on slickspot peppergrass populations (Scholten and Bunting 2001, pp. 7-8), weed control efforts include conservation measures for herbicide applications in slickspot peppergrass populations.

Active habitat restoration projects are ongoing within the range of slickspot peppergrass. For example, BLM is currently increasing habitat diversity in portions of several B-ranked EOs through planting and seeding of native grasses and forbs in the Morley Nelson Snake River Birds of Prey National Conservation Area. BLM also uses native plants in Emergency Stabilization and Rehabilitation (ESR) treatments within burned slickspot peppergrass populations, and the Idaho Army National Guard uses native plants in habitat restoration efforts on the Orchard Combat Training Center. Chemical, biological, and cultural control treatments developed over the past decade that target invasive nonnative annual grasses may be effective at both the site and landscape scale. These tools are being tested for effectiveness for restoration of sagebrush steppe habitats, and may prove to be effective for areas that support slickspot peppergrass. However, potential effects of these chemical, biological, and cultural control treatments on slickspot peppergrass and native plants, including on native forbs and biological soil crusts, are not yet well understood (von Reis 2015, pp. 98-100; De Graaff and Johns 2014, pp. 64, 66, 68). In addition, results of ongoing pilot projects outside the range of slickspot peppergrass, which are examining effectiveness of livestock grazing as cultural control treatments to reduce invasive annual grass cover, has the potential to benefit slickspot peppergrass. Despite these past and ongoing efforts, invasive nonnative plants continue to be a primary threat to slickspot peppergrass populations rangewide.

Invasive nonnative plants, particularly invasive nonnative annual grasses, continue to threaten all slickspot peppergrass populations, regardless of EO ranking. Addressing invasive plants, especially in higher ranked EOs and subEOs, would be expected to maintain or increase current population representation and redundancy. Enhancement, restoration, and connectivity of sagebrush steppe habitats in the low ecological resistance and resilience areas within the range of slickspot peppergrass is challenging. Targeted treatment areas have not been prioritized to identify and implement appropriate recovery measures for the species. Use of native plants in habitat restoration projects is currently not economically or technically feasible on the scale that would be necessary to successfully ameliorate the primary threat of invasive nonnative plants in all slickspot peppergrass populations rangewide over the short-term. Measureable habitat restoration goals and objectives to prioritize habitat restoration efforts for slickspot peppergrass populations, inclusive of specific target acreages, locations, time frames, and monitoring, have yet to be developed.

4.4 Additional Threats

4.4.1 Highly Competitive Nonnative Plants

Seedings of highly competitive nonnative species have been established within landscapes across of the range of slickspot peppergrass, especially in the Jarbidge geographic area (Figure 21). These seedings significantly reduce the risk of soil erosion and increase ecological resistance and resilience where invasive annual grasses are a threat. Long-term monitoring of HIP transects indicated that, of the 61 HIP transects with a 5 percent or more increase in nonnative cover since establishment, 17 transects (27 percent) that primarily had increased cover of seeded highly competitive nonnative species were located in the Jarbidge geographic area (Kinter *et al*. 2012, pp. 12–13, 25-26).

Similarly, in the recent assessment of all slickspot peppergrass populations, of the 105 EOs and subEOs with available data, 29 EOs and subEOs have drill-seeding related disturbance over 71 to 100 percent of their area at serious to extreme levels; the majority of these drill-seeded populations (20 of 29) are located in the Jarbidge geographic area. Nonnative plants within the 29 drill-seeded EOs and subEOs included highly competitive seeded nonnative plants such as crested wheatgrass or intermediate wheatgrass (L. Kinter pers. comm. 2018). The Jarbidge represents the only geographic area where mean canopy cover of seeded introduced plants (e.g., highly competitive nonnative species) exceeded unseeded introduced plants (e.g., cheatgrass) within slick spot microsites (Kinter *et al.* 2014, p. 44).

Many past conservation efforts were limited in their ability to effectively use native plants for habitat restoration within slickspot peppergrass habitats following wildfire so some use of highly competitive nonnative species occurred. Effective control measures for nonnative invasive annual grasses through reestablishment of native plants were not known or were not financially or technically feasible. However, new methods for habitat restoration in degraded sagebrush areas with low ecological resistance and resilience, such as use of activated carbon pellets and seed pillows (Davies 2018, p. 323; Davies *et al.* 2018, p. 19; Madsen *et al.* 2016, entire), are currently in development. Availability of native plant materials that are adapted to area climate and soil conditions for use in sagebrush steppe restoration efforts continues to increase (National Seed Strategy: Making Progress 2019, entire). As described within the 2015-2020 National Seed Strategy, Federal, State, and non-governmental partners have been directed to cooperatively increase availability of native plants for habitat restoration nationwide. Site-appropriate native seeds are also being developed for Great Basin sagebrush steppe habitats, and BLM recently issued west-side native forb and grass seed increase contract award(s) to encourage the agricultural seed industry to produce genetically appropriate native seed by Seed Transfer Zones. Emerging new techniques and increasing awareness of the importance of native plants are promising for increased native sagebrush steppe habitat restoration success for slickspot peppergrass. However, while the availability of native plant materials continues to increase, if demand continues to exceed supplies, nonnative plant materials could likely continue to be selected for use in stabilization and rehabilitation efforts.

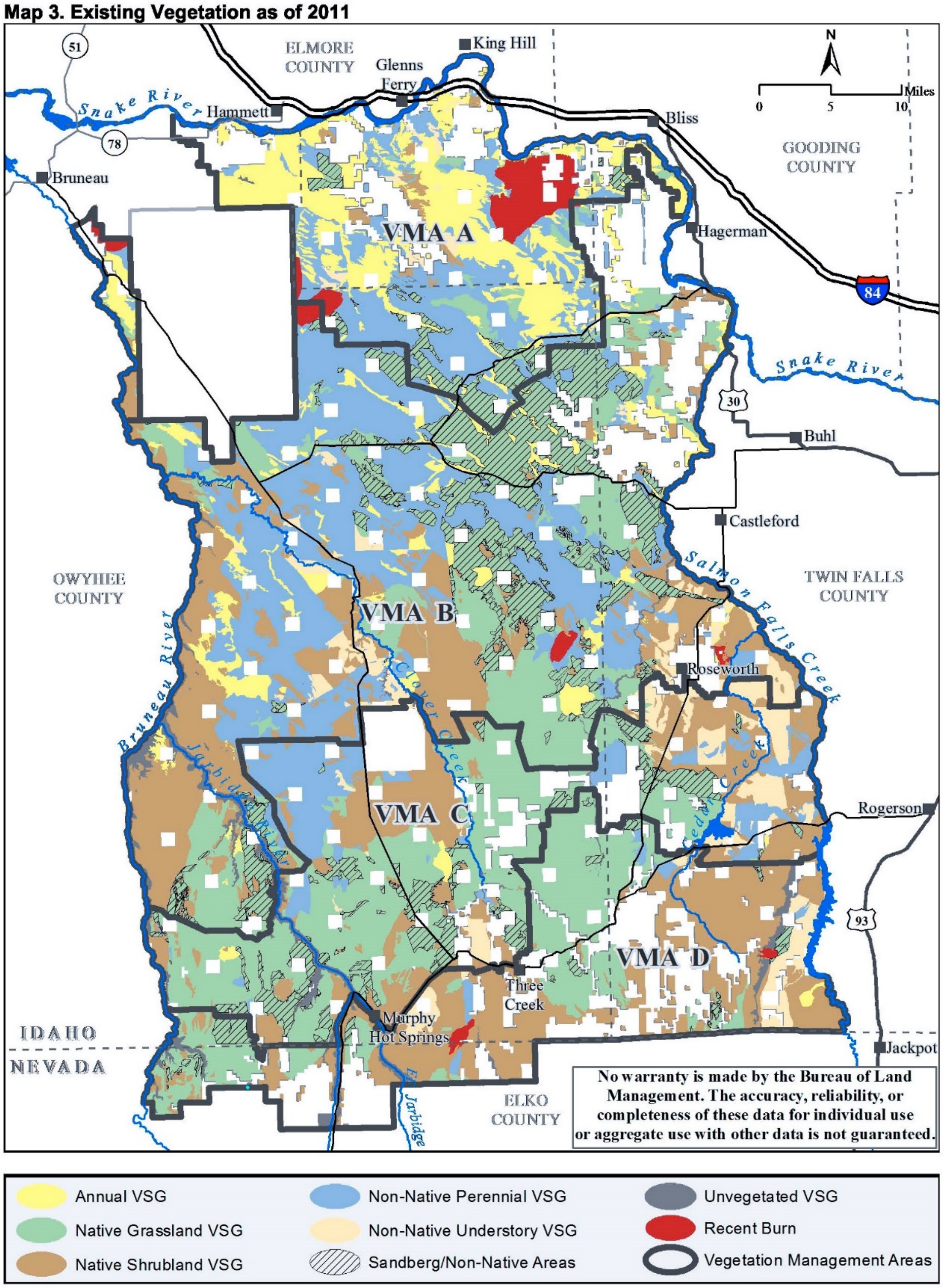


Figure 21. Vegetation Management Areas (VMAs) in the BLM Jarbidge Field Office area as of 2011 showing the extent of areas dominated by seeded highly competitive nonnative species (blue areas labelled as Non-native Perennial VSG (Vegetation Sub-Group)) (from 2015 BLM updated Jarbidge Resource Management Plan Record of Decision).

Active habitat restoration projects are ongoing within the range of slickspot peppergrass. For example, BLM is currently increasing habitat diversity in portions of several B-ranked EOs through planting and seeding of native grasses and forbs in the Morley Nelson Snake River Birds of Prey National Conservation Area. BLM also uses native plants in Emergency Stabilization and Rehabilitation (ESR) treatments within burned slickspot peppergrass populations, and the Idaho Army National Guard uses native plants in habitat restoration efforts on the Orchard Combat Training Center. Chemical, biological, and cultural control treatments developed over the past decade that target invasive nonnative annual grasses may be effective at both the site and landscape scale. These tools are being tested for effectiveness for restoration of sagebrush steppe habitats, and may prove to be effective for areas that support slickspot peppergrass. However, potential effects of these chemical, biological, and cultural control treatments on slickspot peppergrass and native plants, including on native forbs and biological soil crusts, are not yet well understood (von Reis 2015, pp. 98-100; De Graaff and Johns 2014, pp. 64, 66, 68). In addition, results of ongoing pilot projects outside the range of slickspot peppergrass, which are examining effectiveness of livestock grazing as cultural control treatments to reduce invasive annual grass cover, has the potential to benefit slickspot peppergrass. Despite these past and ongoing efforts, invasive nonnative plants continue to be a primary threat to slickspot peppergrass populations rangewide.

Ongoing conservation measures limit the establishment of highly competitive nonnative perennial plants within and adjacent to slickspot peppergrass populations, as appropriate. For example, BLM, the State, and NRCS limit the use of highly competitive seeded nonnative species within or near slickspot peppergrass populations during post-fire emergency stabilization and rehabilitation treatments and in vegetated fuel breaks. However, highly competitive seeded nonnative plants continue to be a threat to slickspot peppergrass populations rangewide where they have previously become established within or adjacent to EOs.

Highly competitive nonnative plants represent a lower level threat to slickspot peppergrass as land management agencies and private landowners have discretion as to where these nonnative plants are used in relation to slickspot peppergrass populations. Continued implementation of conservation measures associated with establishment of highly competitive nonnative plants within or adjacent to slickspot peppergrass populations, especially in higher ranked EOs and subEOs, would be expected to maintain or increase current population representation and redundancy. Enhancement, restoration, and connectivity of sagebrush steppe habitats in the low ecological resistance and resilience areas within the range of slickspot peppergrass is challenging. Targeted treatment areas have not been prioritized to identify and implement appropriate recovery measures for the species. Use of native plants in habitat restoration projects is currently not economically or technically feasible on the scale that would be necessary to successfully ameliorate the primary threat of invasive nonnative plants in all slickspot peppergrass populations rangewide over the short-term. Measureable habitat restoration goals and objectives to prioritize habitat restoration efforts for slickspot peppergrass populations, inclusive of areas identified for the potential use of highly competitive nonnative species as well as specific target acreages, locations, time frames, and monitoring, have not yet been developed.

4.4.2 Development

Slickspot peppergrass populations and habitat, including slick spot microsites and native vegetation, has been lost due to residential, commercial, and agricultural development. Residential, commercial, and agricultural development prior to 1955 has been reported as the cause for 10 extirpations of slickspot peppergrass in the Foothills and Snake River Plain geographic areas (Kinter and Miller 2016, pp. 10, 13, 17-18, 20). Ongoing and planned development projects within or near sites occupied by slickspot peppergrass contribute to the loss of slick spot microsites and further large-scale fragmentation of slickspot peppergrass habitat, potentially resulting in decreased viability of populations through decreased seed production, reduced genetic diversity, and the inherent increased vulnerability of small populations to extirpation. Most recent development effects on slickspot peppergrass have occurred on private lands in the Snake River Plain and Foothills geographic areas, with associated infrastructure effects to the species on private, State, and Federal lands.

Urban and rural development, agriculture, and infrastructure development has been substantial in sagebrush steppe habitat of the Foothills and the Snake River Plain geographic areas. Development within the Jarbidge geographic area is currently limited to scattered military training facilities and livestock infrastructure (such as fences, water developments, and pipelines). Newer land uses, such as solar and wind farms, have impacted additional acreages of sagebrush steppe on the western Snake River Plain, and continue to be of concern for species conservation.

Ongoing and planned residential and urban development currently threaten the long-term viability of slickspot peppergrass occurrences on private land in the Snake River Plain and Foothills geographic areas (Moseley 1994, p. 20; State of Idaho 2008 *in litt.*, pp. 3-4; Stoner 2009, pp. 13-14, 19-20). Development-related construction and maintenance activities may occur year-round, depending on favorable weather and economic conditions. All or portions of 12 slickspot peppergrass EOs covering about 224 acres (about 1 percent of the total area of all EOs, not including EOs managed by cities or counties) occur on private land subject to development. Two of these 12 EOs are smaller than 1 acre and are classified as having fair to poor viability (INHP data as of January 14, 2009); therefore, these populations are particularly vulnerable to extirpation through development.

Current assessments have documented development-related disturbance in slickspot peppergrass regardless of ranking; these impacts were observed primarily in the Snake River Plain geographic area. About 43 percent (45 populations) of the 105 EOs and subEOs with available data were observed to contain some evidence of development (Kinter and Miller 2016, raw data). Of these 45 populations, seven exhibited extreme levels of development-related disturbance over less than one third of their areas. Six of these seven populations were located in the Snake River Plain geographic area; the seventh population (EO 97) is within the Jarbidge geographic area. Addressing development in higher priority populations to either reduce habitat fragmentation or loss of populations within or adjacent to private lands as well as to reduce associated risk of wildfire in unburned populations or to avoid re-burn of the 2 B-ranked EOs with evidence of wildfire disturbance is expected to increase representation and redundancy, and thus the species' ability to persist into the future.

The Endangered Species Act provides limited protection for listed plants, including slickspot peppergrass, on non-Federal lands. Of the 107 populations ranked B through D, 17 populations are located wholly or partially on State lands (1,502 acres) and 20 populations are located partly or wholly on private land (584 acres), which includes three populations located on municipal lands (City of Boise or Ada County administered lands). The two Failed to Find (F-ranked), 5 Historic (H-ranked), and 10 Extirpated (X-ranked) populations are also associated with private lands.

Conservation efforts are being implemented to address, in part, effects of development within the range of slickspot peppergrass. For example, BLM, Idaho Army National Guard, the State of Idaho, and the Mountain Home Air Force Base avoid slick spot microsites that may contain slickspot peppergrass to the extent possible when siting development projects such as power lines, roads, buildings, fuel breaks, and range improvements such as pipelines and fences. Areas where ground disturbance occurs during infrastructure and other construction actions are also revegetated to minimize spread of invasive nonnative plants in EOs. However, slickspot peppergrass populations on private lands are vulnerable to loss due to residential, commercial, and agricultural development as plants listed under the Endangered Species Act have limited protections on non-Federal lands unless Federal administration, permitting, or funding is applicable.

State and Federal agencies continue to focus conservation efforts on avoidance of slickspot peppergrass populations near development projects and retain lands with slickspot peppergrass populations in Federal and State ownership. Construction projects on MHAFB, BLM, and State of Idaho lands, including the Idaho Army National Guard’s Orchard Combat Training Center, avoid slickspot peppergrass populations, where feasible. If projects must occur within or adjacent to populations, actions are taken to minimize potential impacts to the species through restoration of disturbed habitats in EOs with native species as well as avoidance of individual slick spots and requiring actions that avoid inadvertent wildfire ignitions during construction and maintenance activities. However, populations currently located on the approximately 600 acres of private lands, inclusive of municipal lands, remain vulnerable to partial or complete loss due to development.

4.4.3 Owyhee Harvester Ants

Owyhee harvester ants are highly efficient predators of slickspot peppergrass seeds. In the recent assessment of slickspot peppergrass populations, of the 105 EO and subEOs with available data, 62 populations contained Owyhee harvester ants (Kinter and Miller 2016, raw data). These 62 good to poor viability populations are located across the range of the species, with three EOs in the Foothills geographic area, 34 EOs in the Snake River Plain geographic area, and 25 EO and subEOs located in the Jarbidge geographic area. Fifty-eight (about 94 percent) of these 62 populations had slight levels of ant severity over less than 10 percent of the EO and subEO areas surveyed. However, 3 EOs (about 5 percent) of the 62 EO and subEOs had serious severity levels of Owyhee harvester ant presence over 30 to 70 percent of the EO areas surveyed. Of these three EOs, one was B-ranked (EO 18), one was C-ranked (EO 24), and one was CD-ranked (EO 43). All three of these EOs are located in the Snake River Plain geographic area. A single EO (EO 79 in the Jarbidge geographic area) had serious severity levels of Owyhee harvester ant presence over 11 to 30 percent of the EO area surveyed.

Conservation measures that may reduce impacts of Owyhee harvester ants on slickspot peppergrass include seeding or planting shrubs in habitat restoration efforts as harvester ants do not appear to favor areas containing shrubs. In addition, targeted removal of harvester ant colonies using the pesticide Amdro® is a potentially useful short-term solution to alleviate predation pressure on slickspot peppergrass seeds in specific EOs where control efforts are warranted (Robertson *et al.* 2017, p. 6). Targeted removal of ant colonies would allow for the replenishment of seed banks in existing slickspot peppergrass populations and possibly the successful introduction of seeds into suitable new habitat. However, efforts to eradicate harvester ant colonies on a wide scale across the range of slickspot peppergrass habitat are likely not feasible nor desirable given the ants' widespread abundance and recruitment capacity. Moreover, such efforts would represent a failure to recognize the larger ecological role harvester ants play in sagebrush steppe ecosystems, of which slickspot peppergrass is only one component (Robertson 2015, p. 14).

4.4.4 Livestock Grazing

Federal and State lands where slickspot peppergrass occurs (96 percent of the EO and subEO acreage rangewide) are managed for permitted livestock grazing through the BLM, State of Idaho, and MHAFB. Although livestock grazing may be a tool to reduce the primary threats of wildfire and invasive nonnative annual grasses, more information is needed regarding use of targeted livestock grazing or outcome-based livestock management within the range of slickspot peppergrass. While livestock grazing occurs on the Orchard Combat Training Center, authority for all livestock use on this military training area is administered by the BLM and the State of Idaho. Livestock may be present year-round, although many Federal and State grazing permits within the range of slickspot peppergrass allow for some combination of annual spring, winter, and fall grazing due to the lower availability of livestock forage during summer. Livestock grazing may also occur within populations located on private lands, but information is limited.

As shown by statistical analysis of HIP monitoring data (Bond 2017 p. 12; Sullivan and Nations 2009, p.136), high levels of livestock trampling within slick spots can be associated with reduced slickspot peppergrass numbers. Livestock trampling effects on slickspot peppergrass appear to be most detrimental when soils are wet as well as when plants are actively growing and flowering in the spring, and livestock-related trampling effects are most prominent in areas of livestock concentration such as near waters, salt and supplement sites, or fence corners. Because of this, conservation of slickspot peppergrass and its habitat continues to be the focus of current livestock management on Federal and State lands. BLM and State of Idaho both implement measures specifically designed to avoid or minimize livestock-related impacts to slickspot peppergrass, with significant attention focused over the past 15 years. These efforts appear to reduce impacts. For example, HIP monitoring has documented a decline in livestock hoof print thresholds within slick spot microsites detected over 14 years of monitoring (Figure 22). The highest number of livestock hoof print thresholds exceeded was 13 transects in 2005 and 10 transects in 2009; more recent years have documented four or fewer incidences of livestock hoof print thresholds exceeded. With the exception of 2012 and 2014, the majority of transects with livestock hoof print thresholds exceeded were located in the Jarbidge geographic area each year. Livestock hoof print thresholds have only been documented to have been exceeded in the Foothills geographic area in a single year (2018) along one HIP transect.

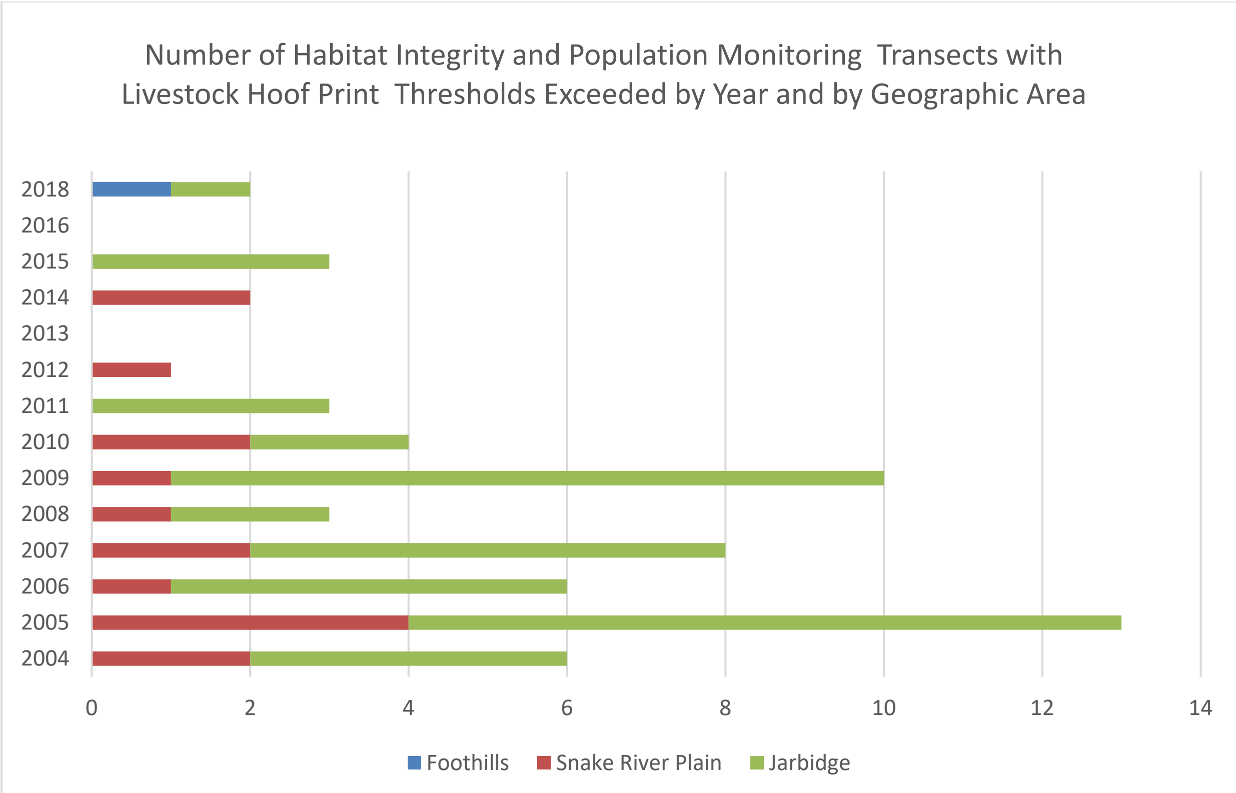


Figure 22. Number of Habitat Integrity and Population (HIP) monitoring transects with livestock hoof print thresholds exceeded by year and by geographic area. HIP data were not collected in 2017.

In addition to hoof print thresholds, HIP monitoring also documents evidence of livestock use (hoof print and livestock feces presence and densities). In the recent assessment of slickspot peppergrass populations, about 70 percent of EOs and subEOs were observed to contain some evidence of livestock use (Kinter and Miller 2016, raw data). However, most (83 percent) livestock related disturbance was categorized as slight to moderate. Only about 6 percent of populations had livestock-related disturbance over 71 to 100 percent of their areas at serious or extreme levels.

Some specific conservation measures the BLM and State of Idaho are implementing that have helped reduce, and continue to reduce the risk of livestock related disturbances include working with livestock permittees to place salt and supplements to draw livestock away from EOs, avoiding livestock trailing through EOs when soils are saturated, delaying livestock turn out when soils are saturated, and confining vehicle use to established roads and tracks within EOs. Livestock permittees also provide information on slickspot peppergrass observations during their normal course of business. Some smaller acreage EOs have been fenced to exclude livestock to avoid potential trampling impacts during spring permitted grazing periods when soils may be saturated and when slickspot peppergrass plants are actively growing and flowering.

Monitoring and subsequent adaptive management appear to have been effective in helping to reduce impacts on slickspot peppergrass. For example, livestock hoof print HIP monitoring data informed BLM's decision to no longer issue livestock trailing permits through EOs in the

Jarbidge geographic area, and to only allow livestock trailing through populations on existing roads and historic trailing routes within the Foothills and Snake River Plain geographic areas.

The majority of transects where livestock hoof print thresholds have been exceeded have been in the Jarbidge geographic area. The wetter climate of the Jarbidge geographic area relative to the remainder of the species range may make this area more susceptible to trampling damage in spring than the Foothills and Snake River Plain geographic areas. Federal 10-year livestock grazing permit renewals are currently being developed in the Jarbidge geographic area. The interrelationship between livestock-related disturbance and slickspot peppergrass populations is difficult to quantify. Therefore, additional strategically located slickspot peppergrass monitoring transects may be needed within the Jarbidge geographic area to ensure potential livestock related disturbance remains within recommended levels for future species viability.

Adherence to livestock-related conservation measures associated with formalized conservation agreements reduces the risk of livestock-related localized impacts on slickspot peppergrass and its habitat. Implementation of livestock-related conservation measures within formalized conservation agreements as well as range readiness criteria also reduce the risk of indirect effects of livestock use on native shrubs, grasses, and forbs important to slickspot peppergrass and its insect pollinators. Continued implementation of conservation measures that discourage concentration of livestock within EOs during sensitive time periods, especially when soils are wet, is expected to maintain current low to moderate, localized risks for livestock trampling impacts on slickspot peppergrass populations and habitat. In addition, a 2015 white paper signed by multiple agencies intended to increase flexibility of livestock management across land ownerships on Idaho rangelands, including private lands (NRCS 2015, entire), has the potential to increase conservation value for slickspot peppergrass associated with livestock grazing practices through incorporation of landscape level livestock management practices to reduce fine fuels while avoiding or minimizing potential trampling impacts to the species.

Pilot studies to examine the effectiveness of targeted grazing and prescriptive grazing, as well as outcome-based grazing management, are ongoing for reduction of fine fuels and can inform decisions on the use of livestock as one tool in the slickspot peppergrass recovery toolbox. However, studies to demonstrate the achievement of goals to reduce cheatgrass while maintaining or increasing deep-rooted perennial grasses are currently lacking (Pyke *et al.* 2016, p. 330). Potential benefits and impacts of livestock use have not yet been evaluated nor site-specific objectives developed for the use of targeted grazing, prescriptive grazing, or outcome-based livestock grazing management in areas that contain slickspot peppergrass populations.

Effectiveness monitoring is typically used to inform adaptive management of permitted livestock grazing. Funding and personnel to conduct monitoring have consistently been in short supply, and the outlook for the future is that they will be even more so. Due to uncertainties related to availability of funding and resources for monitoring of livestock use, conservation efforts may be most effective through focusing on stocking rates and season of use as well as the reduction of livestock concentration within certain areas where slickspot peppergrass may be impacted. The Service is unaware of specific livestock management proposals to reduce fine fuels for lowering wildfire risk that also incorporate measures to avoid or minimize trampling-related ground disturbance and spread of invasive nonnative annual grasses within or adjacent to slickspot peppergrass populations. Achieving a balance between reduced livestock-related disturbance on remnant native sagebrush habitat patches and on slickspot peppergrass, particularly in higher resiliency populations, and reducing fine fuels to decrease wildfire risk would be expected to increase resiliency, representation, and redundancy, and thus the species' ability to persist into the future.

Livestock grazing may be a tool to reduce the primary threats of wildfire and invasive annual grasses at landscape scales; however, more information is needed. Conservation measures have been implemented to avoid or minimize potential impacts of permitted livestock use within the range of slickspot peppergrass. For example, some BLM and State pastures have changed season of use from spring to fall or winter to reduce the potential for trampling saturated slick spot soils and actively growing slickspot peppergrass plants. Similarly, BLM and Mountain Home Air Force Base delay livestock turn out, to the extent possible, when slick spot soils are saturated. In addition, water and supplements on BLM allotments are placed to avoid livestock attraction or trailing through slickspot peppergrass populations. Some populations located on Mountain Home Air Force Base, State of Idaho, and BLM administered lands, including within the Idaho Army National Guard's Orchard Combat Training Center, have been fenced to exclude or limit livestock access to some areas with slickspot peppergrass plants. As all indications are that most seeds are dispersed over a short distance and insect pollinators are limited in their dispersal capabilities, localized livestock-related habitat degradation and direct loss through trampling of plants and seeds in the seed bank has the potential to reduce slickspot peppergrass resiliency through localized decreases in recruitment (loss of plants prior to reproduction, reduced seed bank) and reduced genetic variability (less native forbs available for insect pollinator habitat needs). Although improper livestock grazing may result in localized direct impacts and reductions in the quality of habitat for the species, the Service does not consider current livestock management to be a primary threat to slickspot peppergrass due to the continued implementation of conservation measures intended to avoid or minimize potential livestock grazing-related impacts on BLM and Mountain Home Air Force Base lands. The Service also recognizes the utility of livestock grazing as a tool to address the primary threats to slickspot peppergrass.

4.5 Current Condition of Populations

Current condition of slickspot peppergrass populations varies across its range from good to poor. No populations are ranked A (excellent viability) or AB (good to excellent viability). Twenty-nine EOs and subEOs are ranked B (good viability) or BC (good to fair viability), 49 EOs are ranked C or C? (fair viability), or CD (fair to poor viability), and 29 EOs are ranked D or D? (poor viability). The current rangewide area of all slickspot peppergrass extant EOs and subEOs combined is 16,269 acres (IFWIS January 2018).

Many populations of slickspot peppergrass, particularly in the Foothills and Snake River Plain geographic areas near urban centers, are restricted to small, remnant patches of suitable sagebrush steppe habitat. In addition, 26 populations (about 24 percent of the 107 A- through D-ranked EOs and subEOs) scattered across the species' range supported fewer than 50 plants annually over the past six years of recent monitoring (Kinter and Miller 2016, pp. 3, 57-60 - Table 2). Of these 26 EOs and subEOs, 4 are located in the Foothills geographic area, 10 are in the Snake River Plain geographic area, and 12 are in the Jarbidge geographic area. Many of these small, remnant EOs or subEOs exist within habitat that is substantially degraded. These small slickspot peppergrass populations have likely persisted due to their long-lived seed bank, but the potential risk of depleting each population's seed bank with no new genetic input makes the persistence of these small populations uncertain.

Presence of intact native sagebrush habitat and habitat connectivity corridors provide opportunities for natural insect pollinator movement and gene flow within (and potentially among) slickspot peppergrass populations. The extent to which nonnative plant materials may provide opportunities for pollinator movement is currently unknown (Stout and Tiedenken 2019, p. 41; Bartemeus *et al.* 2008, pp. 767, 769; Drossart *et al.* 2017, pp. 2-5); therefore, the ability of nonnative flowering plants to facilitate slickspot peppergrass gene flow is uncertain. However, the majority of slickspot peppergrass populations are currently separated by distances that would likely preclude movement of genes among populations by either insect pollinators or long-distance seed dispersal (Stillman 2006, p. 32). High levels of landscape fragmentation to the extent that ecological or hydrologic processes are no longer intact has occurred at 30 (about 29 percent) of the 105 extant EOs and subEOs with available data. These 30 EOs encompass 990 acres (about 6 percent) of the approximately 15,941 total acreage of these 105 EOs and subEOs. For the 105 EOs and subEOs, high levels of habitat fragmentation occur in 3 of the 15 total extant EOs (about 20 percent) in the Foothills geographic area, 19 of the total extant 49 EOs (about 39 percent) in the Snake River Plain geographic area, and 8 of the 41 extant EO and subEOs (about 20 percent) in the Jarbidge geographic area (Kinter and Miller 2016, pp. 5, 57-60, Table 2).

As part of the recent rangewide slickspot peppergrass EO and subEO assessment, data describing the current condition of populations were collected during field reviews of all EOs and subEOs, including information on the severity and scope of disturbance factors such as wildfire, invasive nonnative plants, Owyhee harvester ants, development, livestock use, off highway vehicle use, and drill seeding (Appendix D). Disturbance severity and scope data were collected by IDFG to assess current EO and subEO viability through the EO ranking process using protocols developed by NatureServe. IDFG disturbance observations within slickspot peppergrass EOs and subEOs by geographic area are summarized in Table 9 below.

Table 9. Disturbance observed during IDFG slickspot peppergrass EO/subEO field assessments.[+]

Disturbance Categories	Geographic Areas						RANGEWIDE TOTAL	
	Foothills		Snake River Plain		Jarbidge			
	Number of EOs	Percent of EOs	Number of EOs	Percent of EOs	Number of EOs and SubEOs	Percent of EOs and SubEOs	Number of EOs and SubEOs	Percent of EOs and SubEOs
Wildfire	2	13%	17	35%	13	32%	32	**30%**
Nonnative Plants	15	100%	49	100%	41	100%	105	**100%**
Drill Seeding	0	0%	5	10%	27	66%	32	**30%**
Owyhee Harvester Ants	3	20%	35	71%	25	61%	63	**60%**
Development	5	33%	22	45%	18	44%	45	**43%**
Livestock Use	6	40%	33	67%	35	85%	74	**70%**
Recreational Use / OHV Activity	3	20%	15	45%	0	0%	18	**17%**
Trash Dumping	1	6%	20	41%	1	2%	22	**21%**
Badger Digging	8	53%	32	65%	4	10%	44	**42%**
Wildlife Digging/ Trails/ Feces	3	20%	13	27%	7	17%	23	**22%**
Wildfire Suppression Activities	0	0%	3	6%	0	0%	3	**3%**
Agricultural Use	1	6%	2	4%	0	0%	3	**3%**
TOTALS	**15* EOs**	14%	**49~ EOs**	47%	**41 EOs and subEOs**	39%	**105^ EOs and subEOs**	**100%**

[+] Data compiled from IDFG raw field data for Kinter and Miller 2016, entire. Data shown by EO in Appendix D.
*As no data were available for F-ranked EOs 39 and 40 and C?-ranked EO 107, only 15 of the 18 total EOs located in the Foothills geographic area were used in this analysis.
~As no data were available for D?-ranked EO 101, only 49 of the 50 total EOs located in the Snake River Plain geographic area were used in this analysis.
^ As no data were available for 4 of the 109 total EOs and subEOs, 105 total EOs and subEOs were used in this table.

As described in the Population Dynamics and Demographic Trends section, IDFG ranked EOs and subEOs from B through D, which correspond to NatureServe criteria for good to poor viability populations. The disturbance criteria summarized in Table 9 above was used by IDFG to inform the EO ranking process. Highly competitive nonnative seeded plants were a part of IDFG's invasive nonnative plant category when data were collected as well as during EOs and subEOs ranking; therefore, the primary threat of invasive nonnative plants also includes highly competitive nonnative seeded plants presence within EOs and subEOs.

We examined the current disturbance condition of each EO and subEO for the two primary threats of wildfire and invasive nonnative plants (inclusive of highly competitive nonnative plants) relative to IDFG's EO and subEO rankings. IDFG collected disturbance scope and severity raw data for each EO and subEO categorized as extreme, serious, moderate, or slight. These four disturbance categories, which are based on NatureServe disturbance categories, are defined as follows:

- **Extreme**: Threat is likely destroy or eliminate the species, or reduce plant numbers of the EO or subEO by 71–100%
- **Serious**: Threat is likely to seriously degrade/reduce the EO or habitat, or reduce plant numbers of the EO or subEO by 31–70%
- **Moderate**: Threat is likely to moderately degrade/reduce the EO or habitat, or reduce plant numbers of the EO or subEO by 11–30%
- **Slight**: Threat is likely to only slightly degrade/reduce the EO or habitat, or reduce plant numbers of the EO or subEO by 1–10%.

Current disturbance condition for the primary threats of wildfire and invasive nonnative plants on 105 EOs and subEOs are summarized by geographic area and EO/subEO rank in Table 10. For the purposes of our comparison of rangewide disturbance categories for wildfire and invasive nonnative plants, we consider the severity of effects on slickspot peppergrass of the slight disturbance condition for invasive nonnative plants to be similar to the severity condition of the unburned disturbance condition for wildfire. Note that 10 of the 115 extant EOs rangewide did not have IDFG disturbance data collected; thus, these 10 EOs are not included in Table 10. Disturbance data for primary threats for each individual EO and subEO can be found in Appendix D and E.

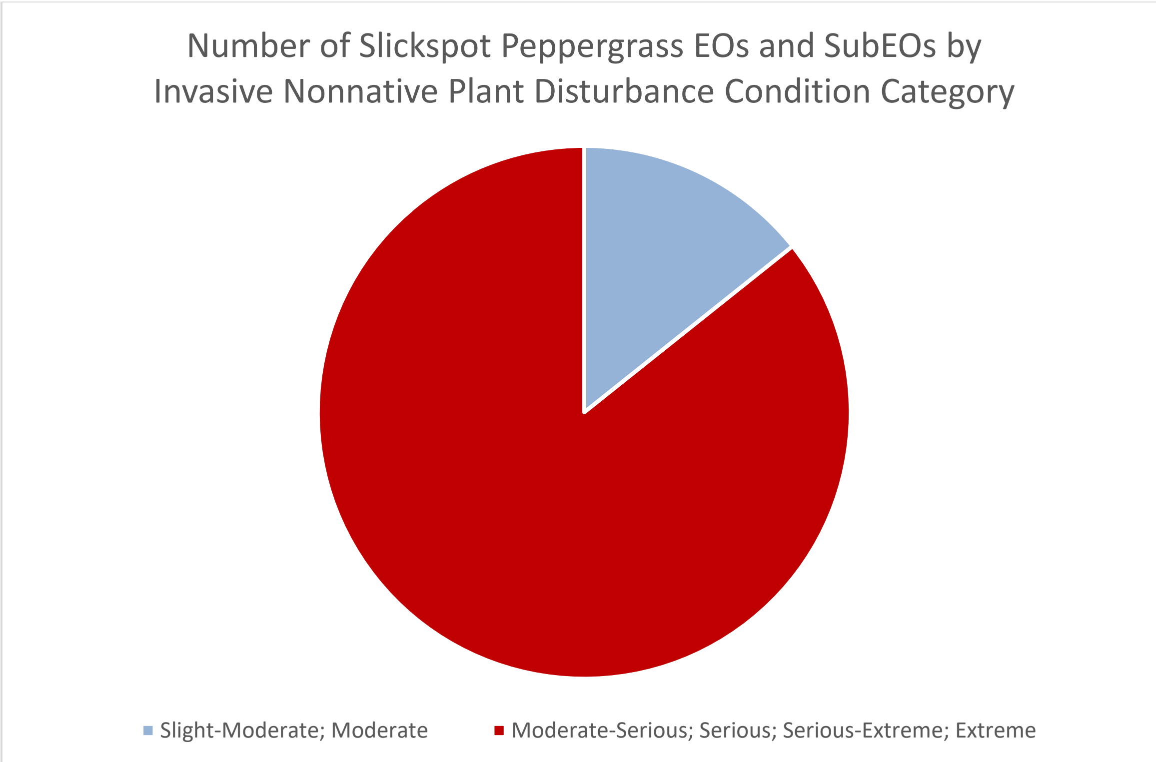
Table 10. Summary of current disturbance condition and acreages of 105 EOs and subEOs relative to the primary threats of wildfire and invasive nonnative plants by geographic area and EO rank.

Geographic Area	EO and subEO Rank	Current Disturbance Condition for Invasive Nonnative Plants	Current Disturbance Condition for Wildfire	Number of EOs / subEOs	Acreage
Foothills	B	slight	unburned	1	19.20
Foothills	B and BC	serious	unburned	6	91.2
Foothills	C and CD	serious	unburned	4	17.72
Foothills	C	serious	extreme	1	0.07

Geographic Area	EO and subEO Rank	Current Disturbance Condition for Invasive Nonnative Plants	Current Disturbance Condition for Wildfire	Number of EOs / subEOs	Acreage
Foothills	D	serious	unburned	2	5.43
Foothills	D	extreme	extreme	1	4.41
Jarbidge	B	slight	unburned	1	0.48
Jarbidge	B and BC	slight-moderate	unburned	1	2.14
Jarbidge	B and BC	moderate	unburned	6	18.44
Jarbidge	B	moderate-serious	unburned	1	74.53
Jarbidge	B and BC	serious	unburned	2	2,255.91
Jarbidge	B	serious	serious	1	19.98
Jarbidge	C	slight-moderate	unburned	3	3.67
Jarbidge	CD	moderate	unburned	1	35.15
Jarbidge	C	moderate-serious	unburned	2	15.36
Jarbidge	C and CD	serious	unburned	4	22.00
Jarbidge	C and CD	extreme	unburned	2	84.13
Jarbidge	C and CD	extreme	serious	3	75.34
Jarbidge	C and CD	extreme	extreme	3	53.26
Jarbidge	D	serious	unburned	4	3.45
Jarbidge	D	serious-extreme	extreme	1	5.14
Jarbidge	D	extreme	unburned	1	0.48
Jarbidge	D	extreme	extreme	5	27.29
Snake River Plain	B	slight-moderate	unburned	1	7,163.63
Snake River Plain	B and BC	serious	unburned	4	1,799.77
Snake River Plain	B	serious	serious	1	91.11
Snake River Plain	B	serious	extreme	2	748.72
Snake River Plain	B	extreme	unburned	2	1,856.98
Snake River Plain	C and CD	serious	unburned	11	316.96
Snake River Plain	C	serious	moderate	1	7.87
Snake River Plain	CD	serious	extreme	2	0.51
Snake River Plain	C and CD	extreme	unburned	6	782.30
Snake River Plain	C and CD	extreme	serious	1	104.65
Snake River Plain	C and CD	extreme	extreme	4	1.94
Snake River Plain	D	moderate	serious	1	71.25
Snake River Plain	D	serious	unburned	2	18.48
Snake River Plain	D	serious	extreme	3	4.31
Snake River Plain	D	extreme	unburned	4	127.53
Snake River Plain	D	extreme	extreme	4	9.69
TOTAL				**105**	**15940.48**

Although the two primary threats of invasive nonnative plants and wildfire are closely related, of these primary threats, invasive nonnative plant disturbance (inclusive of highly competitive nonnative plants) has greater severity levels rangewide relative to wildfire disturbance (Figure 23). Based the current disturbance condition of the 105 EOs and subEOs, 85.71 percent (90 EOs and subEOs) are in moderate-serious, serious, or extreme disturbance condition relative to invasive nonnative plants, with the remaining 14.29 percent (15 EOs and subEOs) in slight, slight-moderate, or moderate disturbance condition. In contrast, 31.43 percent (33 EOs and subEOs) have serious or extreme levels of wildfire disturbance. About 67.62 percent (71 EOs and subEOs rangewide) are unburned, and the remaining 0.95 percent (1 EO) having moderate levels of wildfire disturbance. While a little over 67 percent of EOs and subEOs are currently unburned, only about 14 percent of EOs and subEOs have relatively low levels of invasive nonnative plant disturbance. The predominance of invasive nonnative plants (inclusive of highly competitive nonnative plants) at serious and extreme disturbance levels rangewide suggests that the primary threat with the greatest rangewide influence on current EO and subEO estimated viability is invasive nonnative plants.

Invasive nonnative plant disturbance (inclusive of highly competitive nonnative plants) is widespread within all three geographic areas. The breakdown of EOs and subEOs in the moderate-serious, serious, or extreme disturbance condition categories for nonnative plants by geographic area is 93.3 percent (14 EOs) for Foothills, 70.73 percent (29 EOs and subEOs) for Jarbidge, and 95.92 percent (47 EOs) for Snake River Plain (Figure 24). Only 6.67 percent (1 EO) of Foothills, 29.27 percent (12 EOs and subEOs) of Jarbidge, and 4.08 percent (2 EOs) of Snake River Plain EOs and subEOs are in the slight, slight-moderate, or moderate current disturbance condition category for invasive nonnative plants. In contrast, 86.67 percent (13 EOs) of Foothills, 68.29 percent (28 EOs and subEOs) of Jarbidge, and 61.22 percent (30 EOs) of Snake River Plains EOs and subEOs are unburned, with 2.04 percent (1 EO) in Snake River Plain having moderate levels of wildfire disturbance. The remaining 13.33 percent (2 EOs) of Foothills, 31.71 percent (13 EOs and subEOs) of Jarbidge, and 36.74 percent (18 EOs) of Snake River Plain EOs and subEOs have serious or extreme levels of wildfire disturbance.



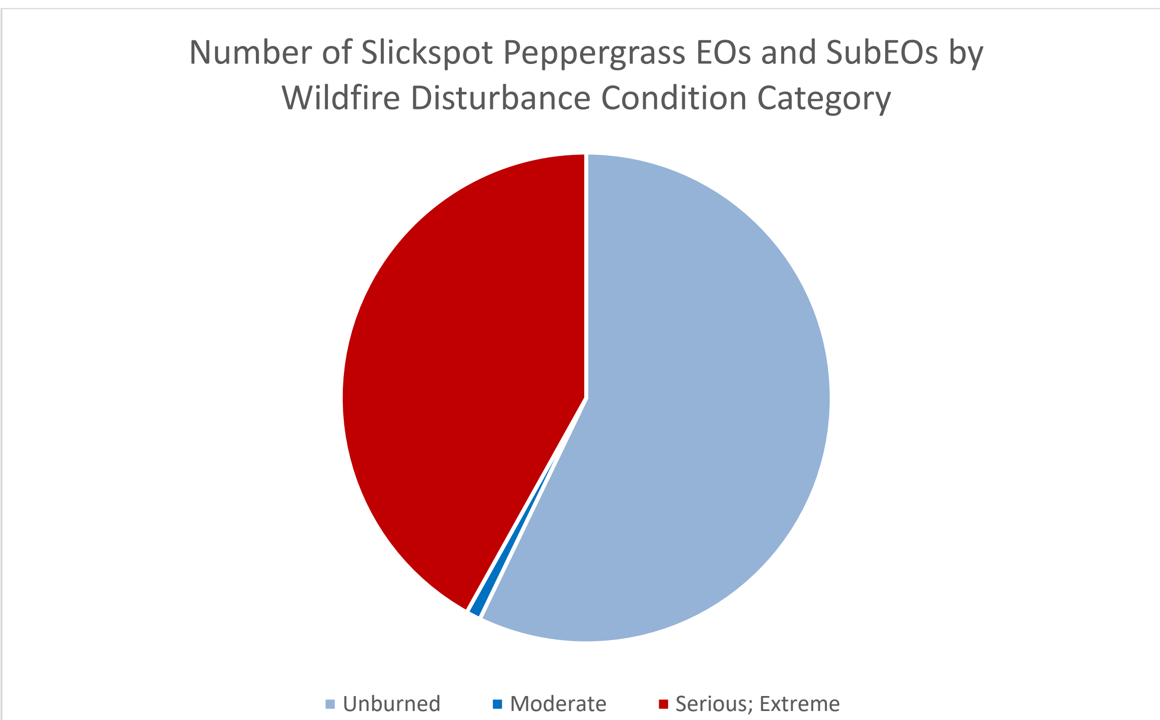


Figure 23. Invasive nonnative plant and wildfire disturbance condition summarized for EOs and subEOs rangewide. The invasive nonnative plant disturbance condition category also includes highly competitive nonnative plants.

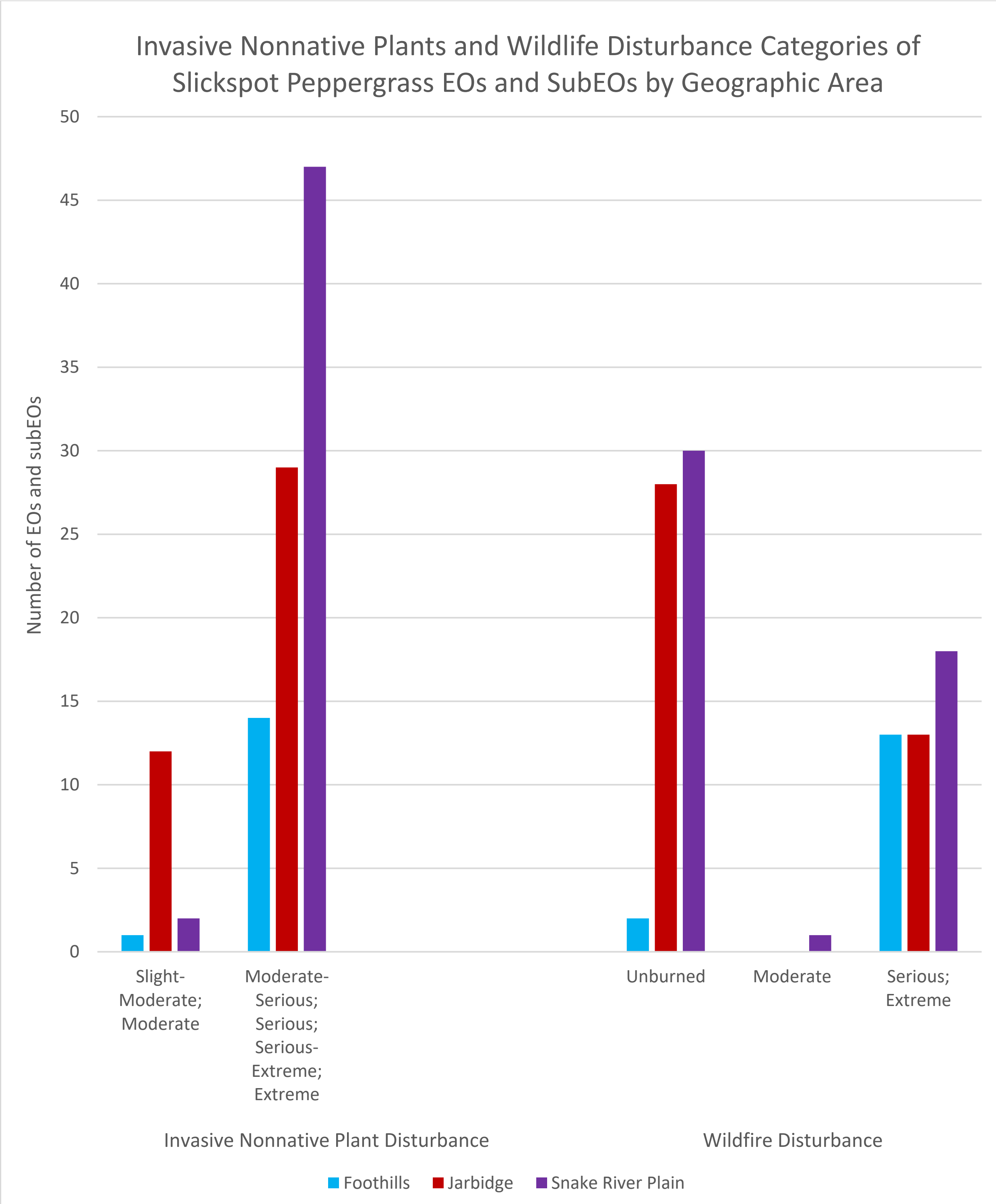
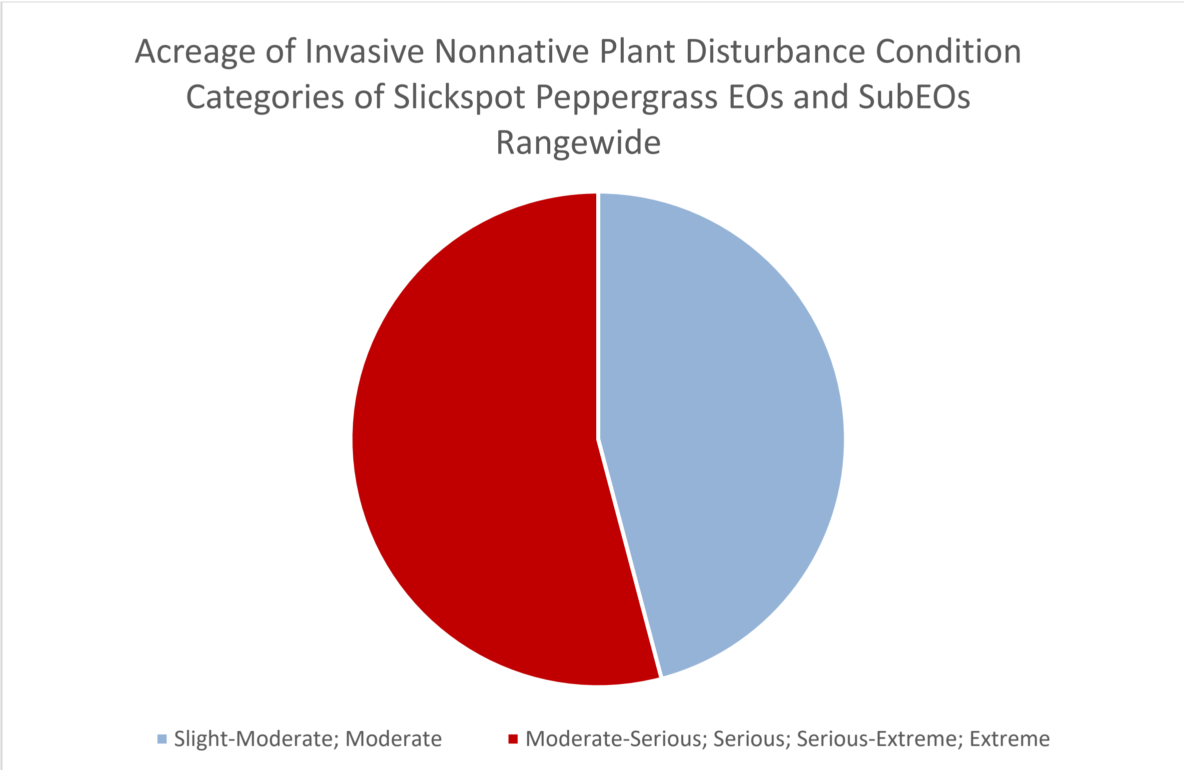


Figure 24. Invasive nonnative plants and wildfire disturbance condition of slickspot peppergrass EOs and subEOs by geographic area. The invasive nonnative plant disturbance condition category also includes highly competitive nonnative plants.

As EOs and subEOs can vary significantly in total area, examination of EO and subEO acreage by current disturbance condition may provide a more meaningful image of the current condition of slickspot peppergrass populations relative to invasive nonnative plants (inclusive of highly competitive nonnative plants) and wildfire (Figure 25). Of the approximately 15,941 total acreage of the 105 EOs and subEOs with available data rangewide, 45.88 percent (7,314 acres) are in the slight, slight to moderate, or moderate condition relative to invasive nonnative plants, with the remaining 54.12 percent (8,627 acres) in the moderate to serious, serious, or extreme condition relative to invasive nonnative plants. In contrast, 92.31 percent (14,715 acres) of EO and subEO acreage rangewide are unburned and 0.05 percent (8 acres) had moderate levels of wildfire disturbance, with the remaining 7.64 percent (1,218 acres) with serious or extreme levels of wildfire disturbance. While the vast majority of EO and subEO acreage across the range of the species is currently unburned, about 54 percent of EO and subEO acreage rangewide has severe to extreme disturbance associated with invasive nonnative plants. Thus, total EO/subEO numbers and acreage data support the suggestion that invasive nonnative plants (inclusive of highly competitive nonnative plants) exert a greater influence on current condition of EOs and subEOs rangewide relative to wildfire.

The breakdown by geographic area for EO and subEO acreages in the slight, slight to moderate, or moderate disturbance condition relative to invasive nonnative plants is 13.91 percent (19 acres) of Foothills, 2.02 percent (60 acres) of Jarbidge, and 55.20 percent (7,235 acres) of Snake River Plain (Figure 26). The breakdown by geographic area for EOs and subEOs in moderate-serious to extreme current disturbance condition for nonnative invasive plants is 86.09 percent (119 acres) of Foothills, 97.98 percent (2,637 acres) of Jarbidge, and 44.80 percent (5,871 acres) of Snake River Plain. The more favorable condition shown for Snake River Plain EO acreage is primarily due to a single 7,164 acre EO (EO 27) categorized as slight-moderate disturbance for invasive nonnative plants.

As described above, the vast majority of EO and subEO acreage rangewide are currently unburned. By geographic area, 96.75 percent (119 acres) of Foothills, 93.29 percent (2,516 acres) of Jarbidge, and 92.06 percent (12,066 acres) of Snake River Plains EO and subEO acreages are unburned, while 0.06 percent (8 acres) of Snake River Plain EO acreage has moderate disturbance from wildfire. The remaining 3.25 percent (4 acres) of Foothills, 6.71 percent (181 acres) of Jarbidge, and 7.88 percent (1,032 acres) of Snake River Plain EO and subEO acreages have serious or extreme levels of wildfire disturbance. However, all EOs and subEOs rangewide continue to be vulnerable to wildfire due to their location within low ecological resistance and resilience areas, many of which are currently dominated by invasive nonnative plants.



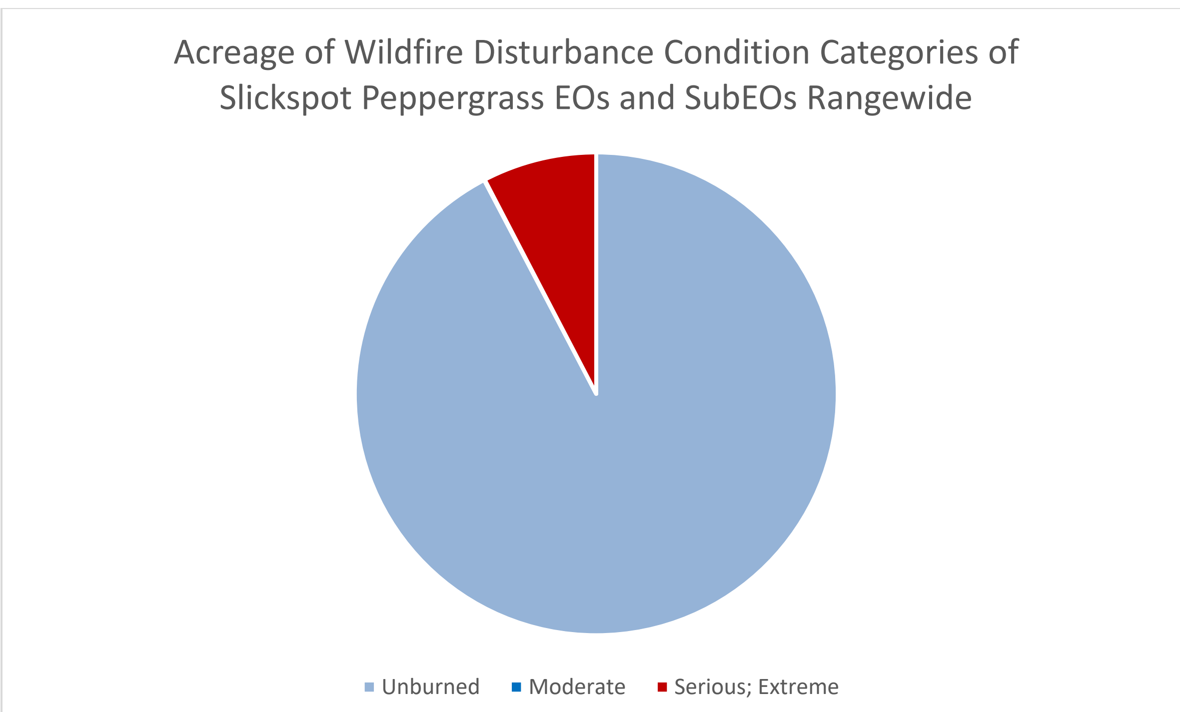


Figure 25. Invasive nonnative plant and wildfire disturbance condition of slickspot peppergrass EO and subEO acreages rangewide. The invasive nonnative plant disturbance condition category also includes highly competitive nonnative plants.

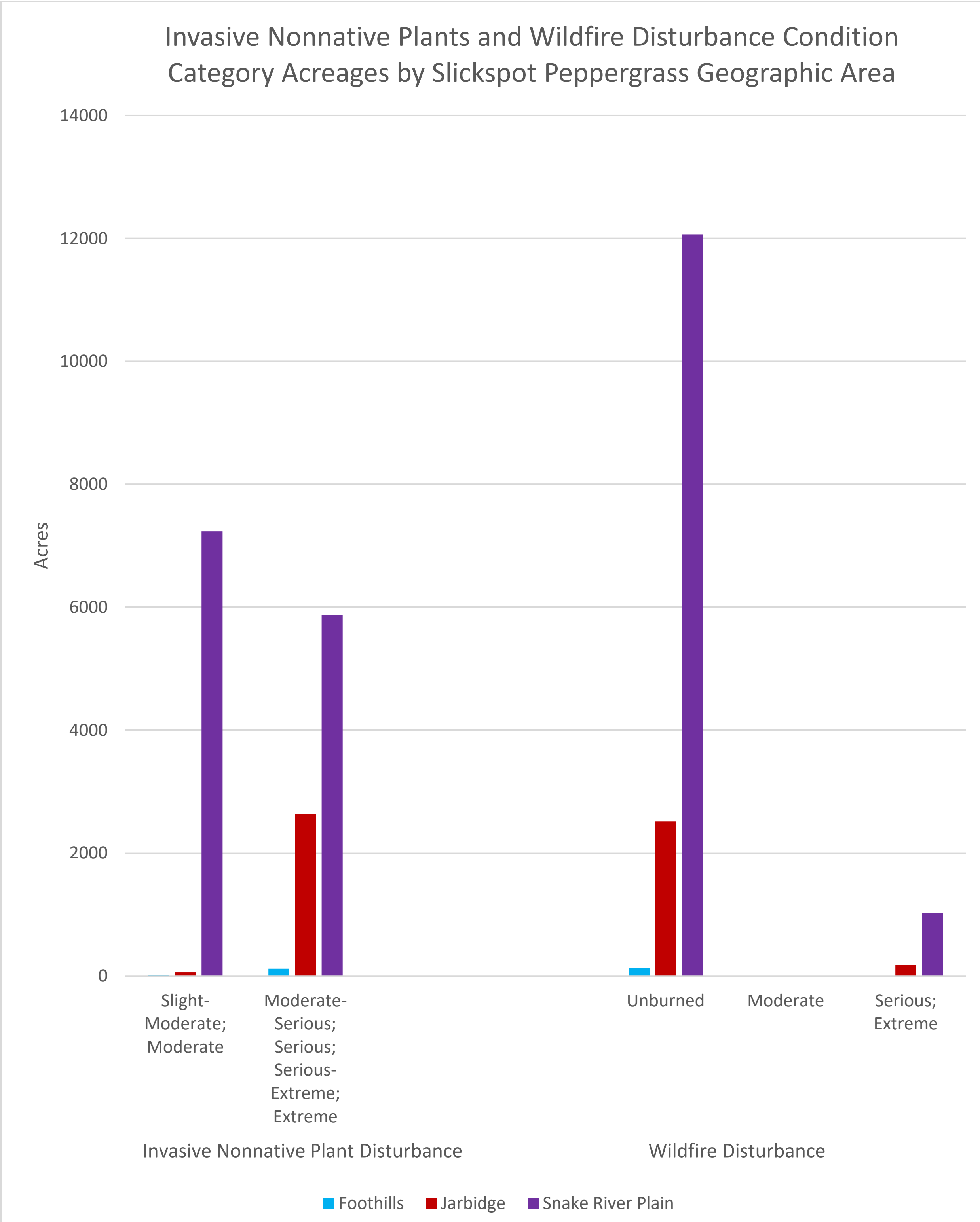


Figure 26. Invasive nonnative plants and wildfire disturbance condition of slickspot peppergrass EO and subEO acreages by geographic area. Note that for this analysis, the invasive nonnative plant disturbance category also includes highly competitive nonnative plants.

4.6 Summary of Current Condition

Viability is the probability of persistence at some demographic status over some period. Species viability is characterized by the current knowledge of species requirements, environmental conditions (including threats and conservation efforts for individuals and their habitat), and definition of viability (including demographic and temporal parameters). Table 11 summarizes the species requirements, factors affecting survival, and current condition of slickspot peppergrass.

Table 11. Summary of requirements, factors affecting survival, and current conditions of slickspot peppergrass individuals and populations, and the species' viability (representation, redundancy, and resiliency).

INDIVIDUALS	**POPULATIONS (EO and subEOs)**	**SPECIES**
I. Requirements of slickspot peppergrass.		
Light Nutrients Adequate water during summer for biennial rosettes survival and in late winter and spring for successful seedling, rosette, and flowering plant growth. Diverse insect pollinators for successful seed production Undisturbed, functional slick spot microsites relatively devoid of competing vegetation for successful seedling, rosette, and flowering plant growth as well as to provide a secure location for the persistent seed bank Shrubs surrounding slick spot microsites, which reduce	Estimated Minimum Viable Population (MVP) of 1,000 plants Minimum patch size of 500 acres of relatively intact sagebrush steppe habitat that contains functional slick spot microsites connected with other habitat patches through corridors of intact habitat Shrub cover to reduce evaporation from sunlight and wind, reduce silt entry into slick spots, and increase water availability due to snow retention and root hydraulic lift Shrub cover to reduce the risk of seed predation by Owyhee harvester ants An abundance of insects that are effective slickspot peppergrass pollinators	Larger populations (≥1,000 plants) located within intact sagebrush steppe habitat (e.g., good to excellent viability) distributed across the range of the species Contiguous intact native sagebrush steppe habitat, including patches of diverse native forbs, between populations to allow for genetic exchange and increased genetic diversity Genetically and physiologically diverse populations (including populations representing the elevation extremes of the species) are adequately distributed across the range of the species to maximize redundancy

INDIVIDUALS	POPULATIONS (EO and subEOs)	SPECIES
evaporation from sunlight and wind, reduce silt entry into slick spots, and increase water availability due to snow retention and root hydraulic lift. Shrubs to also reduce the risk of seed predation by Owyhee harvester ants	Diverse native flowering plants with overlapping bloom times to provide food for pollinators throughout the seasons Low risk of insect pollinator pesticide exposure Relatively intact sagebrush steppe habitat (native shrubs, grasses, forbs, and biological soil crusts) to support insect pollinators within and between populations to allow for genetic exchange and increased genetic diversity Adequate population density that is distributed such that insect pollinator-mediated gene flow occurs between higher viability (A- and B-ranked) populations Sufficient genetic diversity to impart adaptive capability, low inbreeding, and sexual out-crossing Infrequent wildfire disturbance (sagebrush steppe historic wildfire cycle calculated as 169-338 years for Wyoming big sagebrush in Idaho (Bukowski and Baker 2013, p. 557).	
II. Factors affecting the survival of slickspot peppergrass.		
Increased frequency and intensity of wildfire results disturbance that facilitates the	Habitat fragmentation due to increased wildfire frequency increases encroachment and	Degraded habitat conditions and low ecological resistance and resilience result in

INDIVIDUALS	**POPULATIONS (EO and subEOs)**	**SPECIES**
spread of invasive nonnative plants, which reduce slickspot peppergrass numbers through competition Removal of shrubs following frequent wildfire in sagebrush steppe habitats and conversion to early seral grasslands increase habitat availability for Owyhee harvester ants, an efficient seed predator of slickspot peppergrass that can remove up to 100 percent of slickspot peppergrass seeds from individual plants and the soil surface, depending on plant density within slick spots. Increased establishment and spread of invasive nonnative plants result in direct competition with slickspot peppergrass, reducing plant numbers Disturbance within and adjacent to occupied slick spots through recreational traffic, livestock trampling, off road vehicle use, post-fire Emergency Stabilization and Rehabilitation, or wildfire suppression actions can bury seeds too deep for successful seedling emergence, damage or kill individuals when plants are actively growing in spring, or create conditions conducive to establishment of undesirable plants that compete directly with	competition from invasive unseeded nonnative plants and highly competitive seeded nonnative plants result in lower slickspot peppergrass population numbers and reduced habitat patch size Although the persistent seed bank allows for some buffering of populations to periodic disturbance or drought, small population size and habitat patch size increases the risk of reduced population viability associated with stochastic events and reduced genetic fitness Disturbance within and adjacent to populations through recreational traffic, livestock trampling, off road vehicle use, post-fire Emergency Stabilization and Rehabilitation, or wildfire suppression actions can create conditions conducive to establishment of undesirable plants that compete with native plants required to maintain insect pollinators and that facilitate the cheatgrass / wildfire cycle Increased development can result in further loss of remnant native sagebrush steppe habitat and slick spot microsites, partial or complete loss of slickspot	challenges for both habitat conservation and sagebrush steppe habitat restoration efforts for the plant and its insect pollinators Forbs to provide food and shelter for insect pollinators are limited within much of the species' range Degraded habitat condition and habitat fragmentation reduces connectivity between populations as the maximum distance of insect pollinator dispersal is exceeded Climate change can accelerate the risk of wildfire and the spread of invasive nonnative plants throughout the range of slickspot peppergrass.

INDIVIDUALS	**POPULATIONS (EO and subEOs)**	**SPECIES**
slickspot peppergrass and contribute to the increased frequency of wildfire Development and associated infrastructure can result in direct loss of slick spot microsites and slickspot peppergrass plants Predicted climate changes in precipitation and temperature patterns may reduce recruitment of annual and biennial flowering plants though reduced seedling, rosette, and flowering plant survival.	peppergrass populations, and may increase the risk of fire and invasive nonnative plant spread Loss of intact sagebrush steppe habitat to wildfire, invasive nonnative plants, and development within or between populations can increase the extent of fragmentation barriers to insect pollinator-mediated genetic exchange	
III. Current Conditions of slickspot peppergrass.		
Numbers of individual annual and biennial flowering plants closely correlate with winter and spring precipitation levels Wide fluctuations in annual numbers of slickspot peppergrass plants are primarily driven by high plant numbers within a few large populations located in the Snake River Plain geographic area during years of adequate spring rainfall. 28 percent of the 105 EOs and subEOs with data currently have serious to extreme severity levels of wildfire disturbance within	There are currently 115 extant EOs located in 6 Idaho counties On the 58 transects monitored within 45 EOs and subEOs, 48,634 rosettes and flowering plants were observed 2016, the second highest number of plants observed over 13 years of HIP monitoring. In 2018, the second lowest number of plants (9,669) were observed. Statistical analysis of 11 years of monitoring data showed a statistically significant downward trend in slickspot peppergrass EO and subEO numbers over time, particularly in the Jarbidge geographic area	Total acreage occupied by slickspot peppergrass is about 16,279 acres. Rangewide population sampling showed little genetic divergence among populations. Populations have sufficient genetic diversity for fertilization and out-crossing. Higher density populations are well distributed across the species range but are separated by distances that limit genetic exchange among populations.

INDIVIDUALS	POPULATIONS (EO and subEOs)	SPECIES
71 – 100 percent of an individual EO/subEO area. 83 percent of the 105 EOs and subEOs with data currently have serious to extreme severity levels of invasive nonnative plant cover within 71 – 100 percent of an individual EO/subEO area. Competition between slickspot peppergrass plants and invasive nonnative annual grasses (such as cheatgrass) is increasing, and a strong negative correlation exists between cheatgrass cover in slick spot microsites and slickspot peppergrass plant numbers. 43 percent of the 105 EOs and subEOs with data available currently have some level of development disturbance within an individual EO/subEO area. About 1 percent of the 105 EOs and subEOs with data currently have serious to extreme severity levels of development disturbance within 71 – 100 percent of the individual EO/subEO area. 70 percent of the 105 EOs and subEOs with data currently have some level of livestock-related disturbance observed, although most disturbance was at a moderate to slight severity levels within individual EO/subEO	A total of 19 of the 105 EOs and subEOs with available data contain the estimated MVP of 1,000 plants 6 of these 19 EOs and subEOs are located in sites with sufficient patch size (500 acres) and habitat quality to currently be considered viable Genetic studies have shown that slickspot peppergrass populations currently have acceptable levels of genetic diversity; however, this level of genetic diversity may be historic due to buffering by the persistent seed bank Optimal population density would allow gene flow between higher quality (B- and C-ranked) EOs and subEOs within areas where EOs/subEOs are located in closer proximity. The 29 smaller D- and D?-ranked EOs and subEOs are at greater risk for loss of genetic diversity and extirpation than the 29 B-and BC-ranked or the 49 C-, C?-, and CD-ranked populations. No A-ranked EOs/subEOs currently exist. The high proportion of State and Federal land ownership within the species' range has	

INDIVIDUALS	POPULATIONS (EO and subEOs)	SPECIES
areas. About 6 percent of the 105 EOs and subEOs with data currently have serious to extreme levels of livestock-related disturbance within 71 – 100 percent of individual EO/subEO areas.	provided conservation opportunities through agreements, land use plans, and section 7 consultations The predominance of invasive nonnative plants (inclusive of highly competitive nonnative plants) at serious and extreme disturbance levels rangewide suggests that the primary threat with the greatest rangewide influence on current EO and subEO estimated viability is invasive nonnative plants Based on the current condition of 105 populations analyzed rangewide, 85.71 percent (90 EOs and subEOs) of EOs and subEOs contain moderate – serious, serious, or extreme levels of nonnative plant disturbance (inclusive of highly competitive nonnative plants). In contrast, 31.43 percent (33) EOs and subEOs have serious or extreme levels of wildfire disturbance, and a little over 67 percent of EOs and subEOs are currently unburned While 92.31 percent (14,715 acres) of EO and subEO acres across the range of the species are currently unburned, about 54 percent of EO and subEO acreage rangewide has severe to extreme disturbance	

INDIVIDUALS	POPULATIONS (EO and subEOs)	SPECIES
	associated with invasive nonnative plants. Total EO/subEO numbers and acreage data support the suggestion that invasive nonnative plants (inclusive of highly competitive nonnative plants) likely exert a stronger influence on current declining conditions of EOs and subEOs rangewide relative to wildfire.	

5. Analysis of Future Conditions – Species Viability

The viability of slickspot peppergrass depends on maintaining resiliency, representation, and redundancy for the species over time, but uncertainties exist regarding what conditions may be like in the future. Habitat degradation, fragmentation, and loss may continue mainly due to the primary threats of wildfire and invasive nonnative plants (primarily invasive nonnative annual grasses). During recent field assessments by IDFG, invasive nonnative plants and wildfire were identified as future threats that were universal to all EOs and subEOs rangewide (IDFG raw data as summarized in Appendix F). Furthermore, climate change is predicted to facilitate the spread of invasive nonnative plants (especially nonnative annual grasses) and wildfire within the range of slickspot peppergrass. Potential changes in future precipitation levels and temperatures could also directly affect slickspot peppergrass and its habitat because the species is reliant on winter and spring precipitation to replenish available water in slick spot microsite soils.

To address uncertainties of future conditions and the viability of slickspot peppergrass, we developed three scenarios to evaluate the primary threats and their likely impacts on resiliency, redundancy, and representation. Future conditions under these three scenarios were analyzed using species experts, with a focus on the two primary threats of wildfire and invasive nonnative plants.

5.1 Future Scenarios

We developed three future risk scenarios based on the foreseeable future time frame, used in our 2016 listing reinstatement decision, of 50 years. The three future scenarios are described as follows:

5.1.1 Worse Than Expected

No new tools or conservation measures[5] would be available to reduce the risk of wildfire and invasive nonnative annual grass cover, and adequate funding to continue currently implemented conservation measures would not be available over the next 50 years.

5.1.2 Better than Expected

New tools would be available to reduce the current risk levels of wildfire (for example, increased wildfire suppression effectiveness, strategically placed fuel treatments and fuel breaks, and increased livestock grazing management flexibility). Tools would also be available to reduce the current risk levels of invasive nonnative annual grasses (for example, breakthrough biocontrol treatments for cheatgrass and higher success rates and lower costs for native grass and forb reestablishment). All tools would be available and adequately funded over the next 50 years.

5.1.3 Status Quo

The current rate of wildfire and extent of invasive nonnative annual grass cover and their associated effects on slickspot peppergrass populations, as well as implementation of current conservation measures, would continue to occur unchanged over the next 50 years.

5.2 Analyzing Future Condition Using Experts

We elicited expert opinion to assess the future condition and viability of slickspot peppergrass under the three scenarios described above. Expert elicitation is particularly useful in (1) identifying data gaps and (2) clarifying the best available information regarding species' needs and future status. To facilitate information exchange and elicit individual expert opinion on issues relating to the species' future status and viability, the Idaho Fish and Wildlife Office convened two in-person meetings in Boise, Idaho on April 17 and April 26, 2018, with 15 External Species Experts and on-the-ground management practitioners (referred to collectively in this document as External Species Experts; USFWS 2018b *in litt.*, entire). We did not seek consensus among experts. Instead, we focused on fully probing and understanding the basis for, and extent of, differences of opinion or interpretation. Discussions were focused on scientific and technical information; experts were not asked to provide, nor did they voluntarily discuss or recommend, management decisions related to the Endangered Species Act.

We used the SSA Framework to identify information gaps and to develop a series of questions for the External Species Experts to assist the Service in predicting future species viability based on the two primary threats to the species: increased frequency and intensity of wildfire and introduction and spread of invasive nonnative plants. Based on the foreseeable future time frame

[5] Examples of potential new tools or conservation measures included increased availability of genetically appropriate plant materials for use in habitat restoration efforts, new effective techniques for increased desirable plant establishment success, increased availability of effective, selective herbicides and biocontrol agents for control of nonnative annual grasses, use of alternative, economical fuels management techniques (such as increased flexibility from current livestock grazing management parameters), and increased use of coordinated, multiple-entity wildfire suppression efforts beyond current levels.

used in the Service's 2016 listing reinstatement decision, we used a 50-year time frame for this exercise.

Using our three future scenarios, we asked the External Species Experts to choose their levels of confidence that changes in wildfire frequency and invasive nonnative plant introduction and spread over the next 50 years would result in improved slickspot peppergrass plant numbers and habitat condition of current B-, BC-, or C-ranked EOs and subEOs such that some EO rankings would increase. External Species Expert exercises were focused on populations with good to fair viability as lower viability populations (CD- and D-ranked EOs and subEOs) have a reduced probability of persisting into the future. Some lower viability EOs and subEOs may be considered priorities for conservation actions if they are genetically or otherwise unique, but most smaller acreage, D-ranked EOs and subEOs are expected to have a lower probability for increased viability over time even with focused investment of resources to improve habitat conditions and EO and subEO plant numbers.

Thirteen external species experts participated in this exercise. We directed the External Species Experts to express their levels of confidence for scenarios in this exercise based on descriptions of probability from Morgan *et al.* 2009 (p. 27) as shown in Table 12.

Table 12. Verbal descriptions of probability and associated numeric ranges.

Word	Probability Range
Virtually certain	< 0.99
Very likely	0.90 to 0.99
Likely	0.66 to 0.90
Medium likelihood	0.33 to 0.66
Unlikely	0.10 to 0.33
Very unlikely	0.01 to 0.10
Exceptionally unlikely	< 0.01

5.2.1 Worse Than Expected

We asked the External Species Experts to independently relay their opinion on the probability that any current B-, BC-, or C-ranked EOs and subEOs could increase in rank if no new tools or conservation measures would be available to reduce the risk of wildfire and invasive nonnative plants, especially nonnative annual grasses, over the next 50 years. These estimates were also included the assumption that adequate funding to continue to implement current conservation measures would not be available over the next 50 years. No External Species Experts expressed confidence that any current B-, BC-, or C-ranked EOs and subEOs could increase in rank if no advances in wildfire suppression and invasive nonnative plant controls were available and funding was inadequate to fully implement current conservation measures for the species. All External Species Experts considered it either very unlikely (38 percent, or 5 experts) or exceptionally unlikely (62 percent, or 8 experts) that any current B-, BC-, or C-ranked EOs and subEOs could increase in rank over the next 50 years with no new tools and lack of adequate funding available to reduce the risk of wildfire and invasive nonnative plants to the species. Thus, the risk of wildfire and invasive nonnative plants, especially nonnative annual grasses, would be very unlikely to exceptionally unlikely to increase the rankings of any current B-, BC-, or C-ranked EOs and subEOs over the next 50 years under the worse than expected scenario.

5.2.2 Better than Expected

We asked the External Species Experts to independently relay their opinion on the probability that any current B-, BC-, or C-ranked EOs and subEOs could increase in rank if new tools or conservation measures would be available to reduce the risk of wildfire and invasive nonnative plants (especially nonnative annual grass) over the next 50 years. These estimates were also to include the assumption that adequate funding to continue currently implemented conservation measures would be available over the next 50 years. Most External Species Experts expressed confidence that some current B-, BC-, or C-ranked EOs and subEOs could increase in rank if advances in wildfire suppression and invasive nonnative plant controls were available and adequate funding would be available to fully implement conservation measures for the species. Seventy-seven percent of External Species Experts believed that it was either likely (5 experts) or have a medium likelihood (5 experts) that some current B-, BC-, or C-ranked EOs and subEOs could increase in rank over the next 50 years with if new tools and adequate funding would be available to reduce the risk of wildfire and invasive nonnative plants to the species. There were several outliers, as one expert believed it was virtually certain, one expert felt it would be very likely, and one expert who felt it was extremely unlikely that some current B-, BC-, or C-ranked EOs and subEOs could increase in rank over the next 50 years if new tools and adequate funding would be available to reduce the risk of wildfire and invasive nonnative plants to the species. Thus, the reduced risk of wildfire and invasive nonnative plants, especially nonnative annual grasses, would have a medium likelihood or be likely to increase the rankings of at least some current B-, BC-, or C-ranked EOs and subEOs over the next 50 years under the Better than Expected scenario.

5.2.3 Status Quo

We asked the External Species Experts to independently relay their opinion on the probability that any current B-, BC-, or C-ranked EOs and subEOs could increase in rank if the current risk of wildfire and invasive nonnative plant cover, especially nonnative annual grass cover, and associated effects on slickspot peppergrass populations continued over the next 50 years. These estimates also included the assumption that all ongoing threats would continue to impact slickspot peppergrass at current levels and that all current conservation measures intended to ameliorate threats would continue to be implemented. No External Species Experts considered it to be virtually certain, very likely, or likely that any current B-, BC-, or C-ranked EOs and subEOs could increase in rank in 50 years if rates of wildfire and invasive nonnative plants, especially nonnative annual grasses, continued on current trajectories and current conservation measures continued to be implemented.

All External Species Experts considered a medium likelihood or less that some current B-, BC-, or C-ranked EOs and subEOs could increase in rank in 50 years. About 38 percent (5 experts) of the external species experts believed that it was unlikely that current some current B-, BC-, or C-ranked EOs and subEOs could increase in rank, and another 38 percent (5 experts) of the External Species Experts felt it was exceptionally unlikely that some current B-, BC-, or C-ranked EOs and subEOs could increase in rank over the next 50 years under ongoing conditions.

One expert expressed a medium likelihood that some current B-, BC-, or C-ranked EOs and subEOs could increase in rank in 50 years under ongoing conditions, while another two experts believed it was very unlikely that any current B-, BC-, or C-ranked EOs and subEOs could increase in rank under ongoing conditions. Thus, ongoing risk levels of wildfire and invasive nonnative plants, especially nonnative annual grasses, coupled with current conservation measures to ameliorate these risks are primarily unlikely to exceptionally unlikely to increase the rankings of at least some current B-, BC-, or C-ranked EOs and subEOs over the next 50 years.

5.2.4 Summary of Future Condition Using Experts

The outcome for each of the three future scenarios as elicited from individual External Species Experts is summarized in Table 13. Experts projected the probability that some current B-, BC-, or C-ranked EOs and subEOs could maintain or increase in rank over the next 50 years under each scenario.

Table 13. Summary of External Species Expert exercises examining the expected impacts of wildfire and invasive nonnative plants (especially nonnative annual grasses) on slickspot peppergrass under each of three future scenarios.

Probability of Maintaining or Increasing the Rank of Some Current B-, BC- or C-ranked EOs and subEOs over the Next 50 Years	Future Scenarios		
	Worse than Expected: No New Tools & Inadequate Funding for Implementation	Better Than Expected: New Tools & Adequate Funding for Implementation	Status Quo: Maintain Current Management & Conservation Measures
Virtually certain	0	1	0
Very likely	0	1	0
Likely	0	5	0
Medium likelihood	0	5	1
Unlikely	0	0	5
Very unlikely	5	0	2
Exceptionally unlikely	8	1	5
TOTAL	**13**	**13**	**13**

The External Species Experts were also asked to consider the Status Quo, Worse than Expected, or Better than Expected scenarios as described above separately for increased frequency and intensity of wildfire alone and for introduction and spread of invasive nonnative plants, especially nonnative annual grasses, alone. The External Species Experts expressed the need to examine the two primary threats of increased frequency and intensity of wildfire and introduction and spread of invasive nonnative plants simultaneously due to their close relationship within the range of slickspot peppergrass. Most External Species Experts expressed concern that there would likely be no conservation benefit for slickspot peppergrass by addressing one primary threat alone independent of the other primary threat. Therefore, little confidence was expressed that an increase in rankings of at least some current B-, BC-, or C-ranked EOs and subEOs would occur in scenario exercises when only one of the two primary threats was considered. Therefore, addressing both increased frequency and intensity of wildfire as well as introduction and spread of invasive nonnative plants, especially nonnative annual grasses, within complementary time frames would be important for ensuring future viability of slickspot peppergrass EOs and subEOs.

5.3 Estimate of Future Condition Based on Two Primary Threats

Our estimate of future species condition based on the primary threats of invasive nonnative plants and wildfire used the External Species Experts input under our three future scenarios coupled with estimated effects of future climate change. Predicted future resiliency, representation, and redundancy of slickspot peppergrass under each of the three future scenarios are described below.

5.3.1 Worse Than Expected

Resiliency - Estimated future population resiliency to stochastic events under the Worse than Expected scenario is expected to accelerate current downward population trends as slickspot peppergrass plant numbers and habitat condition in B-, BC-, and C-ranked EOs would be reduced and current levels of decline would increase over the next 50 years. While the persistent seed bank would provide some buffering effects, habitat fragmentation and degradation associated with increased rates of wildfire and invasive nonnative plants expansion (especially nonnative annual grasses) are expected to provide minimal resiliency of individual EOs and subEOs to stochastic events such as drought or ground disturbance, particularly with the lack of implementation of conservation measures due to the lack of adequate funding. Stochastic events that occur under these more severe conditions could represent a tipping point that would result in reduced individual EO and subEO viability or the loss of smaller EOs and subEOs due to added stresses of drought or uncontrolled ground disturbance.

Representation - Estimated future species representation across the range of the species under the Worse than Expected scenario is expected to significantly decline. Genetic diversity would likely be reduced, particularly in smaller, more isolated populations, due to fragmentation and limitations on insect pollinator facilitated genetic exchange. Smaller populations, especially populations at the lower elevation extent of the species range, are likely to be lost due to increased wildfires and invasive nonnative plant spread (especially nonnative annual grasses) and associated habitat fragmentation and degradation. With the accelerated increased wildfire frequencies and spread of invasive nonnative plants, the majority of EOs and subEOs, including populations in the genetically unique Jarbidge geographic area, could be lost.

Redundancy - Estimated future population redundancy to withstand catastrophic events across the range of the species under the Worse than Expected scenario is expected to continue in a downward trend as slickspot peppergrass plant numbers and habitat condition in B-, BC-, and C-ranked EOs would continue to decline over the next 50 years. While the persistent seed bank would provide some buffering effects, habitat fragmentation and degradation associated with wildfire and invasive nonnative plant expansion (especially invasive annual grasses) are expected to accelerate as current conservation measures could no longer be implemented. With accelerated wildfire and invasive nonnative plant spread, higher ranked EOs and subEOs across the range of the species are expected to degrade such that future plant numbers, EO condition, and surrounding landscape condition would result in lower rankings. Smaller EOs and subEOs with current CD- or D-rankings would likely be lost or become so degraded and contain such low plant numbers that they would essentially be extirpated.

5.3.2 Better than Expected

Resiliency - Estimated future population resiliency to stochastic events under the Better than Expected scenario is expected to maintain or increase from current levels as slickspot peppergrass plant numbers and habitat condition in B-, BC-, and C-ranked EOs stabilize or improve over the next 50 years. Through buffering effects of the persistent seed bank and maintenance of habitat conditions through decreased rates of wildfire and invasive nonnative plant expansion (especially for nonnative annual grass), resiliency of individual populations to stochastic events such as drought or ground disturbance would be maintained. Increased effectiveness of wildfire suppression and control of invasive nonnative plants would also contribute to success of habitat restoration and population augmentation projects, which would increase resiliency of treated slickspot peppergrass populations to stochastic events.

Representation - Estimated future representation across the range of the species is expected to stabilize at current levels under the Better than Expected scenario. Genetic diversity would be maintained, particularly in larger populations located within more intact habitat with higher potential for insect pollinator facilitated genetic exchange. With reduced wildfire and invasive nonnative plant (especially nonnative annual grass) threats, all EOs and subEOs, including populations in the genetically unique Jarbidge geographic area, have the potential to be effectively restored to conditions conducive to slickspot peppergrass population stability and growth. With control of these two primary threats, the probability of successful augmentation of smaller, more isolated populations would increase and habitat restoration projects could reduce current levels of fragmentation, thereby increasing the potential for insect pollinator facilitated genetic exchange.

Redundancy - Estimated future population redundancy to withstand catastrophic events across the range of the species under the Better than Expected scenario is expected to maintain or improve from current levels as slickspot peppergrass plant numbers and habitat condition in B-, BC-, and C-ranked EOs would stabilize or improve over the next 50 years. While the persistent seed bank would provide some buffering effects, habitat fragmentation and degradation associated with wildfire and invasive nonnative plant expansion (especially for nonnative annual grass), are expected to decrease due to increased funding and use of more effective wildfire suppression and habitat restoration techniques. With reduced risk of wildfire disturbance and invasive nonnative plant introduction and spread (especially nonnative annual grasses), higher ranked EOs across the range of the species are expected to be maintained or improve such that future plant numbers, EO condition, and surrounding landscape condition would result in the same or higher EO ranks relative to current rankings. However, as conservation priority would likely be focused on higher ranked EOs and subEOs, a risk remains that some smaller EOs and subEOs with current CD- or D-rankings may be lost or become so degraded and contain such low plant numbers that they would essentially be extirpated.

5.3.3 Status Quo

Resiliency - Estimated future population resiliency to stochastic events under the Status Quo scenario is expected to continue in a downward trend as slickspot peppergrass plant numbers in B-, BC-, and C-ranked EOs would continue to decline over the next 50 years. While the persistent seed bank would provide some buffering effects, habitat fragmentation and degradation associated with continued rates of wildfire and invasive nonnative plant expansion (especially nonnative annual grasses) are expected to reduce resiliency of individual populations to stochastic events such as drought or ground disturbance despite continued implementation of current conservation measures. Stochastic events that occur under these future reduced plant numbers and degraded habitat conditions would represent a tipping point that would result in reduced viability of individual EOs and subEOs over time.

Representation - Estimated future species representation across the range of the species under the Status Quo scenario is expected to decline. Genetic diversity would be reduced, particularly in smaller, more isolated populations due to continued fragmentation and limitations on insect pollinator facilitated genetic exchange for isolated populations. With the continued incidence of wildfire and spread of invasive nonnative plants (especially nonnative annual grasses), all EOs and subEOs, including populations in the genetically unique Jarbidge geographic area, would continue to degrade to lower than their current viability level, with some populations likely to be lost. Smaller EOs and subEOs with lower viability, especially EOs and subEOs at the lower elevation extent of the species range, may be lost due to increased wildfires and invasive nonnative plant spread and associated habitat fragmentation and degradation.

Redundancy - Estimated future population redundancy to withstand catastrophic events across the range of the species under the Status Quo scenario is expected to continue in a downward trend as slickspot peppergrass plant numbers in B-, BC-, and C-ranked EOs would continue to decline over the next 50 years. While the persistent seed bank would provide some buffering effects, habitat fragmentation and degradation associated with wildfire and invasive nonnative plants expansion (especially nonnative annual grasses) is expected to continue despite ongoing conservation efforts. With continued wildfire and invasive nonnative plant spread, higher ranked EOs across the range of the species are expected to degrade such that future plant numbers, EO condition, and surrounding landscape condition would result in lower EO rankings. Smaller EOs and subEOs with current CD- or D-rankings may be lost or become so degraded and contain such low plant numbers that they would essentially be extirpated. Although at lower than current levels, EO and subEO distribution among three geographic areas would allow for reduced risk to the species from large catastrophic events.

5.4 Summary of Future Condition

The outcomes of our three future scenarios relative to resiliency, representation, redundancy, and viability are summarized in Table 14. The scenario outcomes are based on predicted changes from current condition relative to the primary threats of wildfire and invasive nonnative plants and consider the predicted future effects of climate change.

Table 14. Future slickspot peppergrass resiliency, representation, redundancy, and viability under three future scenarios.

Viability Elements	**Worse than Expected**	**Better than Expected**	**Status Quo**
Population Resiliency	Public and private landowners are unable or unwilling to adequately protect extant EOs and subEOs due to lack of funding and new techniques to address wildfire and invasive nonnative annual grasses Very few to no EOs and subEOs approach, meet, or exceed MVP of 1,000 individuals within intact sagebrush steppe habitat We assume that many EOs and subEOs would have a large reduction in resiliency and would not persist or withstand stochastic events	Many public and private landowners are active participants in long-term protection, monitoring, and management and use new techniques to reduce wildfire and invasive nonnative plants Higher viability EOs and subEOs maintain current MVP levels of 1,000 individuals within intact sagebrush steppe habitat We assume that the majority of EOs and subEOs would maintain higher resiliency to	Most public and some private landowners allow protection, monitoring, and management of EOs and subEOs on their lands using currently available techniques to reduce wildfire and invasive nonnative plants Current management and habitat restoration efforts are implemented, but few EOs and subEOs meet or exceed MVP of 1,000 individuals within intact sagebrush steppe habitat We assume that some EOs and subEOs would have reduced resiliency

Viability Elements	**Worse than Expected**	**Better than Expected**	**Status Quo**
		withstand stochastic events similar to or greater than current levels	and would not persist or withstand stochastic events
Species Representation	We assume that most EOs and subEOs currently classified as fair to poor viability rangewide may be extirpated, resulting in reduced genetic diversity Overall genetic diversity further declines due to increased habitat degradation and fragmentation from accelerated wildfire and invasive nonnative plant spread Multiple EOs and subEOs are not likely to adapt to changing environmental conditions Representation would decline significantly from current levels	We assume that the majority of EOs and subEOs rangewide would persist, maintaining current levels of genetic diversity Genetic diversity within larger EOs and subEOs remains at current levels such that out-crossing would occur within each of the three geographic areas The majority of EOs and subEOs would be able to adapt to changing environmental conditions Representation would remain at or increase from current levels	We assume that some EOs and subEOs currently classified as fair to poor viability rangewide may be extirpated, resulting in reduced genetic diversity Overall genetic diversity further declines due to increased habitat degradation and fragmentation from accelerated wildfire and invasive nonnative plant spread Smaller and more isolated EOs and subEOs may not adapt to changing environmental conditions Representation would be somewhat lower than current levels
Species Redundancy	Through loss of multiple EOs and subEOs currently classified as fair to poor viability rangewide, there likely would not be a sufficient number and acreage of EOs and subEOs for the species	As the majority of EOs and subEOs rangewide would persist, there would remain a sufficient number and acreage of EOs and subEOs to withstand catastrophic events	Through loss of some lower viability EOs and subEOs rangewide, the ability of the species to withstand catastrophic events would be reduced from current levels

Viability Elements	**Worse than Expected**	**Better than Expected**	**Status Quo**
	to withstand catastrophic events Through loss of multiple EOs and subEOs, the ability to spread risk out between them is expected to be extremely limited due to loss of EO and subEOs Redundancy to withstand catastrophic events continues in a downward trend, and would be lowest of the three scenarios	Sufficient numbers and acreages of EOs and subEOs remain such that risk would be spread out between and among the three geographic areas Redundancy to withstand catastrophic events is expected to be maintained at or greater than current levels	Although higher viability EOs and subEOs remain within all three geographic areas, ability to spread risk out between them is expected to be limited due to loss of some EO and subEOs Redundancy to withstand catastrophic events continues in a downward trend
Overall Viability	Poor Species is declining toward endangered status and subsequent extinction due to accelerated wildfire frequency, invasive nonnative annual grass spread, and low success of habitat restoration efforts. Declines in habitat condition and plant numbers across the range of the species further accelerate	Excellent to Good Species viability is improving relative to current levels due to increased populations and habitat conservation, management, and protection. Current viability levels of individual populations are maintained or improved into the future, with current viability of some populations increased due to reduced wildfire frequencies, control of invasive nonnative plants, and native vegetation restoration at priority EOs/subEOs.	Fair to Poor Species is declining toward endangered status despite wildfire suppression and vegetation restoration efforts due to accelerated wildfire frequency, invasive nonnative annual grass spread, and low success of habitat restoration efforts in some EOs and subEOs, although overall population viability is higher than under the Worse than Expected scenario

6. Status Assessment Summary

We used three future scenarios to assess a range of possible conditions of how slickspot peppergrass populations are likely to persist into the future. We assessed future condition using External Species Expert input to predict future species resiliency, representation and redundancy under the three scenarios. Under the Status Quo Scenario, if conditions and funding were to remain the same, we expect that viability of slickspot peppergrass would continue to decline, although at reduced levels than predicted for the Worse than Expected scenario. The Better than Expected scenario predicts species viability that would maintain or improve the current condition based on availability of new conservation tools and adequate funding to address wildfire and invasive nonnative plants. While we may not be able to change potential future effects from predicted altered precipitation and temperature in southwestern Idaho, slickspot peppergrass EOs and subEOs are likely to be maintained or improved relative to current condition through the availability of additional funding as well as implementation of conservation measures and recommended actions (such as those suggested in Appendix G).

7. References

7.1 Literature Cited

Abatzoglou, J.T. and C.A. Kolden. 2013. Relationship between climate and macroscale area burned in the western United States. International Journal of Wildland Fire. Published online July 25, 2013. 18 pp.

Abatzoglou, J.T. and C.A. Kolden. 2011. Climate change in western US deserts: Potential for increased wildfire and invasive annual grasses. Rangeland Ecology and Management. 64(5): 471-478.

Agricultural Resource Service (ARS) Jornada Experimental Range, Bureau of Land Management Assessment, Inventory, and Monitoring Program, and Idaho Chapter of The Nature Conservancy. 2013. Emergency Stabilization and Rehabilitation. The Landscape Toolbox. 3 pp. Available online at: https://wiki.landscapetoolbox.org/doku.php/protocols:esr_monitoring (last accessed on June 13, 2019).

Akhtar, I. and N. Nazir. 2013. Effect of Waterlogging and Drought Stress on Plants. International Journal of Water Resources and Environmental Science. 2(2):34-40.

Allen, C.R., G.S. Cumming, A.S. Garmestani, P.D. Taylor, and B.H. Walker. 2011. Managing for resilience. Wildlife Biology. 17:337-349.

Angell, R.F. 1995. Crested wheatgrass and shrub response to continuous or rotational grazing. Journal of Range Management. 50:160-164.

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

Bakhtar, D, and F. Gray. 1971. Origin of "slick spot" soils of north central Oklahoma. A preliminary report. Proceedings of the Oklahoma Academy of Science. 51: 93-96.

Bakker, J.D., and S.D. Wilson. 2004. Using ecological restoration to constrain biological invasion. Journal of Applied Ecology. 41: 1058-1064.

Balch, J.K., B.A. Bradley, C.M. D`Antonio, and J.Gomez-Dans. 2013. Introduced annual grass increases regional fire activity across the arid western USA (1980-2009). Global Change Biology. 19: 173-183.

Barrett, S.C.H. and J.R. Kohn. 1991. Genetic and evolutionary consequences of small population size in plants: Implications for conservation. Pp. 3–30 *in* D. Falk and K.E. Holsinger, eds. Genetics and Conservation of Rare Plants. Oxford University Press, New York. 283 pp.

Baskin C.C. and J.M. Baskin. 2001. Seed Ecology, Biogeography, and Evolution of Dormancy and Germination. Academic Press. San Diego, California. Pp. 133-164, 399-404, 508-518, 565-570.

Baughman, O.W., A.C. Agneray, M.L. Forister, F.F. Kilkenny, E.K. Espeland, R. Fiegener, M.E. Horning, R.C. Johnson, T.N. Kaye, J. Ott, J.B. St. Clair, and E.A. Leger. 2019. Strong patterns of intraspecific variation and location adaptation in Great Basin plants revealed through a review of 75 years of experiments. Ecology and Evolution. 2019: 1-17. Available online at: https://onlinelibrary.wiley.com/doi/10.1002/ece3.5200 (last accessed June 14, 2019).

Belnap, J., J.H. Kaltenecker, R. Rosentreter, J. Williams, S. Leonard, and D. Eldridge. 2001. Biological soil crusts: Ecology and management. BLM Technical Reference 1730-2. January 2001. 119 pp.

Billinge, S.A. 2006. Reproductive performance as a function of outcrossing distance in *Lepidium papilliferum* (Brassicaceae), a rare plant endemic to Southwest Idaho. Master's thesis, Boise State University, Boise, Idaho. 72 pp.

Billinge, S.A. and I.C. Robertson. 2008. Spatial structure and inbreeding depression in slickspot peppergrass, *Lepidium papilliferum* (Brassicaceae). Botany 86:1002-1008.

Billings, W.D. 1990. Bromus tectorum, a biotic cause of ecosystem impoverishment in the Great Basin. In: Woodwell, G. M., ed. The earth in transition: patterns and processes of biotic impoverishment. New York: Cambridge University Press: 301-322.

Blake, S. 2015. 2104 Slickspot Peppergrass (*Lepidium papilliferum*) Monitoring Permanent Transects Juniper Butte Range. Prepared for United States Air Force, Environmental Management, 366 CES/CEIE, Mountain Home Air Force Base, Idaho. Report by Land Management and Research Demonstration Program, U.S. Fish and Wildlife Service, Mid-Columbia River Refuge Complex, Burbank, Washington. January 2015. 29 pp. + figures and appendices.

Blank, R. S. and T. Morgan. 2012. Suppression of *Bromus tectorum* L. by established perennial grasses: potential mechanisms – Part One. Applied Environmental Soil Science 2012: Article ID 632172. 9 pp

Bond, L. 2017. Trends in counts of Slickspot Peppergrass (*Lepidium papilliferum*) on Habitat Integrity and Population Monitoring transects, 2005 – 2015. Boise State University, Boise, Idaho. Report prepared for the US Fish and Wildlife Service. June 30, 2017. 44 pp. + appendices.

Booth, M.S., M.M. Caldwell, and J.M. Stark. 2003. Overlapping resource use in three Great Basin species: implications for community invisibility and vegetation dynamics. Journal of Ecology. 91:36-48.

Bradley, B.A., and J.F. Mustard. 2006. Characterizing the landscape dynamics of an invasive plant and risk of invasion using remote sensing. Ecological Applications 16(3):1132-1147.

Brooks, M.L., and D.A. Pyke. 2001. Invasive plants and fire in the deserts of North America. Pp. 1-4 in K.E.M. Galley and T.P. Wildson, eds. Proceedings of the Invasive Species

Workshop: the Role of Fire in the Control and Spread of Invasive Species Fire Conference 2000: the First National Congress on Fire Ecology, Prevention, and Management.

Brooks, M.L., C.M. D`Antonio, D.M. Richardson, J.B. Grace, J.E. Keeley, J.M. DiTomaso, R.J. Hobbs, and D. Pyke. 2004. Effects of invasive alien plants on fire regimes. BioScience. 54(7): 677-688.

Brown, T.J., B.L. Hall, and A.L. Westerling. 2004. The impact of twenty-first century climate change on wildland fire danger in the western United States: An application perspective. Climatic Change 62:365-388.

Bukowski, B.E. and W.L. Baker. 2012. Historical fire regimes, reconstructed from land-survey data, led to complexity and fluctuation in sagebrush landscapes. Ecological Applications. 23: 546–564.

Bunting, S.C., J.L. Kingery, and M.A. Schroeder. 2003. Assessing the restoration potential of altered rangeland ecosystems in the Interior Columbia Basin. Ecological Restoration. 21(2):77-86.

CABI. 2019. *Agropyron cristatum* (crested wheatgrass) datasheet. Invasive Species Compendium. Available online at: https://www.cabi.org/isc/datasheet/3723 (last accessed on November 27, 2019).

Caldwell, M.M., T.E. Dawson, and J.H. Richards. 1998. Hydraulic lift: consequences of water effluxed from the roots of plants. Oecologia. 113: 151-161.

CH2MHill. 2007. Slickspot peppergrass (*Lepidium papilliferum*) permanent monitoring plots 2007 Juniper Butte Range. Report prepared by CH2MHill. Boise, Idaho. December 2007. 17 pp. + appendices.

CH2MHill. 2003. Slickspot Peppergrass (*Lepidium papilliferum*) Survey. Enhanced Training in Idaho. Juniper Butte Range and Saylor Creek Range. Report prepared by CH2MHill for U.S. Air Force, Mountain Home Air Force Base, Idaho. September 2003. 22 pp. + appendices.

Chambers, J.C., D.A. Pyke, J.D. Maestas, M. Pellant, C.S. Boyd, S.B. Campbell, S. Espinosa, D.W. Havlina, K.E. Mayer, and A. Wuenschel. 2014a. Using resistance and resilience concepts to reduce impacts of invasive annual grasses and altered fire regimes on the sagebrush ecosystem and greater sage-grouse: A strategic multi-scale approach. General Technical Report RMRS-GTR-326. Fort Collins, Colorado: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 73 pp.

Chambers, J.C., R.F. Miller, D.I Board, D.A. Pyke, B.A. Roundy, J.B. Grace, E.W. Schupp, and R.J. Tausch. 2014b. Resilience and resistance of sagebrush ecosystems: Implications for state-and-transition models and management treatments. Rangeland Ecology and Management. 67:440–454.

Chambers, J. C., B.A. Roundy, R.R. Blank, S.E. Meyer, and A. Whittaker. 2007. What makes Great Basin sagebrush ecosystems invasible by *Bromus tectorum*? Ecological Monographs 77:117-145.

Chambers, J.C., and M. Pellant. 2008. Climate change impacts on northwestern and intermountain United States rangelands. Rangelands. 30(3): 29-33.

Clements, D.D., D.N. Harmon, R.R. Blank, and M. Weltz. 2017. Improving seeding success on cheatgrass-infested rangelands in northern Nevada. Rangelands. 39(6): 174-181.

Clements, D.D., J.A. Young, and D.N. Harmon. 2008. Cheatgrass response to simulated grazing. Abstract of presentation at the Society for Range Management national meeting. Louisville, Kentucky. Available online at: file:///S:/Classification%20Recovery%20Conservation%20Partnerships/Recovery/Lepidium%20papilliferum/Recovery%20Outline/Update/References/Clements_etal_2008_Cheatgrass_Grazing.pdf (last accessed October 2, 2017).

Cole, N.K. 2009. *Lepidium papilliferum* Threats Table. Update of 2006 table summarizing individual EO information and threats using January 14, 2009 Idaho National Heritage Program data with additional hand written refinements by Barbara Chaney, Idaho Fish and Wildlife Office, U.S. Fish and Wildlife Service, Boise, Idaho. Table compiled by Nancy Cole for the Idaho Fish and Wildlife Office, U.S. Fish and Wildlife Service, Boise, Idaho. 5 pp.

Colket, B. 2005. 2004 Habitat integrity and population monitoring of slickspot peppergrass (*Lepidium papilliferum*). Idaho Conservation Data Center, Idaho Department of Fish and Game, Boise, Idaho. 40 pp. + appendices.

Colket, B. 2006. 2005 rangewide habitat integrity and population monitoring of slickspot peppergrass (*Lepidium papilliferum*). Idaho Conservation Data Center, Idaho Department of Fish and Game, Boise, ID. 86 pp. + appendices.

Colket, B. 2008. Slickspot peppergrass (*Lepidium papilliferum*) field study and predictive distribution modeling. Idaho Conservation Data Center, Idaho Department of Fish and Game, Boise, Idaho. 29 pp. + appendices.

Colket, B. 2009. 2004-2008 Rangewide habitat integrity and population monitoring of slickspot peppergrass (*Lepidium papilliferum*). Idaho Conservation Data Center, Idaho Department of Fish and Game, Boise, Idaho. 30 pp. +appendices.

Colket, B., S. Cooke, and M. Mancuso. 2006. Element occurrence review and update for slickspot peppergrass (*Lepidium papilliferum*) in the Idaho Conservation Data Center BIOTICS database. Idaho Conservation Data Center, Idaho Department of Fish and Game, Boise, Idaho. December 2005. 40 pp. + appendices.

Condon, L.A. and D.A. Pyke. 2018. Fire and grazing influence site resistance to *Bromus tectorum* through their effects on shrub, bunchgrass, and biocrust communities in the Great Basin (USA). Ecosystems. Published online February 2018. https://link.springer.com/content/pdf/10.1007%2Fs10021-018-0230-8.pdf

D'Antonio, C.M., and M. Thomsen. 2004. Ecological resistance in theory and practice. Weed Technology. 18: 1572-1577.

D'Antonio, C.M., and P.M. Vitousek. 1992. Biological Invasions by Exotic Grasses, the Grass/Fire Cycle, and Global Change. Annual Review of Ecology and Systematics 23: 63-87.

Davies, K.W. 2018. Incorporating seeds in activated carbon pellets limits herbicide effects to seeded bunchgrasses when controlling exotic annuals. Rangeland Ecology and Management. 71(3): 323-326.

Davies, K.W. and D.D. Johnson. 2017. Established perennial vegetation provides high resistance to reinvasion by exotic annual grasses. Rangeland Ecology and Management. 70(6): 748-754.

Davies, K.W., Boyd, C.S., Madsen, M.D., Kerby, J., Hulet, A. 2018. Evaluating a seed technology for sagebrush restoration across an elevation gradient: support for bet hedging. Rangeland Ecology and Management. 71(1): 19-24.

Davies, K.W., A. Gearhart, C.S. Boyd, and J.D. Bates. 2017. Fall and spring grazing influence fire ignitability and initial spread in shrub steppe communities. International Journal of Wildland Fire. 26: 485-490.

Davies, K.W., A.M. Nafus, C.S. Boyd, A. Hulet, and J.D. Bates. 2016. Effects of using winter grazing as a fuel treatment on Wyoming big sagebrush plant communities. Rangeland Ecology and Management. 69: 179-184.

Davies, K. W.; Boyd, C. S.; Nafus, A. M. 2013. Restoring the sagebrush component in crested wheatgrass–dominated communities. Rangeland Ecology & Management. 66(4): 472-478.

Davis, R.J. 1952. Flora of Idaho. Brigham Young University Press. Provo, Utah. 347 pp.

De Graaff, M. and A. Johns. 2015. Herbicide impacts on forb performance in degraded sagebrush steppe ecosystems. In: Great Basin Native Plant Project 2014 Progress Report. USDA Forest Service, Rocky Mountain Research Station and USDI Bureau of Land Management, Boise, Idaho. April 2015. pp. 60-68.

Diamond, J.M, C.A. Call, and N. Devoe. 2009. Effects of cattle grazing on fire behavior of cheatgrass-dominated rangeland in the northern Great Basin, USA. International Journal of Wildland Fire. 18:944-950.

Dukes, J.S., and H.A. Mooney. 2003. Disruption of Ecosystem Processes in Western North America by Invasive Species. How Landscapes Change, Human Disturbance and Ecosystem Fragmentation in the Americas Series: Ecological Studies 162: 1-62.

Ellstrand, N. C., and D. R. Elam. 1993. Population Genetic Consequences of Small Population Size: Implications for Plant Conservation. Annual Review of Ecology and Systematics. Vol. 24, pp. 217-242.

Elzinga, C.L., D.W. Salzer, and J.W. Willoughby. 1998. Measuring and monitoring plant populations. Bureau of Land Management Technical Report BLMIRS/ST-98/005+1730. July 1998. 492 pp.

Fansler, V.A. and J.M. Mangold. 2011. Restoring native plants to crested wheatgrass stands. Restoration Ecology 19: 16–23.

Fisher, H., L. Eslick, and M. Seyfried. 1996. Edaphic factors that characterize the distribution of *Lepidium papilliferum*. April 1996. Technical Bulletin No.96-6, Idaho Bureau of Land Management. Boise, Idaho. 23 pp.

Folke, C., S. Carpenter, B. Walker, M. Scheffer, T. Elmqvist, L. Gunderson, and C.S. Holling. 2004. Regime shifts, resilience, and biodiversity in ecosystem management. Annual Review of Ecology, Evolution, and Systematics. 35:557–581.

Forman, R.T.T., and L. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics. 29: 207-231.

Foster, S., L. Schmelzer, J. Wilker, B. Schultz, K. McAdoo, S. Swanson, and B. Perryman. 2015. Reducing cheatgrass fuel loads using fall cattle grazing. Special Publication 15-03. University of Nevada Cooperative Extension. University of Nevada. Reno, Nevada. 11 pp.

Frid, L. and J.F. Wilmshurst. 2009. Decision analysis to evaluate control strategies for crested wheatgrass (*Agropyron cristatum*) in Grasslands National Park of Canada. Invasive Plant Science and Management. 2(4): 324-336.

Frost, R.A., and K.L. Launchbaugh. 2003. Prescription Grazing for Rangeland Weed Management. Rangelands. 25(6): 43-47.

Gelbard, J.L., and J. Belnap. 2003. Roads as conduits for exotic plant invasions in a semiarid landscape. Conservation Biology 17(2):420-432.

Given, D.R. 1994. Principles and practice of plant conservation. Chapter 2: How Plants Become Threatened or Extinct. Timber Press, Inc. Pp. 13-36.

Gray, E.C. 2011. An Evaluation of the Invasion Potential of *Kochia prostrata* (forage kochia) in Southwestern Idaho, USA. Master of Science thesis, Oregon State University, Corvallis, Oregon. 73 pp.

Gray, E.C. and P.S. Muir. 2013. Does *Kochia prostrata* Spread From Seeded Sites? An Evaluation From Southwestern Idaho, USA. Rangeland Ecology and Management. 66(2): 191-203.

Greenleaf, S.S., N.M. Williams, R. Winfree, and C. Kremen. 2007. Bee foraging ranges and their relationship to body size. Oecologia. 153(3): 589-596.

Gunnell, K.L., J.R. Willams, and T.A. Monaco. 2011. Clarifying potential successional trajectories in sagebrush communities historically seeded with crested wheatgrass. Natural Resources and Environmental Issues. Vol. 16, Article 17. pp. 131-137.

Gunnell, K.L., T.A. Monaco, C.A. Call, and C.V. Ransom. 2010. Seedling interference and niche differentiation between crested wheatgrass and contrasting native Great Basin species. Rangeland Ecology & Management. 63(4): 443–449.

Hasselquist N., M. J. Germino, J. Sankey, N. Glenn, and J. Ingram. 2011. High potential for nutrient redistribution in aeolian sediment fluxes following wildfire in sagebrush steppe. Biogeosciences 8: 3649-3659.

Heidinga, L., and S.D. Wilson. 2002. The impact of invading alien grass (*Agropyron cristatum*) on species turnover in native prairie. Diversity and Distributions. 8: 249–258.

Hempy-Mayer, K., and D.A. Pyke. 2008. Defoliation effects on *Bromus tectorum* seed production: Implications for grazing. Rangeland Ecology Management. 61: 116–123.

Henderson, D.C., and M.A. Naeth. 2005. Multi-scale impacts of crested wheatgrass invasion in mixed-grass prairie. Biological Invasions 7(5): 639–650.

Hironaka, M., M.A. Fosberg, and A.H. Winward. 1983. Sagebrush-grass habitat types of southern Idaho. Bulletin No. 35. Forest, Wildlife and Range Experiment Station, University of Idaho. Moscow, Idaho. 44 pp.

Hitchcock, C.L., and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press. Seattle, Washington. 170 pp.

Hitchcock, C.L. 1964. *Lepidium.* Pp. 512-521 *in:* C.L. Hitchcock, A. Cronquist, M. Ownbey, and J.W. Thompson, Vascular Plants of the Pacific Northwest, Part 2. University of Washington Press, Seattle, Washington.

Holmgren, N.H., P.K. Holmgren, and A. Cronquist. 2005. Intermountain Flora, Vascular Plants of the Intermountain West, U.S.A.: Volume Two, Part B, Subclass Dilleniidae. The New York Botanical Garden.

Hulet, A., B.A. Roundy, and B. Jessop. 2010. Crested wheatgrass control and native plant establishment in Utah. Rangeland Ecology & Management. 63: 450–460.

Hull, A.C., and G.J. Klomp. 1967. Thickening and spread of crested wheatgrass stands in southern Idaho ranges. Journal of Range Management. 20: 222-227.

Hull, A.C., and G.J. Klomp. 1966. Longevity of crested wheatgrass in the sagebrush-grass type in southern Idaho. Journal of Range Management. 19: 5-11.

Hulvey, K.B., E.A. Leger, L.M. Porensky, L.M. Roche, K.E. Veblen, A. Fund, J. Shaw, and E.S. Gornish. 2017. Restoration Islands: a toll for efficiently restoring dryland ecosystems? Restoration Ecology. 25(S2): S124-S134.

Idaho Army National Guard (National Guard). 2004. Integrated Natural Resource Management Plan and Environmental Assessment 2004-2008. 223 pp.

Idaho Army National Guard (National Guard). 2013. Orchard Combat Training Center Integrated Natural Resource Management Plan (Final). 136 pp. + appendices.

Idaho Conservation Data Center (ICDC). 2008. 2007 rangewide habitat integrity and population monitoring of slickspot peppergrass (*Lepidium papilliferum*). 38 pp. + attachments and appendices.

Idaho Conservation Data Center (ICDC). 2007. 2006 rangewide habitat integrity and population monitoring of slickspot peppergrass (*Lepidium papilliferum*). 35 pp. + attachments and appendices.

Idaho Fish and Wildlife Information System (IFWIS). 2018. Idaho Fish and Wildlife Information System, Species Diversity Database, slickspot peppergrass data. Idaho Department of Fish and Game, Idaho Natural Heritage Data. Boise, Idaho. Slickspot peppergrass data exported January 2018.

InterFire Website. Undated article. Investigating Wildfires: Part one. Possible Wildfire Causes. Electricity, Oil, and Gas Machinery. Available online at: http://www.interfire.org/features/wildfires.asp (last accessed July 18, 2018).

Integrated Taxonomic Information System (ITIS). 2018. ITIS Standard Report page for *Lepidium papilliferum*. 2 pp. Available online at: https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=503383#null (last accessed July 27, 2018).

Intergovernmental Panel on Climate Change (IPCC). 2014a. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. Geneva, Switzerland. 151 pp.

Intergovernmental Panel on Climate Change (IPCC). 2014b. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B, V.R. Barros, D.J. Dokken. K,J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 1132 pp.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Synthesis Report. November 12-17, 2007, Valencia, Spain. 73 pp.

Jeffries, M.I. 2016. An Investigation of Seed Predation and Herbivory on Slickspot Peppergrass. MS thesis in Biology. Boise State University, Boise, Idaho.

Johnston, R. 1997. Introduction to Microbiotic Crusts. United States Department of Agriculture. Natural Resources Conservation Service. 15 pp.

Kearns, C.A., and D.W. Inouye. 1997. Pollinators, flowering plants, and conservation biology. BioScience 47(5):297-307.

Keeley, J.E., C.J. Fotheringham, and M. Morais. 1999. Reexamining fire suppression impacts on brushland fire regimes. Science 284(5421): 1829-1832.

Kinter, C.L. and J.J. Miller. 2016. Assessment of *Lepidium papilliferum* (Slickspot Peppergrass) Element Occurrences. Idaho Natural Heritage Program, Idaho Department of Fish and Game, Boise, Idaho. 71 pp. + appendices.

Kinter, C.L., J.J. Miller, and K.M. Pekas. 2014. Habitat Integrity and Population Monitoring of *Lepidium papilliferum* (Slickspot Peppergrass): 2013. Report prepared for the Bureau of Land Management, Jarbidge and Four Rivers Field Offices and the Idaho Army National Guard by the Idaho Natural Heritage Program, Idaho Department of Fish and Game, Boise, Idaho. 50 pp. + appendices.

Kinter, C.L., D.L. Clay, J.R. Fulkerson, and J.M. Miller. 2012. Habitat Integrity and Population Monitoring of *Lepidium papilliferum* (Slickspot Peppergrass): 2011. Report prepared for the Bureau of Land Management, Jarbidge and Four Rivers Field Offices and the Idaho Army National Guard by the Idaho Natural Heritage Program, Idaho Department of Fish and Game, Boise, Idaho. 58 pp. + appendices.

Kinter, C.L., L.A. Harloe, K.M. Pekas, and J.J. Miller. 2010. Habitat Integrity and Population Monitoring of *Lepidium papilliferum* (Slickspot Peppergrass): 2009. Report prepared for the Bureau of Land Management, Jarbidge and Four Rivers Field Offices and the Idaho Army National Guard by the Idaho Natural Heritage Program, Idaho Department of Fish and Game, Boise, Idaho. 86 pp. + appendices.

Klos, P.Z., J.T. Abatzoglou, A. Bean, J. Blades, M.A. Clark, M. Dodd. T.E. Hall, A. Haruch, P.E. Higuera, J.D. Holbrook, V.S. Jansen, K. Kemp, A. Lankford, T.E. Link, T. Magney, A.J.H. Meddens, L. Mitchell, B. Moore, P. Morgan, B.A. Newingham, R.J. Niemeyer, B. Soderquist, A.A. Suazo, K. T. Vierling, V. Walden, and C. Walsh. 2015. Indicators of Climate Change in Idaho: An Assessment Framework for Coupling Biophysical Change and Societal Perception. Weather, Climate, and Society. 7(3): 238-254.

Klos, P. Z., T. Link, and J. Abatzoglou. 2014. Extent of the rain-snow transition zone in the western U.S. under historic and projected climate. Geophysical Research Letters. 41, doi:10.1002/2014GL060500. Available online at: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2014GL060500 (Last accessed July 30, 2018).

Klos, P.Z., J.T. Abatzoglou, A. Bean, J. Blades, M.A. Clark, M. Dodd. T.E. Hall, A. Haruch, P.E. Higuera, J.D. Holbrook, V.S. Jansen, K. Kemp, A. Lankford, T.E. Link, T. Magney, A.J.H. Meddens, L. Mitchell, B. Moore, P. Morgan, B.A. Newingham, R.J. Niemeyer, B. Soderquist, A.A. Suazo, K. T. Vierling, V. Walden, and C. Walsh. 2012. Indicators of Climate Change in Idaho: The intersection of biophysical change with social perception across a diverse landscape. Paper presented at the Pacific Northwest Climate Conference, Boise, Idaho. *In prep. For submission to Climatic Change.*

Knapp, P.A. 1996. Cheatgrass (*Bromus tectorum* L.) dominance in the Great Basin Desert: History, persistence, and influences to human activities. Global Environmental Change. 6: 37-52.

Knick, S.T. 1999. Requiem for a Sagebrush Ecosystem? Northwest Science. 73: 53-57.

Knick, S.T., and J. Rotenberry 1997. Landscape characteristics of disturbed shrub steppe habitats in southwestern Idaho (U.S.A.). Landscape Ecology 12: 287–297.

Knutson, K.C., D.A. Pyke, T.A. Wirth, R.S. Arkle, D.S. Pilliod, M.L. Brooks, J.C. Chambers, and J.B. Grace. 2014. Long-term effects of seeding after wildfire on vegetation in Great Basin shrubland ecosystems. Journal of Applied Ecology. 51: 1414-1424.

Larson, S.R., C.M. Culumber, R.N. Schweigert, and N.J. Chatterton, 2010. Species delimitation tests of endemic *Lepidium papilliferum* and identification of other possible evolutionary significant units in the *Lepidium montanum* complex (Brassicaceae) of western North America. Conservation Genetics. 11: 57-76.

Launchbaugh, K., B. Brammer, M.L. Brooks, S. Bunting, P. Clark, J. Davison, M. Fleming, R. Kay, M. Pellant, D.A. Pyke, and B. Wylie. 2008. Interactions among livestock grazing, vegetation type, and fire behavior in the Murphy Wildland Fire Complex in Idaho and Nevada, July 2007. U.S. Geological Survey Open-File Report 2008-1214. 42pp.

Lesica, P. and T.H. DeLuca. 1998. Long-term harmful effects of crested wheatgrass on Great Plains grassland ecosystems. Journal of Soil and Water Conservation. 51(5): 408-409.

Littell, J.S., D. McKenzie, D.L. Peterson, and A.L. Westerling. 2009. Climate and wildfire area burned in western U.S. ecoprovinces. Ecological Applications. 19(4): 1003-1021.

Loffredo, E., A.J. Palazzo, N. Senesi, C.E. Clapp, and T.L. Bashore. 2010. Germination and Early Growth of Slickspot Peppergrass (*Lepidium papilliferum*) as Affected by Desert Soil Humic Acid. Soil Science. 175(4): 186-193.

Mace, G.M. and R. Lande. 1991. Assessing extinction threats: Toward re-evaluation of IUCN threatened species categories. Conservation Biology 5: 148–157.

Madsen, M.D., K.W. Davies, C.S. Boyd, J.D. Kerby, and T.J. Svejcar. 2016. Emerging seed enhancement technologies for overcoming barriers to restoration. Restoration Ecology. 24(S2): S77-S84.

Mancuso, M., and R. Moseley. 1998. An ecological integrity index to assess and monitor *Lepidium papilliferum* (slickspot peppergrass) habitat in southwestern Idaho. Idaho Conservation Data Center, Idaho Department of Fish and Game. Boise, Idaho. Report prepared for State of Idaho, Military Division Memorandum of Agreement NGB16-97-0001 Task Order - 002. 15 pp. + appendices.

Marlette, G.M., and J.E. Anderson. 1986. Seed banks and propagule dispersal in crested-wheatgrass stands. Journal of Applied Ecology. 23(1): 161-175.

May C., C. Luce, J. Casola, M. Chang, J. Cuhaciyan, M. Dalton, S. Lowe, G. Morishima, P. Mote, A. Petersen, G. Roesch-McNally, and E. York. 2018. Chapter 24: Northwest. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research

Program, Washington, DC, USA, pp. 1036–1100. Available online at: https://nca2018.globalchange.gov/chapter/northwest (last accessed February 27, 2019).

Mayer, K.E. Compiler. 2018. Wildfire and Invasive Plant Species in the Sagebrush Biome: Challenges that Hinder Current and Future Management and Protection - A Gap Report Update. Western Association of Fish and Wildlife Agencies, Wildfire and Invasive Species Working Group. WAFWA. Boise, Idaho. 62 pp.

Mayer, K. H. 2004. The effects of defoliation on *Bromus tectorum* seed production and growth. Master's thesis. Botany and Plant Pathology Department, Oregon State University. Corvallis, Oregon. 54 pp.

McAdoo, J.K., J.C. Swanson, P.J. Murphy, and N.L. Shaw. Evaluating strategies for facilitating native plant establishment in northern Nevada crested wheatgrass seedings. Restoration Ecology. 25(1): 53-62.

McIntyre, N.E., and M.E. Hostetler. 2001. Effects of urban land use on pollinator (Hymenoptera: Apoidea) communities in a desert metropolis. Basic and Applied Ecology. 2: 209-218.

McKenzie, D. and J.S. Littell. 2017. Climate change and the eco-hydrology of fire: Will area burned increase in a warming western USA? Ecological Applications. 27(1): 26-36.

Mealor, B.A., R.D. Mealor, W.K. Kelley, D.L. Bergman, S.A. Burnett, T.W. Decker, B. Fowers, M.E. Herget, C.E. Noseworthy, J.L. Richards, C.S. Brown, K.G. Beck, and M. Fernandez-Gimenez. 2013. Cheatgrass Management Handbook: Managing and Invasive Annual Grass in the Rocky Mountain Region. University of Wyoming, Laramie Wyoming and Colorado State University, Fort Collins, Colorado. 99 pp. + appendices.

Menakis, J. P., D. Osborne, and M. Miller. 2003. Mapping the cheatgrass-caused departure from historical natural fire regimes in the Great Basin, USA. In: P. N. Omi and L. A. Joyce [EDS.]. Fire, fuel treatments, and ecological restoration: conference proceedings; 16–18 April 2002; Fort Collins, CO, USA. Washington, DC, USA: US Department of Agriculture, Forest Service, RMRS-P-29. p. 281–287.

Menke, C.A. and T.N. Kaye. 2006a. *Lepidium papilliferum* (Slickspot peppergrass) Habitat Integrity Index data analysis (1998-2001). Final Report. March 2006. Cooperative project between the Bureau of Land Management, Idaho Department of Fish and Game, and the Institute for Applied Ecology. 22 pp.

Menke, C.A. and T.N. Kaye. 2006b. *Lepidium papilliferum* (Slickspot peppergrass) Habitat Integrity Index data analysis (1998-2001). Final Report. June 2006. Cooperative project between the Bureau of Land Management, Idaho Department of Fish and Game, and the Institute for Applied Ecology. 21 pp.

Meyer, S.E. and D. Quinney. 1993. A preliminary report on edaphic characteristics of *Lepidium papilliferum* microsites on the Orchard Training Area, Ada County, Idaho. U.S. Forest Service, Intermountain Research Station, Shrub Sciences Laboratory, Provo, Utah and U.S. Army Idaho Army National Guard, Orchard Training Area, Boise, Idaho. 7 pp.

Meyer, S.E. and P.S. Allen. 2005. *Lepidium papilliferum* soil and seed bank characterization on the Orchard Training Area. U.S. Forest Service, Intermountain Research Station, Shrub Sciences Laboratory, Provo, Utah. Department of Plant and Animal Science, Brigham Young University, Provo, Utah. 10 pp.

Meyer, S.E., D. Quinney, and J. Weaver. 2006. A stochastic population model for *Lepidium papilliferum* (Brassicaceae), a rare desert ephemeral with a persistent seed bank. American Journal of Botany. 93(6): 891-902.

Meyer, S.E., D.L. Quinney, and J. Weaver. 2005. A life history study of the Snake River Plains endemic *Lepidium papilliferum* (Brassicaceae). Western North American Naturalist. 65(1): 11-23.

Miller, J.J. and C.L. Kinter. 2018. Field assessment of *Lepidium papilliferum* (slickspot peppergrass) element occurrences: Snake River Plain and adjacent Foothills. Idaho Natural Heritage Program, Wildlife Bureau, Idaho Department of Fish and Game, Boise, Idaho. Prepared for US Fish and Wildlife Service, Boise Idaho. 91 pp. + appendices.

Miller, R.F. and L. Eddleman. 2001. Spatial and temporal changes of sage grouse habitat in the sagebrush biome. Corvallis: Oregon State University, Agricultural Experiment Station. Mooney, H.A. and E.E. Cleland. 2001. The Evolutionary Impact of Invasive Species. Archaea PNAS 98(10). 15 pp.

Miller, R.F., S.T. Knick, D.A. Pyke, C.W. Meinke, S.E. Hanser, M.J. Wisdom, and A.L. Hild. 2011. Chapter 10. Characteristics of Sagebrush Habitats and Limitations to Long-Term Conservation. In: S. Knick and J.W. Connelly, Eds. Greater sage-grouse: ecology and conservation of a landscape species and its habitats. Studies in avian biology. Berkeley, California: University of California Press. pp 145–184.

Mooney, H.A. and E.E. Cleland. 2001. The evolutionary impact of invasive species. Proceedings of the National Academy of Sciences of USA. 98(10): 5446-5451.

Morgan, M.G., H. Dowlatabadi, M. Henrion, D. Keith, R. Lempert, S. McBride, M. Small, and T. Wilbanks. 2009. Best Practice Approaches for Characterizing, Communicating, and Incorporating Scientific Uncertainty in Decision Making. A Report by the Climate Change Science Program and the Subcommittee on Global Change Research. National Oceanic and Atmospheric Administration, Washington, DC. 96 pp.

Moro, M.J., F.I. Pugnaire, P. Haase, and J. Puigdefábregas. 1997. Effect of the canopy of *Retama sphaerocarpa* on its understorey in a semiarid environment. Functional Ecology. 11: 425-431.

Morris, L.R. and R.J. Rowe. 2014. Historic land use and altered habitats in the Great Basin. Journal of Mammalogy. 95(6): 1144-1156.

Moseley, R.K. April 1994. Report on the conservation status of *Lepidium papilliferum*. Idaho Conservation Data Center, Idaho Department of Fish and Game. Boise, Idaho. Status Survey Report prepared for Idaho Department of Parks and Recreation through Section 6 funding from U.S. Fish and Wildlife Service. Region 1. 35 pp. + appendices.

Mosley, J. C. and L. Roselle. 2006. Targeted livestock grazing to suppress invasive annual grasses. Chapter 8 in: Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement. Karen Launchbaugh, Editor and Project Manager, University of Idaho Rangeland Center, Moscow, Idaho. Available online at: http://www.webpages.uidaho.edu/rx-grazing/Handbook.htm. Last accessed October 19, 2018.

Mummenhoff, K., J.L. Bowman, P. Linder, N. Friesen, and A. Franzke. 2004. Molecular evidence for bicontinental hybridogenous genomic constitution in *Lepidium* sensu stricto (Brassicaceae) species from Australia and New Zealand. American Journal of Botany. 91: 252-259.

Mummenhoff, K., H. Bruggemann, and J.L. Bowman. 2001. Chloroplast DNA phylogeny and biogeography of *Lepidium* (Brassicaceae). American Journal of Botany. 88: 2051-2063.

Nafus, A. M.; Svejcar, T. J.; Ganskopp, D. C.; Davies K. W. 2015. Abundances of coplanted native bunchgrasses and crested wheatgrass after 13 years. Rangeland Ecology & Management. 68(2): 211-214.

Narducci, J., C. Sprague, J. Brandt, J. Schneider, J. Moroney, M. Fragkias, and S. Benner. 2017. Projecting Urban Expansion in the Treasure Valley to 2100. Boise State University, Boise, Idaho.

National Seed Strategy for Rehabilitation and Restoration. 2015-2020. Available on-line at: https://www.blm.gov/programs/natural-resources/native-plant-communities/national-seed-strategy (last accessed March 25, 2019).

National Seed Strategy: Making Progress. 2019. Available on-line at: https://www.blm.gov/programs/natural-resources/native-plant-communities/national-seed-strategy (last accessed March 25, 2019).

Natural Resources Conservation Service (NRCS). 2015. Implementing grazing management collaboratively across all lands. White paper developed by NRCS and signed by representatives of 11 Idaho agencies and entities. 2 pp.

Natural Resources Conservation Service (NRCS). 2016. Pollinators. South Dakota Fact Sheet. SD-FS-60. July 2016. 2 pp. + attachments.

Natural Resources Conservation Service (NRCS). 2008. Pollinators. South Dakota Fact Sheet. SD-FS-55. May 2008. 2 pp.

NatureServe. 2002. Element Occurrence Data Standard. NatureServe, Arlington, Virginia.

Nayak, A, D. Marks, D.G. Chandler, and M. Seyfried. 2010. Long-term snow, climate, and streamflow trends at Reynolds Creek Experimental Watershed, Owyhee Mountains, Idaho, United States. Water Resources Research 46, W06519, doi:10.1029/2008WR007525. Available online at: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2008WR007525 (Last accessed on July 30, 2018).

Nei, M. 1972. Genetic distance between populations. The American Naturalist. 106 (949): 283-292.

Neilson, R.P., J.M. Lenihan, D. Bachelet, and R.J. Drapek. 2005. Climate change implications for sagebrush ecosystems. Transactions of the 70th North American Wildlife and Natural Resources Conference. pp. 145-159.

Nelson, A. and F. McBride. 1913. Western Plant Studies. Botanical Gazette. 56: 473-475.

Nettleton, W.D. and F.F. Peterson. 1983. Aridisols. Pages 165-215 *in*: L.P. Wilding, N.E. Smeck, and G.F. Hall (eds.) Pedogenesis and Soil Taxonomy. Elsevier Science Publishing Company Inc., New York.

Newman, D., and D. Pilson. 1997. Increased probability of extinction due to decreased genetic effective population size: experimental populations of *Clarkia pulchella*. Evolution 51(2): 354-362.

Nichol-Driskill, S. 2011. Effects of Trampling and Fire on *Lepidium papilliferum* and Slickspot Habitat. Master's thesis. University of Idaho. Moscow, Idaho. May 2011. 31 pp. + attachments.

Olson, B.E. 1999. Impacts of Noxious Weeds on Ecologic and Economic Systems. Biology and Management of Noxious Rangeland Weeds. Oregon State University Press, Corvallis, Oregon. 1 pp.

Ogle, D. 2002. Crested Wheatgrass. USDA NRCS Plant Fact Datasheet. 3 pp. Available online at: https://plants.usda.gov/factsheet/pdf/fs_agcr.pdf (last accessed November 27, 2019).

Ott, J.E., F.F. Kilkenny, D.D. Summers, and T.W. Thompson. In press. Long-term vegetation recovery and invasive annual suppression in native and introduced postfire seeding treatments. Rangeland Ecology and Management. 14 pp. Available online at: https://doi.org/10.1016/j.rama.2019.02.001 (last accessed on April 18, 2019).

Ott, J.E., F.F. Kilkenny, and J. Irwin. 2017. Dispersal rates of forage kochia (*Bassisa prostrata*) from seeded areas in southern Idaho. Final report prepared for US Fish and Wildlife Service under Recovery Grant IAA F16PG00075 by USFS Rocky Mountain Research Station, Boise, Idaho. 12 pp.

Palazzo, A.J., R.W. Lichvar, T.J. Cary, and T.L. Bashore. 2005. An analysis of the seed bank of *Lepidium papilliferum* (slickspot peppergrass). Unpublished report dated February 23, 2005 submitted to Plant Ecology in March 2005. 22 pp.

Palazzo, A.J., C.E. Clapp, N. Senesi, M.H.B. Hayes, T.J. Cary, J Mao, and T.L. Bashore. 2008. Isolation and characterization of humic acids in Idaho slick spot soils. Soil Science. Vol. 173, No. 6, pp. 375-386.

Pavlik, B.M. 1996. Defining and Measuring Success. Pp. 127–155 *in* D.A. Falk, C.I. Millar, and M. Olwell (eds.), Restoring Diversity: Strategies for reintroduction of endangered plants. Island Press, Washington, D.C. 505 pp.

Pellant, M. 1996. Cheatgrass: The invader that won the West. Unpublished report prepared for the U.S. Forest Service and USDI Bureau of Land Management Interior Columbia Basin Ecosystem Management Project. 22 pp.

Peterson, P.P. 1919. The "slick spots" of middle western Idaho with suggestions for their elimination. Agricultural Experiment Station. Idaho Station Bulletin No. 114. University of Idaho, Moscow, Idaho. pp. 3–11.

Pyke, D.A., J.C. Chambers, M. Pellant, R.F. Miller, J.L. Beck, P.S. Doescher, B.A. Roundy, E.W. Schupp, S.T. Knick, M. Brunson, and J.D. McIver. 2017. Restoration handbook for sagebrush steppe ecosystems with emphasis on greater sage-grouse habitat—Part 3. Site level restoration decisions: U.S. Geological Survey Circular 1426. 62 pp.

Pyke, D.A., J.C. Chambers. J.L. Beck, M.L. Brooks, and B.A. Mealor. 2016. Chapter 8. Land Uses, Fire, and Invasion: Exotic Annual *Bromus* and Human Dimensions. In: Exotic Brome-Grasses in Arid and Semiarid Ecosystems of the Western US. M.J. Germino, J.C. Chambers, and C.S. Brown, eds. Springer International Publishing. Switzerland. pp. 307-337 of 475 pp.

Pyke, D.A. 2011. Restoring and rehabilitating sagebrush habitats. In: Knick, S.T. and J.W. Connelly (eds.), Greater Sage-Grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology (vol. 38), University of California Press. Berkeley, California. pp. 531-548.

Pyke, D.A. 2007. Sagebrush steppe restoration and cheatgrass. Presentation given at the 2007 Restoring the West Conference, Utah State University, Logan, Utah, September 18-20, 2007. Abstract and presentation available online at: http://forestry.usu.edu/videos-conferences-webinars/conferences/restoring-west-conference-2007/david-pyke. (Last accessed July 31, 2018).

Pyke, D.A. and S. Archer. 1991. Plant-plant Interactions Affecting Plant Establishment and Persistence on Revegetated Rangeland. Journal of Range Management 44(6): 550-557.

Quinney, D. 1998. LEPA (*Lepidium papilliferum*). Natural Resources Group, Environmental Management Office, Idaho Army National Guard. Boise, Idaho. Project funding from Department of Defense Legacy and Idaho Army National Guard. 21 pp. + appendices.

Rasmussen, W.W., D.P. Moore, and L.A. Alban. 1972. Improvement of a solonetzic (slick spot) soil by deep plowing, subsoiling, and amendments. Soil Science Society of America Proceedings. 36: 137–142.

Ravi, S., P. D'Odorico, D.D. Breshears, J.P. Field, A.S. Goudie, T.E. Huxman, J. Li, G.S. Okin, R.J. Swap, A.D. Thomas, S. Van Pelt, J.J. Whicker, and T.M. Zobeck. 2011. Aeolian processes and the biosphere. Reviews of Geophysics 49:1-45

Reisner, M.D., J.B. Grace, D.A. Pyke, and P.S. Doescher. 2013. Conditions favouring *Bromus tectorum* dominance of endangered sagebrush steppe ecosystems. Journal of Applied Ecology. 50: 1039-1049.

Rengasamy, P., R.S.B. Greene, and G.W. Ford. 1984. The role of clay fraction in the particle arrangement and stability of soil aggregates - a review. Clay Research 3(2): 53-67.

Robertson, I.C. 2003a. Insect-mediated pollination of *Lepidium papilliferum*: Department of Biology, Boise State University, Boise, Idaho. Report prepared for State of Idaho, Military Division, Idaho Army National Guard, Boise, Idaho. 14 pp. + Tables. December 2003.

Robertson, I. 2003b. Insect pollinator communities of slickspot peppergrass, *Lepidium papilliferum*: Implications for *Lepidium* viability. Unpublished report prepared for the Bureau of Land Management. Boise State University Grant Number: 006G106208 Task Order Number: DAF010016. 17 pp. + figures.

Robertson .I.C, W.H. Clark, C.W. Baun, and K.S. Warner. 2017. Field evaluation of Amdro® granular baits in targeted control of Owyhee harvester ant colonies (*Pogonomyrmex salinus*, Hymenoptera: Formicidae). Journal of the Idaho Academy of Science and Engineering, 53(2): 1-8.

Robertson, I.C. 2015. Habitat associations and dynamics of Owyhee harvester ant colonies located within slickspot peppergrass populations. Department of Biology, Boise State University. Boise, Idaho. Report prepared for United States Fish and Wildlife Service, Boise, Idaho. USFWS Agreement No.: F14AP000134. February 2015. 17 pp. + appendices.

Robertson, I. and J. Crossman. 2012. Insect-mediated pollination and harvester ant seed predation in slickspot peppergrass: 2012 report. Unpublished report prepared for State of Idaho, Idaho Army National Guard. MOA No. NGBID-12-D-003, Task Order No. 001-FY-2012. 17 pp.

Robertson, I. and L. Hannon. 2003. Insect pollinator communities of slickspot peppergrass, *Lepidium papilliferum*: implications for *Lepidium* viability. Unpublished report prepared for the Bureau of Land Management. BSU Grant Number: 006G106208 Task Order Number: DAF010016. 20 pp. + figures.

Robertson, I.C. and D.K. Klemash. 2003. Insect-mediated pollination in slickspot peppergrass, *Lepidium papilliferum* L. (Brassicaceae), and its implications for population variability. Department of Biology, Boise State University. Boise, Idaho. Western North American Naturalist 63(3): 333-342.

Robertson, I.C. and H. Leavitt. 2011. Relative contributions to seed production by floral visitors of slickspot peppergrass, *Lepidium papilliferum* (Brassicaceae). Arthropod-Plant Interactions. 5: 379-389.

Robertson, I. and A. Ulappa. 2004. Distance between pollen donor and recipient influences fruiting success in slickspot peppergrass, *Lepidium papilliferum*. Canadian Journal of Botany 83: 1705-1710.

Robertson, I. and J. White. 2009. Insect-mediated pollination and seed predation in slickspot peppergrass: 2008 Report. Unpublished report prepared for the Idaho Army National

Guard. MOA No. NGBID-07-D-0001, Task Order No. 001-FY-08. Revised 2/16/2009. 28 pp.

Robertson, I. and J. White. 2007. Insect-mediated pollination and seed predation in slickspot peppergrass: 2007 Report. Unpublished report prepared for the Idaho Army National Guard. MOA No. NGBID-07-D-0001, Task Order No. 001-FY-07. December 2007. 14 pp. + appendices.

Robertson, I., H. Leavitt, and S. Billinge. 2004. Insect-mediated pollination in slickspot peppergrass, and the impact of competition for pollinators on reproductive success. Unpublished report prepared for the Bureau of Land Management. Agreement No. DAA010200 Task Order Number: DLF040553. 19 pp. + data.

Robertson, I., H. Leavitt, and S. Billinge. 2006. Importance of insect-mediated pollination and outcrossing on the reproductive performance of slickspot peppergrass, *Lepidium papilliferum*: Report for 2006. Unpublished report prepared for the Bureau of Land Management. Agreement No. DLA060109. 55 pp. + data.

Rollins, R.C. 1993. The Cruciferae of Continental North America, Systematics of the Mustard Family from the Arctic to Panama. Stanford University Press. Stanford, California. 996 pp.

Romero-Calcerrada, R., C.J. Novillo, J.D.A. Millington, and I. Gomez-Jimenez. 2008. GIS analysis of spatial patterns of human-caused wildfire ignition risk in the SW of Madrid (central Spain). Landscape Ecology. 23(3): 341-354.

Romme, W.H., C.D. Allen, J.D. Bailey, W.L. Baker, B.T. Bestelmeyer, P.M. Brown, K.S. Eisenhart, M.L. Floyd, D.W. Huffman, B.F. Jacobs, R.F. Miller, E.H. Muldavin, T.W. Swetnam, R.J. Tausch, and P.J. Weisberg. 2009. Historical and modern disturbance regimes, stand structures, and landscape dynamics in piñon–juniper vegetation of the western United States. Rangeland Ecology and Management. 62: 203–222.

Salihi, D.O. and B.E. Norton. 1987. Survival of perennial grass seedlings under intensive grazing in semi-arid rangelands. Journal of Applied Ecology. 24(1):145-151.

Sankey J., M.J. Germino, and N.J. Glenn. 2012. Dust supply varies with sagebrush microsites and time since burning in experimental erosion events. Journal of Geophysical Research-Biogeosciences 117:1-13.

Sankey J., M.J. Germino, and N.F. Glenn. 2009. Relationships of post-fire aeolian transport to soil and atmospheric moisture. Aeolian Research 1: 75-85.

Schmasow, M.S. 2015. Diet Selection by the Owyhee Harvester Ant (*Pogonomyrmex salinus*) in Southwestern Idaho. Boise State University. Boise, Idaho. May 2015. Master's thesis.

Schmasow, M.S. and I. C. Robertson. 2016. Selective Foraging by *Pogonomyrmex salinus* (Hymenoptera: Formicidae) in Semiarid Grassland: Implications for a Rare Plant. Environmental Entomology. August 2016. 45(1): 952–960. Available online at: https://doi.org/10.1093/ee/nvw071 (Last accessed July 31, 2018).

Scholten D, and S. Bunting. 2001. Long-term effects of selected rehabilitation practices on *Lepidium papilliferum* (slickspot peppergrass). Report submitted to Bureau of Land Management, Lower Snake River District, Boise, Idaho dated March 14, 2001. University of Idaho. Moscow, Idaho. 10 pp. + attachments.

Serpe, M.D., J.M. Orm, T. Barkes, and R. Rosentreter. 2006. Germination and seed water status of four grasses on moss-dominated biological soil crusts from arid lands. Plant Ecology 184: 163–178.

Shaffer, M.L. and B.A. Stein. 2000. Safeguarding our Precious Heritage. Pages 301–321 *in* B.A. Stein, L.S. Kutner, and J.S. Adams (eds.), Precious Heritage: The status of biodiversity in the United States. Oxford University Press. 399 pp.

Sharp, L.A., K. Sanders, and N. Rimbey. 1992. Variability of crested wheatgrass production over 35 years. Rangelands. 14(3): 153-168.

Shinneman, D.J., C.L. Aldridge, P.S. Coates, M.J. Germino, D.S. Pilliod, and N.M. Vaillant. 2018. A conservation paradox in the Great Basin—Altering sagebrush landscapes with fuel breaks to reduce habitat loss from wildfire. US Geological Survey Open-File Report 2018-1034. Available online at: https://pubs.usgs.gov/of/2018/1034/ofr20181034.pdf Last accessed October 19, 2018.

Smith, J.F., A. Stillman, S.R. Larson, C.M. Culumber, I.C. Robertson, and S.J. Novak. 2009. Phylogenetic relationships among *Lepidium papilliferum* (L. Henderson) A. Nels, & J.F. Macbr., *L. montanum* Nutt., and *L. davisii* Rollins (Brassicaceae). Journal of the Torrey Botanical Society. 136(2): 149-163.

Smith, S.D., B.R. Strain, and T.D. Sharkey. 1987. Effects of C02 enrichment on four Great Basin grasses. Functional Ecology. 1987(1): 139-143.

Smith, S.D., T.E. Huxman, S.F. Zitzer, T.N. Charlet, D.C. Housman, J.S. Coleman, L.K. Fenstermaker, J.R. Seemann, and R.S. Nowak. 2000. Elevated CO_2 increases productivity and invasive species success in an arid ecosystem. Nature. 408: 79-82.

State of Idaho, Bureau of Land Management, Idaho Army National Guard, Nongovernmental Cooperators (State of Idaho). 2003. Candidate Conservation Agreement for Slickspot Peppergrass (*Lepidium papilliferum*). 198 pp.

State of Idaho, Bureau of Land Management, Idaho Army National Guard, Nongovernmental Cooperators (State of Idaho). 2006. Candidate Conservation Agreement for Slickspot Peppergrass (*Lepidium papilliferum*) and additional reports. 306 pp.

Steele, R. 1981. *Lepidium montanum* var. *papilliferum*. Page 55 in : Rare and Endangered Plants Technical Committee of the Idaho Natural Areas Council, Vascular Plant Species of Concern in Idaho, Bulletin No. 34, University of Idaho, Forest, Wildlife and Range Experiment Station, Moscow, Idaho.

Steffens, D., B.W. Hutsch, T. Eschholt, T. Losak, and S. Schurbert. 2005. Water logging may inhibit plant growth primarily by nutrient deficiency rather than nutrient toxicity. Plant Soil Environ. 51(12): 545-552.

Stillman, A.J. 2006. Population Genetics of the Rare Polyploid *Lepidium Papilliferum* (Brassicaceae); A Southwestern Idaho Endemic. Master's Thesis. Boise State University. Boise, Idaho. July 2006. 61 pp. + appendices.

Stillman, A., I. Robertson, and S. Novak. 2005. Population genetics of *Lepidium papilliferum* – excerpted from Robertson, I., S. Novak, H. Leavitt, and A. Stillman. 2005. *Lepidium papilliferum*: Analysis of pollination, herbivory, and genetic structure of populations. Unpublished report on file at State of Idaho, Military Division, Idaho Army National Guard (Dec. 2005).

Stoner, L.L. 2009. GIS Analyses for the 2009 Status Review of Slickspot Peppergrass (*Lepidium papilliferum*): a report for the U.S. Fish and Wildlife Service. A Cooperative Ecosystems Studies Unit Task Order. Cooperative Agreement #144209M007. Utah State University. January 30, 2009. 82 pp.

Sturm, M., J.P. McFadden, G.E. Liston, F.S. Chapin III, C.H. Racine, and J. Holmgren. 2000. Snow-shrub interactions in Arctic tundra: a hypothesis with climatic implications. Journal of Climate. 14: 336-344.

Sullivan, J.P. and C.S. Nations. 2009. Analysis of slickspot peppergrass (*Lepidium papilliferum*) population trends on Orchard Training Area and rangewide implications. Unpublished report prepared for Idaho Fish and Wildlife Office, U.S. Fish and Wildlife Service, Boise, Idaho. January 2009. 148 pp. + appendices.

Syphard, A.D., V.C. Radeloff, N.S. Keuler, R.S. Taylor, T.J. Hawbaker, S.I. Stewart, and M.K. Clayton. 2008. Predicting spatial patterns of fire on a southern California landscape. International Journal of Wildland Fire. 17: 602-613.

Tilley, D., C. Taliga, C. Burns, and L. St. John. 2013. Plant Materials for Pollinators and Other Beneficial Insects in Eastern Utah and Western Colorado. Plant Materials Technical Note No. 75. Natural Resources Conservation Service. July 11, 2013. 55 pp.

U.S. Air Force (Air Force). 2017. Integrated Natural Resource Management Plan for Mountain Home Air Force Base, Small Arms Range, Saylor Creek Air Force Range, Juniper Butte Range, and Other Mountain Home Range Complex Sites. 287 pp. + appendices.

U.S. Air Force (Air Force). 2012. Integrated Natural Resource Management Plan for Mountain Home Air Force Base, Small Arms Range, Saylor Creek Air Force Range, Juniper Butte Range, and Other Mountain Home Range Complex Sites. 976 pp. + appendices.

U.S. Air Force (Air Force). 2004. Final Juniper Butte Range Integrated Natural Resource Management Plan. 407 pp.

U.S. Air Force (Air Force). 2002. Final survey and mapping report for slickspot habitat and slickspot peppergrass at Juniper Butte Range. 16 pp.

U.S. Bureau of Land Management (USBLM). 2009. Final biological assessment for slickspot peppergrass (*Lepidium papilliferum*): Jarbidge and Four Rivers Field Offices, land use plans and ongoing actions. September 16, 2009. 29 pp. + appendices.

U.S. Bureau of Land Management (USBLM). 2015. Approved Jarbidge Resource Management Plan and Record of Decision. September 2, 2015. 72 pp. + maps and appendices. Available online at: https://eplanning.blm.gov/epl-front-office/eplanning/planAndProjectSite.do?methodName=dispatchToPatternPage&currentPageId=48879 (Last accessed April 23, 2019).

U.S. Bureau of Land Management and U.S. Fish and Wildlife Service (USBLM and USFWS). 2014. Conservation agreement for Idaho Bureau of Land Management existing land use plans. Agreement to provide land use plan level conservation measures for slickspot peppergrass for all applicable existing Idaho Bureau of Land Management land use plans signed September 15, 2014. 8 pp. + appendices.

U.S. Bureau of Land Management and U.S. Fish and Wildlife Service (USBLM and USFWS). 2013. Conservation agreement for Idaho Bureau of Land Management existing land use plans. Agreement to provide land use plan level conservation measures for slickspot peppergrass for all applicable existing Idaho Bureau of Land Management land use plans signed January 28, 2013. pp. 33.

U.S. Bureau of Land Management and U.S. Fish and Wildlife Service (USBLM and USFWS). 2009. Conservation agreement for Idaho Bureau of Land Management existing land use plans. Agreement to provide land use plan level conservation measures for slickspot peppergrass for all applicable existing Idaho Bureau of Land Management land use plans signed August 27, 2009. pp. 33.

U.S. Bureau of Land Management and U.S. Fish and Wildlife Service (USBLM and USFWS). 2006. Conservation agreement for Idaho Bureau of Land Management existing land use plans. Agreement to provide land use plan level conservation measures for slickspot peppergrass for all applicable existing Idaho BLM land use plans signed August 2006. pp. 32.

U.S. Census Bureau. 2017. Idaho is Nation's Fastest-Growing State, Census Bureau Reports. Release Number: CB17-210. December 20, 2017. Available online at: https://www.census.gov/newsroom/press-releases/2017/estimates-idaho.html Last accessed June 18, 2018.

U.S. Department of the Interior. 1996. Effects of military training and fire in the Snake River Birds of Prey National Conservation Area. U.S. Geological Survey, Biological Research Division, Snake River Field Station. Research Project Final Report submitted to the Bureau of Land Management, Lower Snake River District, Boise Field Office, and the Idaho Army National Guard. Document available online at: https://babel.hathitrust.org/cgi/pt?id=coo.31924080037009;view=1up;seq=41. Last accessed June 13, 2018.

U.S. Fish and Wildlife Service (USFWS). 2006. Draft best available biological information for slickspot peppergrass (*Lepidium papilliferum*). 98 pp. + appendices.

U.S. Fish and Wildlife Service (USFWS). 2016. U.S. Fish and Wildlife Service species status assessment framework: an integrated analytical framework for conservation. Version 3.4. August 2016.

U.S. Fish and Wildlife Service (USFWS). 2018. Final Report. 2017 Grazing Utilization Juniper Butte Range. Prepared for United States Air Force 366CES/CEIE, Mountain Home Air Force Base, Idaho by U.S. Fish and Wildlife Service, Mid-Columbia River National Wildlife Refuge Complex. March 2018. 27 pp. + appendices.

Unnasch, R.S. 2008. *Lepidium papilliferum* (slickspot peppergrass): Evaluation of trends 2004-2007. Unpublished report prepared for the Idaho Department of Fish and Game, Idaho Conservation Data Center by Sound Science. 17 pp.

Vallentine, J .F. 2001. Grazing management. Second edition. Academic Press, San Diego, CA. 659 pp.

Vaness, B.M. and S.D. Wilson. 2008. Impact and management of crested wheatgrass (*Agropyron cristatum*) in the northern Great Plains. Canadian Journal of Plant Science. 87:1023-1028.

Venable, D. L. and L. Lawlor. 1980. Delayed germination and dispersal in desert annuals escape in space and time. Oecologia. 46: 272-282.

von Reis, J.C. 2015. The effects of select herbicides on the biological soil crust in shrub steppe areas of the Columbia Basin, Washington. Washington State University. Doctor of Philosophy dissertation. 110 pp. + appendices.

Welch, B.L. 2005. Big Sagebrush: A Sea Fragmented into Lakes, Ponds, and Puddles. General Technical Report RMRS-GTR-144. USDA Forest Service, Rocky Mountain Research Station, Ft. Collins.

Weltz, M.A., K. Spaeth, M.H. Taylor, K. Rollins, F. Pierson, L. Jolley, M. Nearing, D. Goodrich, M. Hernandez, S.K. Nouwakpo, and C. Rossi. 2014. Cheatgrass invasion and woody species encroachment in the Great Basin: Benefits of conservation. Journal of Soil and Water Conservation. 69(2): 39A-44A.

West, N. E. 1988. Intermountain deserts, shrub steppes, and woodlands. In: M. G. Barbour and W. D. Billings [EDS.]. North American terrestrial vegetation. Cambridge, United Kingdom: Cambridge University Press. pp. 209-230.

West, N.E. and J.A. Young. 2000. Intermountain valleys and lower mountain slopes. In: Barbour, M.G.; Billings, W.D eds. North American terrestrial vegetation. Second edition. Cambridge, UK: Cambridge University Press. pp. 255-284.

Westerling, A., T. Brown, T, Schoennagel, T. Swetnam, M. Turner, and T. Veblen. 2014. Briefing: Climate and Fire in Western U.S. Forests. In: Forest Conservation and Management in the Anthropocene: Conference Proceedings. V.A. Sample and R.P. Bixler, editors. RMRS-P-71. Fort Collins, CO: US Department of Agriculture, Forest Service. Rocky Mountain Research Station. pp. 81-102.

Western Regional Climate Center. 2016a. Boise WSFO Airport, Idaho (101022) monthly climate summary, 01/01/1940 to 06/09/2016. Accessed 11 June 2018 at: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?id1022 Last accessed 06/11/18.

Western Regional Climate Center. 2016b. Murphy Hot Springs, Idaho (106250) monthly climate summary, 12/03/1987 to 6/10/2016. Accessed 11 June 2016 at: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?id6250 Last accessed 06/11/18.

Whisenant, S.G. 1990. Changing fire frequencies on Idaho's Snake River Plains: Ecological and management implications. In: McArthur, E.D., E.M. Romney, S.D. Smith, and P.T. Tueller, comps. Symposium proceedings—Cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management. Gen. Tech. Rep. INT-GTR-276. Ogden, Utah: U.S. Department of Agriculture, Intermountain Forest and Range Experiment Station. pp. 4-10.

White, J.P. and I.C. Robertson. 2009a. An unusual life history strategy in *Lepidium papilliferum* (Brassicaceae), a rare mustard endemic to southwestern Idaho. Northwest Science. 83(3): 287-290.

White, J.P. and I.C. Robertson. 2009b. Intense seed predation by the Owyhee harvester ants on a rare mustard. Ecoscience. 16(4): 508-513.

Young, J. 2007. Effects of livestock trampling on *Lepidium papilliferum*, its habitat, and subsequent hydrology in southwestern Idaho. Master's thesis. University of Idaho. Moscow, Idaho. May 2007. 41 pp.

Zanette, L.R.S., R.P. Martins, and S.P. Ribeiro. 2005. Effects of urbanization on Neotropical wasp and bee assemblages in a Brazilian metropolis. Landscape and Urban Planning. 71: 105-121.

Zhou, W. and X. Guo. 2007. Discriminating invasive crested wheatgrass (*Agropyron cristatum*) in northern mixed grass prairie using remote sensing technology. Unpublished report funded by Grasslands National Park, Canada. 18 pp.

Zouhar, K., J.K. Smith, S. Sutherland, and M.L. Brooks. 2008. Wildland fire in ecosystems: Fire and nonnative invasive plants. Gen. Tech. Rep. RMRS-GTR-42-vol. 6. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah. 355 pp.

7.2 In Litteris References

Barbour, L. and D.H. Mansfield 2014, *in litt.* Morphological analysis suggests that the rare endemic *Lepidium papilliferum* (Brassicaceae) constitutes two distinct varieties. Poster presented at Idaho Rare Plant Conference. The College of Idaho, Caldwell, Idaho.

Bashore, T. L. 2014, *in litt.* Comments on U.S. Fish and Wildlife Service's proposed additional Endangered and Threatened Wildlife and Plants; Threatened Status for *Lepidium papilliferum* (Slickspot Peppergrass) Throughout Its Range. March 14, 2014. 20 pp.

Colket, B., and I. Robertson. 2006*, in litt*. Email communications between Beth Colket, Botanist, Idaho Conservation Data Center, Idaho Department of Fish and Game, Boise, Idaho and Dr. Ian Robertson, Professor, Biology Department, Boise State University, Boise, Idaho regarding use of a 1 km (0.6 mi) separation distance in delineating *Lepidium papilliferum* Element Occurrences. Email dated February 13, 2006.

DeBolt, A. 2002, *in litt.* Letter from Ann DeBolt, District Botanist, Boise District, Bureau of Land Management, Boise, Idaho dated October 4, 2002.

Findley, J. 2003, *in litt*. Letter from Jean Findley, Botanist, Bureau of Land Management, Vale District Oregon to U.S. Fish and Wildlife Service (May 22, 2003). Subject: Request for documentation of Slickspot peppergrass in Oregon.

Hardy, N. 2016*, in litt*. 2015 Geospatial analysis spreadsheet. April 2015.

Idaho Department of Fish and Game (IDFG). 2018, *in litt*. Letter from Idaho Department of Fish and Game, Boise, Idaho to Idaho Fish and Wildlife Office, Boise, Idaho providing comments on the U.S. Fish and Wildlife Service's Species Status Assessment for Slickspot Peppergrass (*Lepidium papilliferum*) dated March 21, 2018. 11 pp.

Idaho Department of Lands (IDL). 2018, *in litt*. Undated letter from Patrick Seymour of Idaho Department of Lands, Boise, Idaho to Idaho Fish and Wildlife Office, Boise, Idaho providing comments on the U.S. Fish and Wildlife Service's Species Status Assessment for Slickspot Peppergrass (*Lepidium papilliferum*). 1 pp.

Interagency *Lepidium papilliferum* Group (ILPG). 1999, *in litt*. Meeting notes from December 7, 1999. Attendance included Bureau of Land Management, Idaho Army National Guard, U.S. Air Force, Idaho Conservation Data Center, U.S. Fish and Wildlife Service. Subject: Discussion of Programs/Activities with High Risk Potential for Slickspot Peppergrass Management.

Kinter, L. 2019, *in litt*. PowerPoint slide provided by IDFG of chart documenting slickspot peppergrass plant numbers from 2005 through 2018 documented at Habitat Integrity and Population Monitoring (HIP) transects. Received at the March 26, 2019 Slickspot Peppergrass Technical Team Meeting, Boise, Idaho. 1 p.

Kinter, L. 2017, *in litt*. Handouts provided by IDFG of charts documenting slickspot peppergrass plant numbers from 2005 through 2016 documented at Habitat Integrity and Population Monitoring (HIP) transects. Received at the March 21, 2017 Slickspot Peppergrass Technical Team Meeting, Boise, Idaho. 2 pp.

LEPA Technical Team (LTT). 2016, *in litt*. LEPA Technical Team Meeting Minutes. February 4, 2016. 9:00 am – 4:00pm. 12 pp. + attachments.

Lichvar, R. 2002, *in litt*. U.S. Air Force Response to Proposal to List *Lepidium papilliferum* as Endangered (67 FR 46441). Comments on the Taxonomic Status of *Lepidium papilliferum*.

Quinney, D., R. Marrs, L. Evans, J, Anderson, and S. Miller. 2002, *in litt.* Draft Forage kochia/*Lepidium papilliferum* Slick Spot Report. Idaho Army National Guard Draft Technical Report 12. 4 pp.

Rosentreter, R. 2003, *in litt*. Slick spot peppergrass (*Lepidium papilliferum*) trip report for 5/15/03. Report for field review of impacts to slick spots from livestock use during moist soil conditions in May 2003 written by BLM Idaho State Botanist Roger Rosentreter. 3 pp.

Seronko, P. 2004, *in litt*. Memo from Paul Seronko, Environmental Protection Specialist, Bureau of Land Management, Boise, Idaho to Mark Steiger, Botanist, Bureau of Land Management, Boise, Idaho. Subject: Formation of slick spots.

Seronko, P. 2006, *in litt*. Email dated February 9, 2006, at 11:19 am from Paul Seronko, Environmental Protection Specialist, Bureau of Land Management, Boise, Idaho to Barbara Chaney, Biologist, U.S. Fish and Wildlife Service, Boise, Idaho. Subject: Re: Slickspot peppergrass.

Spokesman Review. 2015, *in litt*. Tough Idaho fire season destroys state, federal land. Spokesman Review newspaper article by Betsy Z. Russell dated September 6, 2015. Spokane, Washington. Available online at: http://www.spokesman.com/stories/2015/sep/06/tough-idaho-fire-season-destroys-state-federal/ (last accessed on August 31, 2017).

State of Idaho. 2008, *in litt.* Request for Information for Slickspot Peppergrass. Letter from Nathan A. Fisher, Administrator, State of Idaho, Office of Species Conservation, Boise, Idaho to Jeff Foss, Supervisor, US Fish and Wildlife Service, Boise, Idaho in response to the Service's request for information on slickspot peppergrass. 10 pp.

U.S. Air Force (Air Force). 2003, *in litt*. Comments on the Issues Pertaining to the Proposed Listing of the Slick Spot Peppergrass. 45 pp.

U.S. Bureau of Land Management (USBLM). 2010, *in litt*. Slickspot Peppergrass Inventory and Clearance Standards. May 13, 2010. 5 pp. + attachments.

U.S. Geological Service (USGS). 1999, *in litt.* News Release Re: USGS studies wildfire ecology in the Western United States. 9 pp.

U. S. Fish and Wildlife Service (USFWS). 2018a, *in litt.* Damele slickspot peppergrass bladed fenceline monitoring report. May 31, 2018. Report compiled by Barbara Schmidt, Fish and Wildlife Biologist, Idaho Fish and Wildlife Office, U.S. Fish and Wildlife Service, Boise, Idaho. 15 pp. + attachments.

U. S. Fish and Wildlife Service (USFWS). 2018b, *in litt.* Minutes of the April 28, 2018 Slickspot Peppergrass External Species Expert elicitation meeting hosted by the Idaho Fish and Wildlife Office, U.S. Fish and Wildlife Service, Boise, Idaho. 80 pp.

7.3 Personal Communications

Baun, C. 2019. Review comments on draft Slickspot Peppergrass Species Status Assessment provided to Idaho Fish and Wildlife Office, U.S. Fish and Wildlife Service, Boise, Idaho from Charles Baun, Idaho Army National Guard, Boise, Idaho. Received June 19, 2019.

Kinter, L. 2018. Record of telephone conversation between Fish and Wildlife Biologist Barbara Schmidt of the Idaho Fish and Wildlife Office, US Fish and Wildlife Service, Boise, Idaho and Botanist Lynn Kinter of the Idaho Department of Fish and Game, Boise, Idaho on September 24, 2018. The purpose of this contact was to request clarification regarding the IDFG's March 21, 2018 slickspot peppergrass written comments as well as to request clarification regarding drill seeding in the landscape surrounding slickspot peppergrass populations as part of the IDFG Element Occurrence ranking process.

Luke, R. 2019. Review comments on draft Slickspot Peppergrass Species Status Assessment provided to Idaho Fish and Wildlife Office, U.S. Fish and Wildlife Service, Boise, Idaho from Ruth Luke, Idaho Department of Lands, Boise, Idaho. Received April 15, 2019.

Mansfield, D., 2019. Email from Dr. Don Mansfield, College of Idaho, Caldwell, Idaho to Barbara Schmidt, Idaho Fish and Wildlife Office, U.S. Fish and Wildlife Service, Boise Idaho regarding evaluation of the taxonomic status of slickspot peppergrass. Received August 22, 2019.

Quinney, D., and J. Weaver. 1998. Contact Record by Edna Rey-Vizgirdas, Botanist, U.S. Fish and Wildlife Service of conversation with Dana Quinney and Jay Weaver, botanists with the Idaho Army National Guard (April 21, 1998).

Robertson, I. 2018. Review comments on draft Slickspot Peppergrass Species Status Assessment provided to Idaho Fish and Wildlife Office, U.S. Fish and Wildlife Service, Boise, Idaho from Dr. Ian Robertson, Boise State University, Boise, Idaho. Received September 25, 2018.

Stillman, A. 2018. Review comments on draft Slickspot Peppergrass Species Status Assessment provided to Idaho Fish and Wildlife Office, U.S. Fish and Wildlife Service, Boise, Idaho from Amy Stillman, Boise District, Bureau of Land Management, Boise, Idaho. Received October 3, 2018.

8. Acronyms Used

F –Foothills Geographic Area

BLM – Bureau of Land Management

EO – Element Occurrence

J – Jarbidge Geographic Area

IDARNG – Idaho Army National Guard

IFWIS – Idaho Fish and Wildlife Information System

INRMP – Integrated Natural Resource Management Plan

MHAFB – Mountain Home Air Force Base

OCTC – Orchard Combat Training Center (previously OTA)

OTA – Orchard Training Area (currently OCTC)

SRP – Snake River Plain Geographic Area

UPGMA - Unweighted Pair Group Method with Arithmetic Mean

Appendix A. Glossary of Scientific and Technical Terms

Term	Definition
Allele	Alternate forms of a gene.
Anther	The pollen-bearing part of the stamen. (Correll and Johnston 1979).
Catastrophic event	Disastrous events that impact ecosystems such as floods, hurricanes, tornadoes, volcanoes, earthquakes, and wildfires.
Chromosome	An organized structure consisting of DNA and protein containing a cell's genes, regulatory elements, and other nucleotide sequences (Wikipedia 2013).
Conservation Measures	Actions to benefit or promote the recovery of listed species that are included by the Federal agency as an integral part of the proposed action. These actions will be taken by the Federal agency or applicant, and serve to minimize or compensate for, project effects on the species under review. These may include actions taken prior to the initiation of consultation, or actions which the Federal agency or applicant have committed to complete in a biological assessment or similar document (USFWS and NMFS 1998, p. xii).
Edaphic	Adjective referring to soil.
Element Occurrence	An area of land or water in which a species or natural community is, or was, present (NatureServe 2002).

Endangered	"…any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man." U.S. Congress 1988.
Endemic	An organism restricted to a specific habitat or geographic range.
Forb	A broad-leafed herbaceous plant.
Gene flow	The transfer of alleles or genes from one population to another (Wikipedia 2013).
Genetic drift	A change in allele frequencies within a population over time.
GIS	Geographic Information System; computer software used to store, analyze, and create maps using geographic data.
Habitat	Ecological or environmental area that is inhabited by a particular species of animal, plant or other type of organism (Wikipedia 2013).
Herbarium	A repository for long-term storage and study of preserved plant specimens.
Historic population	A previously documented population that has been extirpated or can no longer be found.

Inbreeding	Sexual reproduction between closely-related individuals.
Inbreeding depression	The reduction of fitness caused by mating between relatives (Edmands 2007, p. 464).
Invasive	Species that is non-native (or alien) to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Clinton 1999; 64 FR:6183–6186, February 3, 1999).
Metapopulation	A group of spatially separated populations of the same species that interact at some level (Wikipedia 2016).
Micro-habitat	Very specific or fine-scale portion of a habitat that is occupied by a species.
Microsite	Micro-habitat.
Minimum Viable Population	The fewest individuals required for a specified probability of survival over a specified period of time (Pavlik 1996; Mace and Lande 1991); see Population Viability Analysis.
Outbreeding depression	The reduction in reproductive fitness in the first or later generations following attempted crossing of populations (Frankham *et al.* 2011, p. 466).
Outcome-based grazing management	A grazing management system which enables flexibility to meet ecological rangeland health goals based on current conditions rather than through rigid permitting requirements.
Outcross	In plants, sexual fertilization involving the union of gametes from different individuals.

Perennial	A plant that lives for more than one full year.
Pleistocene	Geological epoch beginning about 2,588,000 years ago and ending about 11,700 years ago (Wikipedia 2013).
Population	Collection of inter-breeding organisms of a particular species (Wikipedia 2016).
Population dynamics	Changes in the size and age composition of populations over time, and the biological and environmental processes influencing those changes (Farlex, Inc. 2011).
Population Viability Analysis	Statistical models used to predict the probability of extinction of a population after a specified period of time.
Prescriptive grazing	Controlled harvest of vegetation with browsing and grazing animals to achieve specific goals on the land such as control of invasive plants (see also “targeted grazing”).
Ramet	An individual member of a clone of plants derived by vegetative reproduction from a single parent plant.
Recruitment	Addition of new individuals to a population.
Redundancy	The number of populations or sites necessary to endure catastrophic losses (Shaffer and Stein 2000, pp. 308-310).
Reintroduction	Restoration of populations of a species where it is currently absent but within its former range and habitat.
Representation	The genetic diversity necessary to conserve long-term adaptive capability (Shaffer and Stein 2000, pp. 307-308).
Resiliency	The size of populations necessary to endure random environmental variation (Shaffer and Stein 2000, pp. 308-310).

Section 6	Cooperative Endangered Species Conservation Fund (Section 6 of the ESA). (USFWS 2009)
Section 7	The section of the Endangered Species Act of 1973, as amended, outlining procedures for interagency cooperation to conserve Federally listed species and designated critical habitats (USFWS and NMFS 1998, p. xviii).
Self-fertilization	Sexual reproduction involving the union of gametes from a single individual.
Self-pollination	Fertilization of a flower with pollen from the same individual.
Soil seed bank	Dormant and non-dormant seeds present in the soil that are able to germinate.
Speciation	The evolutionary process by which new biological species arise (Wikipedia 2016).
Species viability	A species' ability to sustain populations in the wild beyond the end of a specified period, assessed in terms of its resiliency, redundancy, and representation (USFWS 2015).
Stochastic	Random.
Systematics	The study of the diversification of life on the planet Earth, both past and present, and the relationships among living things through time, visualized as evolutionary trees (Wikipedia 2016).
Taproot	Predominantly long or thick central root; may function to access deep soil moisture, storage of water and carbohydrates, or both.

Targeted grazing	The application of a specific kind of livestock at a determined season, duration, frequency, and intensity to accomplish defined vegetation and landscape goals (see also "prescriptive grazing").
Taxonomy	Scientific classification of living organisms.
Threatened	"…any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." United States Congress 1988.
Unweighted Pair Group Method with Arithmetic Mean (UPGMA)	A simple agglomerative (bottom-up) hierarchical clustering method generally attributed to Sokal and Michener.

Appendix B. Ongoing Conservation Efforts

Currently, there are four formalized plans that contain conservation measures for slickspot peppergrass. The BLM administers about 12,154 acres (75 percent) of slickspot peppergrass populations on Federal lands, including land uses within the Idaho Army National Guard's Orchard Combat Training Center boundary. BLM represents a key conservation partner for the species and implements multiple conservation measures through two conservation agreements. Both the Idaho Army National Guard and the U.S. Air Force's Mountain Home Air Force Base (MHAFB) have incorporated conservation measures within their respective Integrated Natural Resource Management Plans (INRMPs) that avoid or minimize effects of threats, such as wildfire, nonnative invasive plants, herbicide use, and ground disturbance, on slickspot peppergrass. Conservation efforts by and with these Federal partners and others will continue to be important into the future.

The Service's evaluation of planned conservation efforts (as described in the 2009 and 2016 final listing rules (74 FR 52014, 81 FR 55083)) indicates that not all of the measures identified in ongoing conservation plans or other conservation efforts have been implemented and most have not been demonstrated to effectively reduce or eliminate the most significant threats (wildfire and invasive nonnative plants) to the species. Many of these conservation efforts are limited in their ability to effectively reduce the long-term habitat degradation and destruction occurring within slickspot peppergrass habitats from the effects of a changed wildfire regime and nonnative plant invasions. In many cases, effective control measures for these threats are not yet known, financially or technically feasible, or logistically possible to implement on the scale that would be necessary to successfully ameliorate the threat of fire and invasive nonnative plants within sagebrush steppe habitat of the Great Basin, including within the range of slickspot peppergrass. Ongoing conservation efforts that have been demonstrated to be effective, such as the IDARNG's efforts to control the effects of wildfire on slickspot peppergrass habitats at the Orchard Combat Training Center through rapid wildfire suppression response and avoidance of military training activities in areas containing the species, are a positive step toward the conservation of slickspot peppergrass. Other conservation measures, including those designed to reduce the impact of ground disturbances caused by livestock, have likely reduced the severity of threats to the species.

Provided below are brief descriptions of the four existing formalized conservation plans for slickspot peppergrass as well as other ongoing actions that provide benefits to the species.

State of Idaho Candidate Conservation Agreement (CCA)

The majority of the individual conservation efforts being implemented for slickspot peppergrass are contained in the State of Idaho CCA, which was originally drafted in 2003, and updated in 2006. The State of Idaho's CCA incorporated conservation measures for the species at three interrelated levels: the LEPA Consideration Zone (all areas that may or do contain slickspot peppergrass); specified Management Areas; and specific priority EOs. This three-tiered approach was used to address the need to reduce, mitigate, and eliminate threats that may vary in presence or severity throughout the range of slickspot peppergrass (State of Idaho 2003. p. 21). The State of Idaho's Candidate Conservation Agreement encompasses all BLM, State, and National Guard lands across the range of the species.

To date, the CCA remains in effect until a status review determines that further conservation measures are no longer necessary. The CCA includes rangewide efforts that are intended to address the need to: maintain and enhance slickspot peppergrass habitat; reduce intensity, frequency, and size of natural- and human-caused wildfires; minimize loss of habitat associated with wildfire-suppression activities; reduce the potential for invasion of invasive nonnative plant species from wildfire; minimize loss of habitat associated with rehabilitation and restoration techniques; minimize the establishment of nonnative species; minimize the degradation or loss of habitat from off-road vehicle (ORV) use; mitigate the negative effects of military training and other associated activities on the Orchard Combat Training Center; and minimize the impact of ground disturbances caused by livestock during periods when soils are saturated. As a signatory of the CCA, the BLM is the primary land management agency implementing conservation efforts for slickspot peppergrass on their lands.

Although the majority of conservation measures identified in the CCA have been implemented to date, relatively few of these measures were determined to be measurably effective for conserving slickspot peppergrass at the time of listing. With the exception of several conservation efforts implemented at the IDARNG's Orchard Combat Training Center that have been successful in controlling wildfire effects on slickspot peppergrass habitats, many of the remaining conservation efforts and adaptive management provisions identified in the CCA were implemented over a long enough period of time to demonstrate their effectiveness in reducing threats to the species. In addition, many of the implemented measures include conducting surveys, monitoring, or providing for public outreach and education, which have limited direct or long-term conservation benefits to the species. The majority of conservation measures in the CCA addressed potential effects due to livestock use. Since implementation of the CCA, HIP monitoring has detected a decline in livestock trampling triggers tripped over the 12 years of monitoring data available. The highest number was eight triggers tripped in 2007; more recent years have shown a low incidence of livestock triggers tripped (one livestock trigger tripped in 2012, zero livestock triggers tripped in 2013 and two livestock triggers tripped in 2014, three livestock triggers tripped in 2015, and zero livestock triggers tripped in 2016). Furthermore, the conservation measures identified in the CCA are concentrated on slickspot peppergrass EOs. While this focus is helpful, effectively controlling the most significant threats to slickspot peppergrass (wildfire and invasive nonnative plant species) requires efforts that extend well beyond the boundaries of EOs since these threats are naturally expansive and occur throughout the Great Basin at landscape levels. The Service recognizes conservation efforts identified in the CCA have a conservation benefit for slickspot peppergrass, but rangewide their effectiveness in reducing or eliminating the most significant threats to the species (wildfire and invasive nonnative plants) has not been demonstrated at this time.

Idaho Army National Guard – Gowen Field/ Orchard Combat Training Center Integrated Natural Resource Management Plan

The IDARNG, another signatory to the CCA, also implements conservation efforts for slickspot peppergrass through its Integrated Natural Resource Management Plan (INRMP) (IDARNG

2013, Appendix 2). The IDARNG's Orchard Combat Training Center on the Snake River Plain contains 7,213 acres of occupied slickspot peppergrass habitat, 7,163 ac of which represents some of the highest-quality occupied slickspot peppergrass habitat in the Snake River Plain geographic area. The INRMP, which has been in place since 1997 and was updated in 2004 and again in 2013, provides a framework for managing natural resources. Conservation measures included in the INRMP avoid or minimize impacts on slickspot peppergrass, slick spot microsites, and sagebrush steppe habitat while allowing for the continued implementation of the IDARNG's military training mission.

The INRMP also addresses wildfire and invasive nonnative plant species; for example, the INRMP includes objectives for maintaining and improving slickspot peppergrass habitat and restoring areas damaged by wildfire. The plan specifies that the Orchard Combat Training Center will use native species and broadcast seeding, collecting, and planting small amounts of native seed not commercially available, and will monitor the success of seeding efforts (IDARNG 2013, Appendix 2, pp. 31, 34). Since 1991, the Orchard Combat Training Center has restored several areas using native seed and vegetation that was present prior to past wildfires. Many of the conservation efforts, such as prohibiting military training activities within areas reserved for conservation of slickspot peppergrass, have been implemented by the IDARNG since 1991 (27 years), and have been demonstrated to be effective in minimizing impacts to the species.

Mountain Home Air Force Base Integrated Natural Resource Management Plan

The U.S. Air Force (Air Force), Mountain Home Air Force Base, which includes the Juniper Butte Range (JBR) in the Jarbidge geographic area, has an INRMP in place that provides conservation benefits for slickspot peppergrass. This INRMP has been in place for this military training facility since 2004, and was updated in 2012 and again in 2018. The Air Force manages 1,948 acres of habitat supporting slickspot peppergrass within the JBR. The INRMP contains specific measures developed to minimize the impacts from military training and the associated indirect effects from wildfire, invasive nonnative plant species, and livestock use on slickspot peppergrass, slick spot microsites, and sagebrush steppe habitat, while allowing for continued implementation of the Air Force mission.

For example, the Air Force has a number of ongoing efforts to address wildfire suppression on the entire 12,141 acre JBR. Wildfire prevention is addressed through reducing standing fuels and weeds, planting wildfire-resistant vegetation in areas with a higher potential for ignition sources such as along roads, and using wildfire indices to determine when to restrict military activities when wildfire hazard rating is extreme (U.S. Air Force 2004, p. 6–55; U.S. Air Force 2012, p. 4-3). As a result, the risk of wildfire to slickspot peppergrass associated with Air Force training activities is reduced within the JBR.

Bureau of Land Management and Fish and Wildlife Service Conservation Agreement

The Conservation Agreement (CA) between the BLM and the Service was finalized on August 22, 2006, and updated in 2009, 2013, and 2014 (USBLM and USFWS 2014, entire). This CA provides for the conservation of slickspot peppergrass related to programs within existing Idaho BLM land use plans (LUPs) which provide guidance for the development and implementation of individual project level activities. The CA and associated conservation measures serve as the basis for section 7 consultation on these BLM LUPs until such time that the plans are updated to include slickspot peppergrass conservation measures of equivalent or greater conservation value. There are two remaining BLM LUPs that are addressed under the scope of the CA: the 1983 Kuna Management Framework Plan (MFP) and the 1988 Cascade Resource Management Plan (RMP). Currently, a LUP revision is in progress for the Four Rivers Field Office (the Four Rivers RMP) that will update and replace these two LUPs. To date, the CA is no longer applicable to the Morley Nelson Snake River Birds of Prey National Conservation Area and the Jarbidge planning area as their RMPs contain management direction for slickspot peppergrass similar to what is found within the CA. Associated section 7 consultation has been completed on the RMPs for the Morley Nelson Snake River Birds of Prey National Conservation Area and the Jarbidge planning area.

Conservation measures outlined in the CA describe desired recovery and conservation objectives with corresponding implementation actions and have been analyzed in the BLM's associated September 2009 Biological Assessment; the Service completed the Biological Opinion on existing BLM RMPs in November 2009, on ongoing BLM livestock grazing in January 2010, and on other BLM permitted actions in June 2011. Conservation measures implemented to date include delayed livestock turn out when slick spot soils are saturated, emphasis on habitat conservation and restoration for the plant and its insect pollinators, and establishment of Ecological Reference Areas (ERAs) in selected slickspot peppergrass EOs to evaluate land health conditions associated with the species. BLM defines ERAs as a landscape unit in which ecological processes are functioning within a normal range of variability and the plant community has adequate ecological resistance to and resilience from most disturbances. ERAs are lands that best represent the potential of a specific ecological site in both physical function and biological health (USBLM 2001, p. I-3). To date, two fenced ERAs have been established on lands administered by the BLM. An additional nine fenced Habitat Enhancement Areas (HEAs) have been established on BLM lands for use in development of effective habitat restoration techniques for slickspot peppergrass EOs of varying habitat quality.

A significant change to the updated CA in 2014 included more specific requirements such as to avoid use of potentially invasive nonnative plant species such as *Bassia prostrata* (forage kochia) in ESR treatments and fuel breaks within 1.5 miles of EOs as well as to require rigorous monitoring and subsequent removal of forage kochia if the species establishes outside of seeded areas. The 2014 CA also clarified invasive nonnative plant species control requirements associated with land use permits, leases, and rights-of-way that overlap EOs. In addition, the 2014 updated CA was clarified to allow for livestock trailing through EOs, proposed critical habitat, or Occupied Habitat [currently known as extant EOs and their surrounding Habitat Integrity Zones] on existing roads or historic trailing routes within the BLM's Four Rivers Field Office area; livestock trailing in these previously disturbed corridors is not expected to reduce the survival or recovery of the species.

Clarification and update of these conservation measures in 2014 allow BLM greater land management flexibility while providing for continued conservation of the species. BLM has stated that, with the update of the CA in 2014, implementation of projects intended to address threats to the sagebrush steppe ecosystem is not impeded by more general conservation measures for the species that were included in previous versions of the CA.

Idaho Rangeland Fire Protection Associations and Slickspot Peppergrass

In addition to formalized plans for conservation of slickspot peppergrass, other actions are being implemented that contribute to conservation of the species. Rangeland Fire Protection Associations (RFPAs) are currently being established in parts of southern Idaho. These RFPAs are designed to provide ranchers and landowners in rural areas with necessary tools and training to allow them to assist with wildfire prevention and respond quickly to wildfire. Two of these RFPAs, the Three Creek RFPA and the Saylor Creek RFPA, have been established within the slickspot peppergrass Jarbidge geographic area, where both slickspot peppergrass and the greater sage-grouse co-occur. The Mountain Home RFPA, which was expanded in 2015 to include additional slickspot peppergrass EOs, also contains a portion of habitat occupied by slickspot peppergrass within the Snake River Plain geographic area.

Approximately 45 percent of slickspot peppergrass habitat is currently located within RFPA or Mutual Aid boundaries, and 70 percent of EO acres located on State Endowment Trust Lands are within fire protection boundaries (1.015 of 1,454 acres) (IDL *in litt.* 2018, p. 1). However, these areas continue to be at a high risk of large catastrophic wildfires based on conditions associated with low ecological resistance and resilience areas (Chambers *et al.* 2014a, entire). In addition, while RFPAs have the potential to influence the overall effect of wildfires, they do not address the threat from existing invasive nonnative plant species, the second of two primary threats identified for the species, or the conservation need for sagebrush steppe habitat restoration. Therefore, while the formation of RFPAs are a positive conservation step for sagebrush steppe habitat, RFPAs have not yet shown to be sufficiently effective to offset the primary threat of wildfire to the species.

BLM Greater Sage-Grouse Conservation Efforts and Slickspot Peppergrass

The Service recognizes the future potential benefits to sagebrush steppe habitats associated with the BLM's efforts to conserve greater sage-grouse through amendment of existing land use plans, including increased measures to limit wildfire impacts to sagebrush steppe habitats and revegetation efforts. The Service considered several greater sage-grouse conservation efforts that may provide benefits to slickspot peppergrass habitat, including the land use plan amendments, the Fire and Invasives Assessment Team (FIAT) planning areas, and activities identified in response to Secretarial Order (SO) 3336. Less than 21 percent of the known area of slickspot peppergrass occurrences overlap with greater sage-grouse habitats where the BLM will implement land use plan amendment conservation measures (including habitat restoration and wildfire suppression actions). Furthermore, conservation measures within the BLM land use plan amendment for greater sage-grouse are largely directed at Priority and Important Habitat Management Areas. Only 17 percent of known slickspot peppergrass occurrences overlap with designated Important Habitat Management Areas (IHMA), 4 percent occur in General Habitat Management Areas, and none of the remaining 79 percent of known slickspot peppergrass occurrences are located in Priority Habitat Management Areas.

Although slickspot peppergrass does occur in areas designated as IHMA, the actions identified in the land use management plan amendments were prioritized by the FIAT and are focused on providing benefits to greater sage-grouse. Projects were prioritized to address breeding habitat for greater sage-grouse within areas that are the most ecologically resistant and resilient to wildfire. Only a very small area, approximately 1 percent of slickspot peppergrass EO acres, occurs in prioritized areas. The likelihood of projects occurring in slickspot peppergrass EOs is very low and, therefore, unlikely to provide a significant benefit to the species.
SO 3336 commits to large-scale conservation to address wildfire and invasive nonnative plants; however, the initial focus is on sagebrush ecosystems and greater sage-grouse habitat. While the SO includes commitments to ensure restoration will be initiated following wildfire, since projects are prioritized relying on FIAT prioritization, the vast majority of areas where slickspot peppergrass occurs have not been identified as a priority.

In addition, differences exist in the vulnerability of greater sage-grouse and slickspot peppergrass to landscape-level threats such as wildfire and invasive nonnative plants. Greater sage-grouse are distributed across a much wider range than slickspot peppergrass and occur in areas of varying ecological resilience to disturbance and resistance to invasion by annual grasses. Due to the wider range and variety of habitat conditions, greater sage-grouse are more capable of absorbing the impact of large wildfires. Conversely, slickspot peppergrass has a narrow range, is found overwhelmingly (99 percent of occurrences) in areas of low habitat ecological resilience to disturbance and resistance to invasion by annual grasses, and could be heavily impacted by a single catastrophic wildfire such as the 2015 Soda Fire in southwest Idaho and Eastern Oregon, which burned 283,000 acres (National Interagency Fire Center 2015). Further, greater sage-grouse conservation efforts have recognized the difficulty in preventing wildfire and controlling invasive nonnative plants in areas with low ecological resistance and resilience (where 99 percent of slickspot peppergrass occurs) and have thus focused on implementing wildfire prevention and restoration in areas within habitats with higher ecological resistance and resilience. As such, the Service does not anticipate BLM land use plan amendments, FIAT, or SO 3336 will significantly alter the rangewide foreseeability of threats to slickspot peppergrass. Furthermore, limited funding and resources for habitat conservation and restoration are currently focused on greater sage-grouse prioritized habitats, which may limit resources available for restoration in ecologically low resistance and resilience habitats for slickspot peppergrass recovery.

Large-scale Fuel Break Programs

Two large-scale fuel break programs, the Paradigm Fuel Breaks Project and the Jarbidge Fuel Breaks Project, have the potential to influence wildfire frequency and spread within slickspot peppergrass populations. The Service is aware of potential future long-term benefits that may occur associated with compartmentalization of future wildfires in the Great Basin, including within the range of slickspot peppergrass. The Service also acknowledges risks associated with seeded nonnative invasive plant species like *Bassia prostrate* (forage kochia), in areas that support slickspot peppergrass. As such, the Service continues to encourage our partners to minimize any potential adverse impacts of proposed fuel break projects in the vicinity of slickspot peppergrass habitat. For example, guidance on how to avoid or minimize potential effects of fuels management projects on slickspot peppergrass and its habitat has been provided in the 2014 Conservation Agreement (CA) for slickspot peppergrass between BLM and the Service, and the Service anticipates the BLM will adhere to the CA.

The BLM is currently implementing the Jarbidge Fuel Breaks Project, which is located approximately 5 air miles east of known slickspot peppergrass populations in the Jarbidge geographic area; this fuel breaks project could reduce the risk of a large wildfire reaching slickspot peppergrass populations within the disjunct Jarbidge geographic area by increasing wildfire suppression effectiveness. In addition, the BLM and Natural Resource Conservation Service (NRCS) are also currently implementing the Paradigm Fuel Breaks project, a large fuel break project to address increased frequency and intensity of wildfires between the Boise and the Glenns Ferry areas of the northern Great Basin. Subsequent to the publication of our proposed reconsideration of the final rule, the Service coordinated with the BLM regarding strategies to avoid or minimize potential effects of the proposed Paradigm Fuel Breaks Project on slickspot peppergrass. This Project encompasses about 18 percent of the total area of slickspot peppergrass EOs and subEOs rangewide.

The Service is not aware of any long-term data regarding suppression effectiveness of fuel breaks in areas of low ecological resistance and resilience, which is where more than 99 percent of slickspot peppergrass occurs. However, anecdotal evidence, sporadic project monitoring, and limited record-keeping indicate that fuel treatments do accomplish their intended goals under certain conditions. However, a history of incomplete and insufficient record-keeping has resulted in a lack of systematically collected data on fuel treatments in general, and fuel breaks specifically, that would allow for a ready and objective analysis of how often and under what conditions linear fuel breaks are effective. Spatially and temporally comprehensive datasets on fuel breaks are lacking, including locations, treatment types, maintenance history, fire environments (for example, fire-weather conditions, fuel loadings), and firefighting response (for example, whether or not used for suppression activities, and in what manner) to accomplish such an analysis at this time. However, as agency-wide databases continue to be compiled and improved, such analyses may become prudent, at least for portions of the Great Basin with consistent record keeping (Shinneman *et al.* 2018, p. 26).

While the Jarbidge and the Paradigm fuel breaks projects have the potential to reduce the risk of wildfires within portions of the range of slickspot peppergrass, these fuel break projects do not address the co-occurring effects of existing invasive nonnative plant species, one of two primary threats identified for the species, or the conservation need for sagebrush steppe habitat restoration. Addressing existing invasive nonnative plants and the restoration of sagebrush steppe habitat are not within the scope of these fuel breaks projects. Considering all of these factors, it is unlikely that these large fuel break projects on their own will adequately address threats such that rangewide future species viability is maintained or improved. Although wildfire suppression, including RFPAs, and fuels management efforts currently in place are a positive conservation step for slickspot peppergrass and its habitat, they are not sufficient at this time to offset effects of current and future extent of invasive nonnative plants or other threats across the range of the species.

Appendix C. Section 7 Consultation Cause and Effect Evaluations

Section 7 Consultation Slickspot Peppergrass Cause and Effect Evaluations Table R = Reproduction, P = Pollination, N = Nutrition, D = Dispersal

Activity	Exposure		Biology			Consequences				
						Individuals		Populations	Species	Avoid/Minimize/Mitigation
Terminal Activity	DIRECT Interaction	INDIRECT Interaction	Resources or Individuals Exposed	Life Stage Affected	Resource Function (R,P,N,D)	Responses to exposure	Effects	Effects to Reproduction, Numbers, Distribution	Resiliency Representation Redundancy	
OHV use through slick spots & surrounding habitat	Crush plants Deep burial of seeds	Spread of invasive nonnative plants Impacts to slick spot function Wildfire ignition Wind or water facilitated soil or dust deposition on slick spots Impacts to pollinators (Soil or dust; reduced forbs or habitat)	Individual plants Slick spot microsites Native grasses, forbs, shrubs, & biological soil crusts	Seeds, seedling, rosette, flowering annuals / biennials	R,P,N,D	Trauma Competition from invasive plants Reduced seed set due to dust-covered flowers or dust-impacted pollinators Seedlings unable to reach soil surface	Death Reduce seed production Reduce seed rain into seed bank	Decreased contribution to seed bank	↓Resiliency →Representation →Redundancy	No vehicle use or parking in slick spots Avoid off road travel when soil saturated or fine fuels dry Remove and properly dispose of plant parts from vehicles and trailers prior to OHV use in the vicinity of EOs
Vegetation removal	Direct loss of LEPA plants, including seeds	Loss of grasses, forbs, and shrubs for insect pollinator food and shelter Lowered available water due to shrub removal If shrubs removed, potential for increased Owyhee harvester ant density	Flowering plants Native grasses, forbs, shrubs, & biological soil crusts Seeds	Seeds, seedling, rosette, flowering annuals / biennials Seeds	R,P,N,D R,D	Trauma Reduced seed set Seeds lost due to herbivory	Death Reduce seed production Reduce seed rain into seed bank	Decreased contribution to seed bank	↓Resiliency ↓Representation ↓Redundancy	Control invasive plants Retain native plants Restore native vegetation Restore native shrubs (ants) In limited cases at select EOs, ant control measures

Activity	Exposure		Biology			Consequences				
						Individuals		Populations	Species	Avoid/Minimize/Mitigation
Terminal Activity	**DIRECT Interaction**	**INDIRECT Interaction**	**Resources or Individuals Exposed**	**Life Stage Affected**	**Resource Function (R,P,N,D)**	**Responses to exposure**	**Effects**	**Effects to Reproduction, Numbers, Distribution**	**Resiliency Representation Redundancy**	
Drill seeding	Crush plants Deep burial of seeds (see Scholten and Bunting 2001)	Spread of invasive nonnative plants through disturbance Seeded species compete with LEPA if seeded in slick spots Long-term benefit from reduced competition with invasive nonnative plants and lowered wildfire risk, if native or non-invasive nonnative plants are seeded	Individual plants Slick spot microsites Native grasses, forbs, shrubs, & biological soil crusts	Seeds, seedling, rosette, flowering annuals / biennials	R,P,N,D	Trauma Competition from invasive plants Seedlings unable to reach soil surface Beneficial if reduced fire risk and reduced competition due to reduced nonnative annual grasses	Death Reduce seeds	Decreased contribution to seed bank	If seed highly competitive nonnatives in slick spot microsites: ↓Resiliency ↓Representation ↓Redundancy If seed natives with conservation measures to avoid slick spots and minimize ground disturbance/reduce nonnative annuals: ↑Resiliency ↑Representation ↑Redundancy	Avoid occupied slick spots and use least ground disturbing methods Use invasive plant control measures Retain existing native plants Restore native vegetation using locally adapted plant materials Remove and properly dispose of plant parts from equipment and trailers prior to implementation in the vicinity of EOs
Walking / riding through slick spots (humans, livestock, etc.)	Crush plants Deep burial of seeds	Spread of invasive nonnative plants	Individual plants Slick spot microsites Native grasses, forbs, shrubs, & biological soil crusts	Seeds, seedling, rosette, flowering annuals / biennials	R,P,N,D	Trauma Competition from invasive plants Seedlings unable to reach soil surface	Death Reduce seeds	Decreased contribution to seed bank	↓Resiliency ↓Representation ↓Redundancy	Avoid slick spots when soils are saturated & when plants are actively growing / flowering Place water / salt to draw livestock away from EOs Trail livestock on existing roads & routes Delay livestock turn out when slick spot soils are saturated Avoid construction of hiking / biking recreational trails through slick spot microsites / EOs

Activity	**Exposure**		**Biology**			**Consequences**				
						Individuals		**Populations**	**Species**	**Avoid/Minimize/Mitigation**
Terminal Activity	**DIRECT Interaction**	**INDIRECT Interaction**	**Resources or Individuals Exposed**	**Life Stage Affected**	**Resource Function (R,P,N,D)**	**Responses to exposure**	**Effects**	**Effects to Reproduction, Numbers, Distribution**	**Resiliency Representation Redundancy**	
Livestock use, including targeted grazing or prescriptive grazing, and outcome-based livestock grazing management	Crush plants Deep burial of seeds Beneficial effects of reduced fine fuels for reduced wildfire risk	Spread of invasive nonnative plants Reduced vigor or loss of native grasses and forbs	Individual plants Slick spot microsites Native grasses, forbs, shrubs, & biological soil crusts	Seeds, seedling, rosette, flowering annuals / biennials	R,P,N,D	Trauma Competition from invasive plants & loss of native forbs Impacts to pollinators Seedlings unable to reach soil surface	Death Reduce seeds	Decreased contribution to seed bank	For targeted spring grazing in sites with occupied slick spots: ↓Resiliency ↓Representation ↓Redundancy For targeted or prescriptive grazing and outcome-based management grazing outside of EOs and subEOs with conservation measures to avoid slick spots and minimize ground disturbance: ↑Resiliency ↑Representation ↑Redundancy	Avoid occupied slick spots when soils are saturated & when plants are actively growing / flowering Place water / salt to draw livestock away from EOs Trail livestock on existing roads & routes Delay livestock turn out when slick spot soils are saturated Use management techniques to minimize exposure to trampling (stocking rates, rotational spring grazing, fall/winter grazing, etc.)
Herbicide use	Direct loss of or injury to LEPA plants Inhibition of seed germination due to pre-emergent herbicide exposure (see Scholten and Bunting 2001)	Benefit from reduced competition with other plants, if tolerant of herbicide used Loss of non-target natives needed by pollinators	Individual plants Native grasses, forbs, shrubs, & biological soil crusts	Seeds, seedling, rosette, flowering annuals / biennials	R,P,N,D	Trauma Reduced seed set	Injury or death Reduce seeds	Decreased contribution to seed bank due to loss of 1 year of seed cohort	If application results in contact of non-tolerated herbicide with LEPA plants and non-target forbs: ↓Resiliency ↓Representation ↓Redundancy If application avoids contact of non-tolerated herbicide with LEPA plants and non-target forbs: ↑Resiliency ↑Representation ↑Redundancy	Avoid application of herbicides that may injure or kill LEPA within occupied slick spots. Avoid herbicide contact with non-target native plants Revegetate treated EOs with native plants following herbicide treatments
Use of construction equipment or other large vehicles (tractors, military equipment, etc.)	Crush plants Deep burial of seeds	Spread of invasive nonnative plants Loss of slick spots Wind or water facilitated soil or dust deposition on slick spots Impacts to pollinators	Individual plants Slick spot microsites Native grasses, forbs, shrubs, & biological soil crusts	Seeds, seedling, rosette, flowering annuals / biennials	R,P,N,D	Trauma Reduced seed set due to dust-covered flowers or dust-impacted pollinators Competition from invasive plants Seedlings unable to reach soil surface	Death Reduce seed production	Decreased contribution to seed bank	↓Resiliency ↓Representation ↓Redundancy	Avoid occupied slick spots and use least ground disturbing methods Use dust abatement and erosion control measures Use invasive species control measures Avoid native plants Restore native vegetation No vehicle use or parking in slick spots Avoid off road operation when soils are saturated or fine fuels are dry

Activity	Exposure		Biology			Consequences				
						Individuals		Populations	Species	Avoid/Minimize/Mitigation
Terminal Activity	**DIRECT Interaction**	**INDIRECT Interaction**	**Resources or Individuals Exposed**	**Life Stage Affected**	**Resource Function (R,P,N,D)**	**Responses to exposure**	**Effects**	**Effects to Reproduction, Numbers, Distribution**	**Resiliency Representation Redundancy**	
		(Soil or dust; reduced forbs or habitat) Wildfire ignition								Remove and properly dispose of plant parts from equipment and trailers prior to implementation in the vicinity of EOs
Construct or maintain infra-structure (fences, corrals, roads, power lines, pipelines)	Crush plants Deep burial of seeds Soil or dust covered plants	Spread of invasive nonnative plants Damage to or loss of slick spots Wind or water facilitated soil or dust deposition on slick spots Impacts to pollinators (Soil or dust; reduced forbs or habitat) Wildfire ignition	Individual plants Slick spot microsites Native grasses, forbs, shrubs, & biological soil crusts	Seeds, seedling, rosette, flowering annuals / biennials	R,P,N,D	Trauma Reduced seed set due to dust-covered flowers or dust-impacted pollinators Competition from invasive plants or highly competitive seeded species Seedlings unable to reach soil surface	Death Reduce seed production	Decreased contribution to seed bank	↓Resiliency ↓Representation ↓Redundancy	Avoid occupied slick spots and use least ground disturbing methods Use dust abatement and erosion control measures Use invasive species control measures Avoid native plants Restore native vegetation No vehicle use or parking in slick spots Avoid off road travel when soil saturated or fine fuels dry Remove and properly dispose of plant parts from equipment and trailers prior to implementation in the vicinity of EOs
Pesticide use (Mormon crickets, Owyhee harvester ants, etc.)		Injury or death of nontarget insect pollinators Beneficial if targeting Owyhee harvester ants at priority EOs	Individual plants Insect pollinators	Seeds, flowering annuals / biennials	R,P	Reduced seed set If ants, more seeds available to enter seed bank as seed predation decreased	Reduce seeds If ants, local seed bank larger	Decreased contribution to seed bank If ants, increased contribution to seed bank	↓Resiliency →Representation →Redundancy If ants, ↑Resiliency →Representation →Redundancy	Avoid occupied sites and corridors Use specific chemical/ biocontrol agent that target pest species only

Appendix D. Current Disturbance Scope and Severity within Element Occurrences

EO Rankings and Disturbance Severity and Scope Documented within Slickspot Peppergrass Element Occurrences (severity and scope information derived from IDFG slickspot peppergrass element occurrence assessment field data; Geographic area, EO rank, and acreages from July 2018 IFWIS data).

EO Number	Geo-graphic Area	EO Rank	Acres	Nonnative Plants	Wildfire	Owyhee Harvester Ants	Development^	Livestock Use	Recreation Activity	OHV Activity	Badger Activity	Drill Seeding	Trash Dumping	Wildlife Digging/ Trails/ Feces	Wildfire Suppression Activities	Erosion	Agricultural Activities
2	SRP	C	2.48	S - ↑	*	L - ↓	*	M - ↑	*	*	*	*	*	*	*	*	*
8	SRP	B	1020.48	S - ↑	*	L - ↓	E - ↓	M - ↑	*	*	E - ↔	*	*	*	*	*	*
10	SRP	D	3.93	S - ↑	*	L - ↓	*	M - ↑	S - ↓	S - ↓	*	*	*	*	*	*	*
12	F	D	0.48	S - ↑	*	*	*	*	L - ↑	*	*	*	*	*	*	*	*
15	SRP	C	156.01	E - ↑	*	L - ↓	*	M - ↔	*	S - ↔	*	*	*	*	*	*	*
18	SRP	B	1818.43	E - ↑	*	S - ↔	*	L - ↑	*	*	S - ↓	S - ↑	*	*	*	*	*
20	SRP	C	3.21	S - ↑	*	L - ↓	*	M - ↑	S - ↓	S - ↓	E - ↓	*	*	*	*	*	*
21	SRP	C	100.15	S - ↑	*	L - ↓	*	*	*	*	E - ↓	*	S - ↓	*	*	*	*
22	SRP	D	126.40	E - ↑	*	*	M - ↓	*	*	*	S - ↓	*	*	*	*	*	*
23	F	CD	5.79	S - ↑	*	*	*	*	L - ↓	*	*	*	*	M - ↔	*	*	*
24	SRP	C	180.51	S - ↑	*	S - ↔	*	L - ↑	L - ↓	S - ↓	S - ↓	*	L - ↓	*	*	*	*
25	SRP	B	38.55	E - ↑	*	L - ↓	L - ↓	*	S - ↑	S - ↓	*	S - ↑	*	*	*	*	*
26	SRP	B	708.31	S - ↑	E - ↓	L - ↔	E - ↓	M - ↔	*	*	E - ↓	*	*	*	*	*	*
27	SRP	B	7163.63	L-M - ↑	*	*	L-M - ↔	M - ↑	E - ↔	E - ↔	E - ↓	*	*	*	*	*	*
28	SRP	C	0.48	S - ↑	*	L - ↓	*	M - ↓	*	*	E - ↓	*	*	L - ↓	*	*	*
29	SRP	C	104.65	E - ↑	S - ↑	L - ↓	E - ↓	M - ↓	L - ↓	S - ↓	E - ↓	*	L - ↓	L - ↑	E - ↓	*	*
30	SRP	BC	702.32	S - ↑	*	L - ↓	*	M - ↑	*	*	E - ↓	S - ↔	*	*	*	*	*
31	SRP	D	71.25	M - →	S - ↑	*	L-M - ↓	S - ↔	*	*	*	*	L - ↓	*	*	*	*
32	SRP	C	619.07	E - ↑	*	M - ↓	L-S - ↓	L - ↓	E - ↓	E - ↓	M - ↓	*	M - ↓	M - ?	E - ↓	*	*

EO Number	Geo-graphic Area	EO Rank	Acres	Nonnative Plants	Wildfire	Owyhee Harvester Ants	Development^	Livestock Use	Recreation Activity	OHV Activity	Badger Activity	Drill Seeding	Trash Dumping	Wildlife Digging/ Trails/ Feces	Wildfire Suppression Activities	Erosion	Agricultural Activities
36	F	C	5.79	S - ↑	*	*	*	*	*	*	*	*	*	*	*	*	*
38	F	BC	28.44	S - ↑	*	*	*	*	*	*	*	*	*	*	*	*	*
39	F	F?	1.93													*	*
40	F	F?	8.04													*	*
42	SRP	D	2.11	S - ↑	E - ↑	L-M - ↓	L - ↓	*	*	*	S - ↔	*	M-S - ↓	*	*	*	*
43	SRP	CD	0.95	E - ↑	*	S - ↔	*	*	*	*	S - ↓	*	*	*	M - ↓	*	*
48	SRP	C	1.79	S - ↑	*	*	*	*	*	*	E - ↓	*	S - ↓	L - ↓	*	*	*
49	SRP	C	3.86	S - ↑	*	*	*	*	*	*	*	*	*	*	*	*	*
50	SRP	C	4.25	E - ↑	*	L - ↓	E - ↓	*	*	*	E - ↓	*	L - ↓	L - ↑	*	*	*
51	SRP	D	3.78	E - ↑	E - ↑	*	*	*	M - ↓	M - ↓	E - ↓	*	L - ↓	M - ↓	*	*	*
52	F	B	31.72	S - ↑	*	*	L - ↓	*	*	*	*	*	*	*	*	L - ↓	*
53	SRP	B	40.41	S - ↑	E - ↔	*	*	M - ↑	S - ↓	S - ↓	*	*	L - ↓	*	*	*	*
54	SRP	D	1.93	S - ↑	E - ↑	L - ↓	S - ↑	M - ↑	*	*	*	*	*	*	*	*	*
56	F	D	4.95	S - ↑	*	L - ↓	L - ↓	L - ↓	*	*	M - ↓	*	*	*	*	*	*
57	SRP	CD	0.48	S - ↑	E - ↑	L - ↑	L - ↓	L-M - ↑	*	*	S - ↔	*	*	*	*	*	*
58	SRP	CD	1.93	E - ↑	*	*	L - ↓	L-M - ↑	*	*	*	*	*	*	*	*	*
60	SRP	D	14.55	S - ↑	*	L - ↓	*	M - ↑	*	*	S - ↔	*	*	*	*	*	*
61	SRP	C	15.83	S - ↑	*	*	*	M - ↑	*	*	E - ↔	S - ↔	S - ↓	*	*	*	*
62	SRP	D	5.85	E - ↑	E - ↑	L - ↓	*	L-M - ↓	M - ↓	M - ↓	*	*	L - ↓	L - ↓	*	*	*
63	SRP	C	7.87	S - ↑	M - ↑	L - ↓	*	M - ↑	*	*	*	*	*	*	*	*	*
64	SRP	C	1.97	S - ↑	*	*	E - ↔	*	*	*	M - ↓	*	*	*	*	*	*

EO Number	Geo-graphic Area	EO Rank	Acres	Nonnative Plants	Wildfire	Owyhee Harvester Ants	Development^	Livestock Use	Recreation Activity	OHV Activity	Badger Activity	Drill Seeding	Trash Dumping	Wildlife Digging/ Trails/ Feces	Wildfire Suppression Activities	Erosion	Agricultural Activities
65	F	C	1.94	S - ↑	*	*	*	*	L-M - ↓	*	*	*	*	*	*	*	*
66	F	B	9.20	L - ↓	*	*	?	*	*	*	S - ↓	*	*	*	*	*	*
67	SRP	B	9.61	S - ↑	*	*	*	*	*	*	*	*	*	*	*	*	*
68	F	B	6.91	S - ↑	*	*	L-M - ↓	E - ↔	*	*	S - ↓	*	*	*	*	*	*
69	F	C	4.20	S - ↑	*	*	L - ↓	L - ↓	*	*	M - ↓	*	*	*	*	*	*
70	F	B	2.07	S - ↑	*	*	*	*	*	*	*	*	*	*	*	*	*
72	SRP	B	67.36	S - ↑	*	L - ↓	*	M - ↑	*	*	*	*	*	*	*	*	*
73	J	CD	35.15	M - ↑	*	L - ↓	M - ↓	M - ↑	*	*	M - ↓	E - ↑	*	*	*	*	*
74	J	B	2.59	M - ↔	*	L - ↓	*	M - ↑	*	*	*	*	*	L-M - ↔	*	*	*
75	J	B	0.97	M - ↑	*	L - ↓	L-M - ↓	M - ↑	*	*	*	*	*	*	*	*	*
76	F	B	21.94	S - ↑	*	*	*	*	*	*	S-E - ↓	*	*	L - ↓	*	*	*
77	SRP	C	4.24	S - ↑	*	L - ↓	M - ↓	M - ↑	*	*	*	*	*	*	*	*	*
78	J	C	0.97	L-M - ↑	*	L - ↓	*	M - ↓	*	*	*	*	*	*	*	*	*
79	J	C	0.97	E - ↑	S - ↑	S - ↔	L - ↓	M - ↑	*	*	*	E - ↑	*	*	*	*	*
80	J	D	4.54	E - ↑	E - ↑	L - ↓	L - ↓	M - ↑	*	*	*	E - ↑	*	*	*	*	*
81	J	BC	0.48	M - ↑	*	*	L - ↓	M - ↑	*	*	*	*	*	*	*	*	*
83	J	B	0.48	L - ↑	*	L - ↓	*	M - ↑	*	*	*	*	*	*	*	*	*
84	J	B	2.14	L-M - ↑	*	*	L-M - ↓	M - ↑	*	*	*	*	*	*	*	*	*
85	J	C	9.49	S - ↑	*	L - ↓	*	M - ↑	*	*	*	*	*	*	*	*	*
87	J	C	0.48	E - ↑	E - ↑	*	*	M - ↑	*	*	*	E - ↑	*	M - ↓	*	*	*
89	J	D	0.48	E - ↑	*	*	*	E - ↑	*	*	*	E - ↑	*	*	*	*	*

EO Number	Geo-graphic Area	EO Rank	Acres	Nonnative Plants	Wildfire	Owyhee Harvester Ants	Development^	Livestock Use	Recreation Activity	OHV Activity	Badger Activity	Drill Seeding	Trash Dumping	Wildlife Digging/ Trails/ Feces	Wildfire Suppression Activities	Erosion	Agricultural Activities
90	J	C	1.07	L-M - ↑	*	L - ↓	*	M - ↑	*	*	*	*	*	*	*	*	*
91	J	CD	3.40	E - ↑	E - ↑	*	M - ↓	S - ↑	*	*	S - ↓	E - ↑	*	*	*	*	*
92	J	CD	40.24	E - ↑	*	*	*	*	*	*	*	E - ↑	*	*	*	*	*
93	J	C	5.38	M-S - ↑	*	L - ↓	*	M-S - ↑	*	*	*	S-E - ↑	*	L-M - ↔	*	*	*
94	J	C	1.45	S - ↔	*	*	*	M - ↔	*	*	*	*	*	*	*	*	*
95	J	D	2.38	E - ↑	E - ↑	*	L-M - ↓	M - ↑	*	*	*	S - ↑	*	*	*	*	*
96	J	C	49.38	E - ↑	E - ↑	*	*	*	*	*	*	E - ↑	*	*	*	*	*
97	J	B	19.98	S - ↑	S - ↑	L - ↓	E - ↓	M - ↓	*	*	*	S - ↑	*	*	*	*	*
98	J	BC	8.65	M - ↑	*	L - ↓	S - ↓	M - ↑	*	*	*	*	*	*	*	*	*
99	J	B	5.27	M - ↑	*	L - ↓	*	L-M - ↑	*	*	*	*	*	*	*	*	*
101	SRP	D?	0.48														
102	SRP	C	2.41	S - ↑	*	*	M - ↓	*	*	*	M - ↓	*	*	L - ↓	*	*	*
103	SRP	D	0.57	E - ↑	*	L - ↓	*	M - ↑	S - ↓	S - ↓	*	*	*	*	*	*	*
104	SRP	B	91.11	S - ↑	S - ↑	*	*	M - ↑	*	*	E - ↓	*	*	*	*	*	*
105	SRP	D	0.54	E - ↑	*	L - ↓	L - ↓	*	*	*	*	*	*	*	*	*	*
106	SRP	CD	0.48	S - ↑	*	*	*	M - ↑	M - ↓	M - ↓	*	*	M - ↓	*	*	*	*
107	F	C?	0.48														
108	F	D	4.41	E - ↑	E - ↑	L - ↓	M-E - ↓	E - ↓	*	*	E - ↓	*	L - ↓	L - ↓	*	*	L - ↔
111	SRP	D	0.27	S - ↑	E - ↑	L - ↓	L - ↓	*	M - ↓	M - ↓	E - →	*	M - ↓	*	*	*	*
112	SRP	D	0.02	E - ↑	*	L - ↓	*	*	*	*	E - ↓	*	*	*	*	*	*
113	SRP	D	0.03	E - ↑	E - ↑	L - ↓	*	L - ↓	*	*	E - ↓	*	L - ↓	L-M - ↓	*	*	*

EO Number	Geo-graphic Area	EO Rank	Acres	Nonnative Plants	Wildfire	Owyhee Harvester Ants	Development^	Livestock Use	Recreation Activity	OHV Activity	Badger Activity	Drill Seeding	Trash Dumping	Wildlife Digging/ Trails/ Feces	Wildfire Suppression Activities	Erosion	Agricultural Activities
114	F	C	0.07	S - ↑	E - ↑	L - ↓	*	M - ↓	*	*	E - ↓	*	*	*	*	*	*
115	SRP	C	0.09	E - ↑	*	E - ↓	M - ↓	M-S - ↓	*	*	E - ↓	*	*	L - ↑	*	*	L - ↓
116	SRP	C	0.03	E - ↑	*	L - ↓	L-E - ↓	M - ↓	*	*	E - ↓	*	L - ↓	L - ↑	*	*	L - ↓
117	SRP	D	0.03	E - ↑	E - ↑	L - ↓	E - ↓	*	*	*	E - ↓	*	L - ↓	*	*	*	*
118	F	B	0.12	S - ↑	*	*	*	L - ↓	*	*	M - ↓	*	*	*	*	*	*
119	SRP	CD	0.03	S - ↑	E - ↑	L - ↓	*	S - ↑	S-M - ↓	L-M - ↓	M-S - ↔	*	L - ↓	*	*	*	*
120	SRP	C	0.71	E - ↑	E - ↑	L - ↓	M - ↓	L - ↓	*	*	S - ↔	E - ↑	S - ↓	M - ↓	*	*	*
121	SRP	C	0.72	E - ↑	E - ↑	L - ↓	*	S - ↑	*	*	S - ↔	*	L - ↓	M - ↓	*	*	*
122	SRP	NA	320.60														
123	J	NA	0.08														
124	J	NA	0.08														
700	J	B	0.48	M - ↑	*	*	*	M - ↑	*	*	*	*	*	M - ↓	*	*	*
701	J	C	9.98	M-S - ↑	*	L - ↓	*	M - ↑	*	*	*	*	*	*	*	*	*
702	J	B	74.53	M-S - ↑	*	L - ↓	L-M - ↓	M - ↑	*	*	*	M - →	*	*	*	*	*
703	J	C	61.65	E - ↑	S - ↑	L - ↓	*	M - ↑	*	*	*	E - ↑	*	L-M - ↓	*	*	*
704	J	B	2216.01	S - ↑	*	L - ↓	L-M - ↓	S - ↑	*	*	*	S - ↑	*	*	*	*	*
705	J	D	5.14	S-E - ↑	E - ↑	*	L-M - ↓	M - ↑	*	*	*	S-E - ↑	*	*	*	*	*
706	J	CD	3.13	S - ↑	*	*	*	*	*	*	*	S - ↑	*	*	*	*	*
708	J	D	19.41	E - ↑	E - ↑	*	?	E - ↑	*	*	*	E - ↑	*	*	*	*	*
709	J	D	0.48	E - ↑	E - ↑	L - ↓	*	M - ↑	*	*	*	E - ↑	*	M - ↓	*	*	*
712	J	B	39.90	S - ↑	*	L - ↓	S - ↔	S - ↑	*	*	*	E - ↑	*	*	*	*	*

EO Number	Geo-graphic Area	EO Rank	Acres	Nonnative Plants	Wildfire	Owyhee Harvester Ants	Development^	Livestock Use	Recreation Activity	OHV Activity	Badger Activity	Drill Seeding	Trash Dumping	Wildlife Digging/ Trails/ Feces	Wildfire Suppression Activities	Erosion	Agricultural Activities
715	J	C	43.89	E - ↑	*	*	*	*	*	*	*	E - ↑	*	*	*	*	*
716	J	C	12.72	E - ↑	S - ↑	L - ↓	*	M - ↑	*	*	*	E - ↑	*	*	*	*	*
717	J	D	1.10	S - ↑	*	L - ↓	L-M - ↓	*	*	*	*	S - ↑	*	*	*	*	*
719	J	D	0.48	E - ↑	E - ↑	L - ↓	*	*	*	*	*	E - ↑	*	*	*	*	*
720	J	C	1.63	L-M - ↑	*	L - ↓	L-M - ↓	M - ↑	*	*	S - ↓	E - ↑	*	*	*	*	*
721	J	D	0.90	S - ↑	*	L - ↓	*	M - ↑	*	*	*	*	*	M - ↔	*	*	*
722	J	D	0.97	S - ↑	*	L - ↓	L - ↓	S - ↑	*	*	S-M - ↓	E - ↑	L - ↓	*	*	*	*
725	J	C	7.93	S - ↑	*	*	*	M - ↑	*	*	*	S - ↑	*	*	*	*	*
726	J	D	0.48	S - ↑	*	*	M - ↓	M - ↑	*	*	*	S - ↑	*	*	*	*	*
727	J	NA	3.58														
728	J	NA	0.15														
729	J	NA	2.78														
Total			**16, 278.67**														
Minus Acres without Data			**338.2**														
Analysis Total			**15,940.47**														

Geographic Area Codes: F = Foothills; SRP = Snake River Plain; J = Jarbidge

EO-Ranking Codes: B = Good, BC = Good to Fair, C= Fair, CD = Fair to Poor, D= Poor, F = Failed to Find, NA = Unranked; A "?" qualifier may be used with the most appropriate rank if there is incomplete information on the EO size, EO condition, and landscape context factors.

Disturbance Severity Codes: E = Extreme: Within the scope, the Threat is likely to destroy or eliminate the occurrences of an ecological community, system or species, or reduce the species population by 71–100%

S = Serious: Within the scope, the Threat is likely to seriously degrade/reduce the effected occurrences or habitat or, for species, to reduce the species population by 31–70%

M = Moderate: Within the scope, the Threat is likely to moderately degrade/reduce the effected occurrences or habitat or, for species, to reduce the species population by 11–30%

L = Slight: Within the scope, the Threat is likely to only slightly degrade/reduce the effected occurrences or habitat or, for species, to reduce the species population by 1–10%

Disturbance Scope Codes: ↑ = 71-100 percent; → = 31-70 percent; ↔ = 11-30 percent; ↓ = ≤10 percent

* = Not described as being affected by that disturbance category ^ IDFG defines development to include infrastructure such as fences, corrals, roads, two-track roads, and pipelines/power lines

Table rows for 10 EOs and subEOs without disturbance data available are indicated by yellow highlighting.

As no disturbance data are available for four ranked EOs (EOs 39, 40, 101, 107) and six unranked EOs and subEOs (EOs 122, 123, 124 and subEOs 727, 728, 729), disturbance data are only available for 105 of the 115 EOs and subEOs.

Appendix E. Primary Threats of Wildfire and Invasive Nonnative Plants from Disturbance Data Used for Slickspot Peppergrass Element Occurrence Assessments (see Appendix D)

EO Number	Geographic Area	Acres	EO Rank	EO Rank Viability	Nonnative Plant Current Condition	Wildfire Current Condition	Primary Threat Influencing Current EO Ranking
52	F	31.72	B	good	serious	unburned	nonnative plants
66	F	19.2	B	good	slight	unburned	nonnative plants
68	F	6.91	B	good	serious	unburned	nonnative plants
70	F	2.07	B	good	serious	unburned	nonnative plants
76	F	21.94	B	good	serious	unburned	nonnative plants
118	F	0.12	B	good	serious	unburned	nonnative plants
38	F	28.44	BC	good/fair	serious	unburned	nonnative plants
36	F	5.79	C	fair	serious	unburned	nonnative plants
65	F	1.94	C	fair	serious	unburned	nonnative plants
69	F	4.2	C	fair	serious	unburned	nonnative plants
114	F	0.07	C	fair	serious	extreme	nonnative plants and wildfire
23	F	5.79	CD	fair/poor	serious	unburned	nonnative plants
12	F	0.48	D	poor	serious	unburned	nonnative plants
56	F	4.95	D	poor	serious	unburned	nonnative plants
108	F	4.41	D	poor	extreme	extreme	nonnative plants and wildfire
74	J	2.59	B	good	moderate	unburned	nonnative plants
75	J	0.97	B	good	moderate	unburned	nonnative plants
83	J	0.48	B	good	slight	unburned	nonnative plants
84	J	2.14	B	good	slight - moderate	unburned	nonnative plants
97	J	19.98	B	good	serious	serious	nonnative plants and wildfire
99	J	5.27	B	good	moderate	unburned	nonnative plants
700	J	0.48	B	good	moderate	unburned	nonnative plants
702	J	74.53	B	good	moderate - serious	unburned	nonnative plants
704	J	2216.01	B	good	serious	unburned	nonnative plants
712	J	39.9	B	good	serious	unburned	nonnative plants
81	J	0.48	BC	good/fair	moderate	unburned	nonnative plants
98	J	8.65	BC	good/fair	moderate	unburned	nonnative plants
78	J	0.97	C	fair	slight - moderate	unburned	nonnative plants
79	J	0.97	C	fair	serious	serious	nonnative plants and wildfire

EO Number	Geographic Area	Acres	EO Rank	EO Rank Viability	Nonnative Plant Current Condition	Wildfire Current Condition	Primary Threat Influencing Current EO Ranking
85	J	9.49	C	fair	serious	unburned	nonnative plants
87	J	0.48	C	fair	extreme	extreme	nonnative plants and wildfire
90	J	1.07	C	fair	slight - moderate	unburned	nonnative plants
93	J	5.38	C	fair	moderate - serious	unburned	nonnative plants
94	J	1.45	C	fair	serious	unburned	nonnative plants
96	J	49.38	C	fair	extreme	extreme	nonnative plants and wildfire
701	J	9.98	C	fair	moderate - serious	unburned	nonnative plants
703	J	61.65	C	fair	extreme	serious	nonnative plants and wildfire
715	J	43.89	C	fair	extreme	unburned	nonnative plants
716	J	12.72	C	fair	extreme	serious	nonnative plants and wildfire
720	J	1.63	C	fair	slight - moderate	unburned	nonnative plants
725	J	7.93	C	fair	serious	unburned	nonnative plants
73	J	35.15	CD	fair/poor	moderate	unburned	nonnative plants
91	J	3.4	CD	fair/poor	extreme	extreme	nonnative plants and wildfire
92	J	40.24	CD	fair/poor	extreme	unburned	nonnative plants
706	J	3.13	CD	fair/poor	serious	unburned	nonnative plants
80	J	4.54	D	poor	extreme	extreme	nonnative plants and wildfire
89	J	0.48	D	poor	extreme	unburned	nonnative plants
95	J	2.38	D	poor	extreme	extreme	nonnative plants and wildfire
705	J	5.14	D	poor	serious - extreme	extreme	nonnative plants and wildfire
708	J	19.41	D	poor	extreme	extreme	nonnative plants and wildfire
709	J	0.48	D	poor	extreme	extreme	nonnative plants and wildfire
717	J	1.1	D	poor	serious	unburned	nonnative plants
719	J	0.48	D	poor	extreme	extreme	nonnative plants and wildfire
721	J	0.9	D	poor	serious	unburned	nonnative plants
722	J	0.97	D	poor	serious	unburned	nonnative plants
726	J	0.48	D	poor	serious	unburned	nonnative plants
8	SRP	1020.48	B	good	serious	unburned	nonnative plants

EO Number	Geographic Area	Acres	EO Rank	EO Rank Viability	Nonnative Plant Current Condition	Wildfire Current Condition	Primary Threat Influencing Current EO Ranking
18	SRP	1818.43	B	good	extreme	unburned	nonnative plants
25	SRP	38.55	B	good	extreme	unburned	nonnative plants
26	SRP	708.31	B	good	serious	extreme	nonnative plants and wildfire
27	SRP	7163.63	B	good	slight - moderate	unburned	nonnative plants
53	SRP	40.41	B	good	serious	extreme	nonnative plants and wildfire
67	SRP	9.61	B	good	serious	unburned	nonnative plants
72	SRP	67.36	B	good	serious	unburned	nonnative plants
104	SRP	91.11	B	good	serious	serious	nonnative plants and wildfire
30	SRP	702.32	BC	good/fair	serious	unburned	nonnative plants
2	SRP	2.48	C	fair	serious	unburned	nonnative plants
15	SRP	156.01	C	fair	extreme	unburned	nonnative plants
20	SRP	3.21	C	fair	serious	unburned	nonnative plants
21	SRP	100.18	C	fair	serious	unburned	nonnative plants
24	SRP	180.51	C	fair	serious	unburned	nonnative plants
28	SRP	0.48	C	fair	serious	unburned	nonnative plants
29	SRP	104.65	C	fair	extreme	serious	nonnative plants and wildfire
32	SRP	619.07	C	fair	extreme	unburned	nonnative plants
48	SRP	1.79	C	fair	serious	unburned	nonnative plants
49	SRP	3.86	C	fair	serious	unburned	nonnative plants
50	SRP	4.25	C	fair	extreme	unburned	nonnative plants
61	SRP	15.83	C	fair	serious	unburned	nonnative plants
63	SRP	7.87	C	fair	serious	moderate	nonnative plants and wildfire
64	SRP	1.97	C	fair	serious	unburned	nonnative plants
77	SRP	4.24	C	fair	serious	unburned	nonnative plants
102	SRP	2.41	C	fair	serious	unburned	nonnative plants
115	SRP	0.09	C	fair	extreme	unburned	nonnative plants
116	SRP	0.03	C	fair	extreme	unburned	nonnative plants
120	SRP	0.71	C	fair	extreme	extreme	nonnative plants and wildfire
121	SRP	0.72	C	fair	extreme	extreme	nonnative plants and wildfire
43	SRP	0.95	CD	fair/poor	extreme	unburned	nonnative plants
57	SRP	0.48	CD	fair/poor	serious	extreme	nonnative plants and wildfire
58	SRP	1.93	CD	fair/poor	extreme	unburned	nonnative plants

EO Number	Geographic Area	Acres	EO Rank	EO Rank Viability	Nonnative Plant Current Condition	Wildfire Current Condition	Primary Threat Influencing Current EO Ranking
106	SRP	0.48	CD	fair/poor	serious	unburned	nonnative plants
119	SRP	0.03	CD	fair/poor	serious	extreme	nonnative plants and wildfire
10	SRP	3.93	D	poor	serious	unburned	nonnative plants
22	SRP	126.4	D	poor	extreme	unburned	nonnative plants
31	SRP	71.25	D	poor	moderate	serious	nonnative plants and wildfire
42	SRP	2.11	D	poor	serious	extreme	nonnative plants and wildfire
51	SRP	3.78	D	poor	extreme	extreme	nonnative plants and wildfire
54	SRP	1.93	D	poor	serious	extreme	nonnative plants and wildfire
60	SRP	14.55	D	poor	serious	unburned	nonnative plants
62	SRP	5.85	D	poor	extreme	extreme	nonnative plants and wildfire
103	SRP	0.57	D	poor	extreme	unburned	nonnative plants
105	SRP	0.54	D	poor	extreme	unburned	nonnative plants
111	SRP	0.27	D	poor	serious	extreme	nonnative plants and wildfire
112	SRP	0.02	D	poor	extreme	unburned	nonnative plants
113	SRP	0.03	D	poor	extreme	extreme	nonnative plants and wildfire
117	SRP	0.03	D	poor	extreme	extreme	nonnative plants and wildfire

Geographic Area Codes: **F** = Foothills; **J** = Jarbidge; **SRP** = Snake River Plain

Extreme: Within the scope, the Threat is likely to destroy or eliminate the occurrences of an ecological community, system or species, or reduce the species population by 71–100%

Serious: Within the scope, the Threat is likely to seriously degrade/reduce the effected occurrences or habitat or, for species, to reduce the species population by 31–70%

Moderate: Within the scope, the Threat is likely to moderately degrade/reduce the effected occurrences or habitat or, for species, to reduce the species population by 11–30%

Slight: Within the scope, the Threat is likely to only slightly degrade/reduce the effected occurrences or habitat or, for species, to reduce the species population by 1–10%.

For the purposes of our comparison of rangewide disturbance categories for wildfire and invasive nonnative plants, we consider the severity of effects on slickspot peppergrass of the slight disturbance condition for invasive nonnative plants to be similar to the severity condition of the unburned disturbance condition for wildfire.

Appendix F. Predicted Future Threats for Slickspot Peppergrass Element Occurrences

Predicted Future Threats for Slickspot Peppergrass Element Occurrences (future threats data compiled from Kinter and Miller 2016, entire; EO and subEO location and acreage data from July 2018 IFWIS database).

EO / SubEO Number	Geo-graphic Area	2018 EO / subEO Rank	2018 Acreage	Nonnative Plants	Wildfire	Harvester Ants	Development^	Livestock Use	Recreation Activities	OHV Activities	Badger Activity	Drill Seeding	Trash Dumping	Wildlife Digging	Wildfire Suppression Activities	Erosion	Agricultural Activities	Road Maintenance
2	SRP	C	2.48	X	X					X								
8	SRP	B	1020.48	X	X		X											
10	SRP	D	3.93	X	X					X								
12	F	D	0.48	X	X		X											
15	SRP	C	156.01	X	X													
18	SRP	B	1818.43	X	X		X			X								
20	SRP	C	3.21	X	X													
21	SRP	C	100.15	X	X					X								
22	SRP	D	126.40	X	X													
23	F	CD	5.79	X	X		X		X									
24	SRP	C	180.51	X	X		X			X			X					
25	SRP	B	38.55	X	X		X			X								
26	SRP	B	708.31	X	X		X											
27	SRP	B	7163.63	X	X					X								
28	SRP	C	0.48	X	X					X								
29	SRP	C	104.65	X	X					X								
30	SRP	BC	702.32	X	X					X								
31	SRP	D	71.25	X	X													
32	SRP	C	619.07	X	X					X								
36	F	C	5.79	X	X		X		X									

EO / SubEO Number	Geo-graphic Area	2018 EO / subEO Rank	2018 Acreage	Nonnative Plants	Wildfire	Harvester Ants	Development^	Livestock Use	Recreation Activities	OHV Activities	Badger Activity	Drill Seeding	Trash Dumping	Wildlife Digging	Wildfire Suppression Activities	Erosion	Agricultural Activities	Road Maintenance
38	F	BC	28.44	X	X		X											
39	F	F?	1.93															
40	F	F?	8.04															
42	SRP	D	2.11	X	X													
43	SRP	CD	0.95	X	X		X			X								
48	SRP	C	1.79	X	X													
49	SRP	C	3.86	X	X													
50	SRP	C	4.25	X	X													
51	SRP	D	3.78	X	X													
52	F	B	31.72	X	X		X			X								X
53	SRP	B	40.41	X	X					X								
54	SRP	D	1.93	X	X					X								
56	F	D	4.95	X	X		X											
57	SRP	CD	0.48	X	X													
58	SRP	CD	1.93	X	X		X			X								
60	SRP	D	14.55	X	X													
61	SRP	C	15.83	X	X													
62	SRP	D	5.85	X	X													
63	SRP	C	7.87	X	X		X			X								
64	SRP	C	1.97	X	X		X											
65	F	C	1.94	X	X													

EO / SubEO Number	Geo-graphic Area	2018 EO / subEO Rank	2018 Acreage	Nonnative Plants	Wildfire	Harvester Ants	Development^	Livestock Use	Recreation Activities	OHV Activities	Badger Activity	Drill Seeding	Trash Dumping	Wildlife Digging	Wildfire Suppression Activities	Erosion	Agricultural Activities	Road Maintenance
66	F	B	9.20	X	X													
67	SRP	B	9.61	X	X													
68	F	B	6.91	X	X													
69	F	C	4.20	X	X													
70	F	B	2.07	X	X													
72	SRP	B	67.36	X	X													
73	J	CD	35.15	X	X													
74	J	B	2.59	X	X													
75	J	B	0.97	X	X													
76	F	B	21.94	X	X													
77	SRP	C	4.24	X	X													
78	J	C	0.97	X	X													
79	J	C	0.97	X	X													
80	J	D	4.54	X	X													
81	J	BC	0.48	X	X													
83	J	B	0.48	X	X													
84	J	B	2.14	X	X													
85	J	C	9.49	X	X													
87	J	C	0.48	X	X													
89	J	D	0.48	X	X													
90	J	C	1.07	X	X													

EO / SubEO Number	Geo-graphic Area	2018 EO / subEO Rank	2018 Acreage	Nonnative Plants	Wildfire	Harvester Ants	Development^	Livestock Use	Recreation Activities	OHV Activities	Badger Activity	Drill Seeding	Trash Dumping	Wildlife Digging	Wildfire Suppression Activities	Erosion	Agricultural Activities	Road Maintenance
91	J	CD	3.40	X	X													
92	J	CD	40.24	X	X													
93	J	C	5.38	X	X													
94	J	C	1.45	X	X													
95	J	D	2.38	X	X													
96	J	C	49.38	X	X													
97	J	B	19.98	X	X									X				
98	J	BC	8.65	X	X													
99	J	B	5.27	X	X													
101	SRP	D?	0.48															
102	SRP	C	2.41	X	X													
103	SRP	D	0.57	X	X					X								
104	SRP	B	91.11	X	X					X								
105	SRP	D	0.54	X	X		X			X								
106	SRP	CD	0.48	X	X													
107	F	C?	0.48															
108	F	D	4.41	X	X					X								
111	SRP	D	0.27	X	X													
112	SRP	D	0.02	X	X													
113	SRP	D	0.03	X	X													
114	F	C	0.07	X	X													

EO / SubEO Number	Geo-graphic Area	2018 EO / subEO Rank	2018 Acreage	Nonnative Plants	Wildfire	Harvester Ants	Development^	Livestock Use	Recreation Activities	OHV Activities	Badger Activity	Drill Seeding	Trash Dumping	Wildlife Digging	Wildfire Suppression Activities	Erosion	Agricultural Activities	Road Maintenance
115	SRP	C	0.09	X	X					X								
116	SRP	C	0.03	X	X		X											
117	SRP	D	0.03	X	X													X
118	F	B	0.12	X	X													
119	SRP	CD	0.03	X	X													X
120	SRP	C	0.71	X	X													
121	SRP	C	0.72	X	X													
122	SRP	NA	320.60															
123	J	NA	0.08															
124	J	NA	0.08															
700	J	B	0.48	X	X													
701	J	C	9.98	X	X													
702	J	B	74.53	X	X													
703	J	C	61.65	X	X													
704	J	B	2216.01	X	X													
705	J	D	5.14	X	X													
706	J	CD	3.13	X	X													
708	J	D	19.41	X	X													
709	J	D	0.48	X	X													
712	J	B	39.90	X	X													
715	J	C	43.89	X	X													

EO / SubEO Number	Geo-graphic Area	2018 EO / subEO Rank	2018 Acreage	Nonnative Plants	Wildfire	Harvester Ants	Development^	Livestock Use	Recreation Activities	OHV Activities	Badger Activity	Drill Seeding	Trash Dumping	Wildlife Digging	Wildfire Suppression Activities	Erosion	Agricultural Activities	Road Maintenance
716	J	C	12.72	X	X													
717	J	D	1.10	X	X													
719	J	D	0.48	X	X													
720	J	C	1.63	X	X													
721	J	D	0.90	X	X													
722	J	D	0.97	X	X													
725	J	C	7.93	X	X													
726	J	D	0.48	X	X													
727	J	NA	3.58															
728	J	NA	0.15															
729	J	NA	2.78															727
TOTALS				105 of 105 total EOs (100%)	105 of 105 total EOs (100%)	0 of 105 total EOs (0%)	17 of 105 total EOs (16%)	0 of 105 total EOs (0%)	2 of 105 total EOs (2%)	22 of 105 total EOs (21%)	0 of 105 total EOs (0%)	0 of 105 total EOs (0%)	1 of 105 total EOs (1%)	1 of 105 total EOs (1%)	0 of 105 total EOs (0%)	0 of 105 total EOs (0%)	0 of 105 total EOs (0%)	3 of 105 total EOs (3%)

Geographic Area Codes: F = Foothills; SRP = Snake River Plain; J = Jarbidge

EO-Ranking Codes: B = Good, BC = Good to Fair, C= Fair, CD = Fair to Poor, D= Poor, F = Failed to Find, NA = Unranked; A "?" qualifier may be used with the most appropriate rank if there is incomplete information on the EO size, EO condition, and landscape context factors.

^ IDFG defines development to include infrastructure such as fences, corrals, roads, two-track roads, and pipelines/power lines

Table rows for 10 EOs and subEOs with no future disturbance predictions available are indicated by yellow highlighting.

As no future disturbance predictions are available for four ranked EOs (EOs 39, 40, 101, 107) and six unranked EOs and subEOs (EOs 122, 123, 124 and subEOs 727, 728, 729), future threats data are only available for 105 of the 115 total EOs and subEOs.

Appendix G. External Species Expert Recommended Actions to Increase Future Viability of Slickspot Peppergrass

The following recommended actions were elicited from External Species Experts by the Idaho Fish and Wildlife Office during meetings conducted on April 17 and April 26, 2018 for use in the Fish and Wildlife Service's Recovery and Implementation process for *Lepidium papilliferum* (slickspot peppergrass). This brainstormed list of potential actions does not reflect consensus among External Species Experts, and some ideas may have limited utility due to high cost or other constraints.

Prioritization & Planning

Prioritize Element Occurrences (EOs) for population augmentation (larger versus smaller acreage EOs; higher ranked versus lower ranked EOs, etc.) or establishing connectivity corridors with new slickspot peppergrass populations between existing EOs. Consider genetic similarity when using seed source for augmentation or new population establishment.

Prioritize future actions (habitat restoration, use of conservation measures, etc.) so funds and resources are directed to the most important projects for slickspot peppergrass conservation (e.g., EOs with highest priority for species redundancy).

Prioritize management of areas for the highest and best use (e.g., habitat restoration in poorer quality EOs may not be biologically or economically feasible).

Develop a connectivity model for use in prioritizing restoration treatments (leverage sites with existing EO resiliency first and areas with management flexibility secondarily). Ensure models are ground-truthed. Consider contacting Dr. Trevor Caughlin at BSU, who specializes in quantitative spatial ecology. For example, modeling landscape level patterns of colonization by invasive plants. http://www.trevorcaughlin.com/?page_id=97

Prioritize restoration efforts in habitat surrounding slick spot microsites to provide habitat for insect pollinators and reduce wildfire risk.

Prioritize EOs to determine whether loss of half or all of certain EOs to wildfire (or other factors) would or would not result in reduced future species representation or redundancy.

Tailor habitat restoration efforts to focus on slickspot peppergrass conservation needs (initial efforts could be pilot projects in BLM Habitat Enhancement Areas).

Use streamlined NEPA and Section 7 processes to allow for more rapid implementation of slickspot peppergrass habitat restoration projects.

Incorporate ant control options into new BLM National Environmental Policy Act (NEPA) documents so this option can be used, as needed.

Develop a common database for storage of data applicable to slickspot peppergrass conservation that is accessible to all agencies / entities that manage the species (surveys and habitat information, wildfire analyses, annual grassland grazing techniques, etc.).

Use travel management planning process to address off highway vehicle (OHV) issues near and within EOs.

Encourage continued use of a 5-year time frame for completion of Emergency Stabilization and Restoration (ESR) actions to increase the probability of revegetation success (avoid past outcomes, where drought during years subsequent to wildfires severely limited the success of some post-fire ESR seeding).

Provide for greater flexibility in BLM livestock permits to allow for fall/winter grazing following wildfire in cheatgrass dominated pastures (in the past, most BLM Land Use Plans require 2 years of rest from grazing following wildfire).

Prioritize habitat stabilization within and between EOs before identifying connectivity needs (will consider pollinator movement distances and distance that populations can exchange genetic material).

Focus on habitat condition in the larger landscape for the slickspot peppergrass SSA and in subsequent recovery planning.

Habitat Restoration

Consider use of new methods for establishment of seeded species (e.g., coat seeds to increase water availability & reduce herbicide exposure of seeds).

Prioritize EO habitat restoration efforts in Paradigm Fuel Breaks Project area as wildfire risks are reduced due to presence of fuel breaks.

Restore cheatgrass dominated rangelands with native plant community in slickspot peppergrass areas to increase the carrying capacity of these sites. Restoration of cheatgrass-dominated sites has the potential to increase animal unit months (AUMs) for livestock grazing due to greater biomass production by perennial grasses over annual grasses.

Provide slickspot peppergrass habitat restoration project leads with suggested plant materials and acceptable herbicide application concentrations and timing compatible with EOs/species conservation.

Use nontraditional techniques (winter prescribed burning of cheatgrass-dominated areas) to reduce cheatgrass cover and encourage forb germination in degraded EOs or degraded areas between EOs (more feasible to initially implement as pilot project on nonfederal lands).

Use nontraditional techniques (intensive winter livestock grazing on frozen ground) for seedbed preparation (reduces the need for herbicide use) prior to heavy seeding with shrubs and subsequently seed perennial grasses and forbs in degraded EOs or degraded areas between EOs (more feasible to initially implement as pilot project on nonfederal lands).

Restore mycorrhizal fungi in EO soils to facilitate restoration of native shrubs, grasses, and forbs.

Collect seed for future research or EO population augmentation or new LEPA population establishment during high seed production years.

While ESR is important, focus on a long term pro-active habitat restoration program rather than depending on reactive ESR only. For example, identify higher quality B- and C-ranked EOs for restoration as well as areas for restoration that would provide connectivity between these EOs.

Increase seed sources of preferred perennial shrubs, grasses, and forbs to allow for increased habitat diversity for slickspot peppergrass insect pollinators.

Increased Frequency and Intensity of Wildfire

Increase public education to reduce human-caused wildfire ignitions along I-84 (dragging trailer chains, etc.).

Continue fuel break program along I-84 and other areas (Paradigm, Jarbidge, Tri-State, etc.).

Use smarter designs for fuel breaks and prioritize fuel break locations for slickspot peppergrass conservation.

Increase public education on wildfire ignition risks of recreational shooting and use of exploding targets on hot, dry days.

Modify the current grazing regime to reduce fine fuels for reduced wildfire risk.

Re-establish lightening watch satellite stations to inform rapid response suppression actions within and adjacent to EOs.

Prioritize wildfire suppression actions in higher quality EOs, especially in areas that overlap with greater sage-grouse habitats, keeping in mind that protection of human life and property, including firefighter safety, are always a higher priority than species conservation.

Where firefighter safety considerations allow, focus wildfire suppression actions closer to the burning area to minimize the potential wildfire footprint within and adjacent to EOs.

Introduction and Spread of Invasive Nonnative Plants (unseeded)

Incorporate conservation measures to allow for livestock adaptive management that uses recent research to reduce cheatgrass fuel loads through fall grazing (see research by Dr. Barry Perryman of University of Nevada - Reno).

Because the risk of wildfire is high in cheatgrass-dominated areas, it is important to revegetate EOs and surrounding areas following wildfire with shrubs and to plant perennial grasses/forbs into shrub interspaces.

Continue to explore emerging cheatgrass control methods, such as bio-herbicide use, to reduce cheatgrass cover in the range of slickspot peppergrass.

Prioritize EOs to allow for management or experimental actions for cheatgrass control in lower priority (e.g., D-ranked) EOs.

Control invasive nonnative plants through treatments in year 1, with potential retreatments and replanting in years 2-3, as needed. Balance the possible short-term adverse effects of treatments on slickspot peppergrass with long term benefits to species conservation.

Control vectors that perpetuate cheatgrass. For example, if a project area is surrounded by cheatgrass, reduce ground disturbance on the site and replace cheatgrass with perennial bunchgrass.

For areas with high pre-fire cheatgrass cover, intensively graze livestock in the fall/winter following wildfire (increase AUMs after wildfire, etc.) to remove up to 100 percent of cheatgrass, particularly in low elevations with highly degraded habitat such as in the Mountain Home area.

Actively manage invasive grasses by grazing to reduce fine fuels to under 800 lbs. per acre while timing livestock use to reduce invasive nonnative annual grasses and increase perennial grasses and forbs.

Seed Predation by Owyhee Harvester Ants (tied to wildfire)

Use control measures for short-term, strategic ant removal at certain struggling EOs (especially in years with lower plant numbers) or at high quality EOs to allow for seed bank replenishment and associated genetic variability and diversity.

Control ants in EOs following wildfire to decrease risk to seed bank replenishment at wildfire-impacted EOs.

Control ants in higher quality EOs to further strengthen seed bank through reduced ant seed predation.

Prioritize ant control measures to EO locations where habitat restoration efforts are being focused, such as sites where shrubs are being re-established.

Avoid planting monocultures of grasses that are preferred by ants such as Sandberg bluegrass in the vicinity of EOs. – *This action was added as requested by one External Species Expert on October 3, 2018.*

For further understanding of the extent of potential seed predation by ants, model areas with non-*Bromus* grasses that lack shrubs to focus future ant survey efforts within and adjacent to associated EOs.

Wildfire Suppression, Fuels Management, & ESR Activities

Prior to wildfire season, provide Fire Crew Leaders and Resource Advisors (and Incident Commanders during wildfire incidents) with a clear, locale-specific action plan that includes more specific information on suppression actions that should be followed to avoid or reduce impacts on prioritized EOs/critical habitat.

Provide BLM fire crews with EO boundaries in addition to Occupied Habitat [*currently known as extant EOs and surrounding HIZs*] boundaries (EO + 0.5 mile pollinator buffer) to inform wildfire suppression action locations for decreased risks to slickspot peppergrass, if possible.

Continue to focus ESR actions in EOs and Critical Habitat to include revegetation with native shrub, grass, and forb components, where and when feasible and practicable.

Provide BLM Fuels program with suggested plant materials and acceptable herbicide application concentrations and timing compatible with EOs/species conservation.

Focus specialized ESR activities on small areas for slickspot peppergrass conservation rather than using broad-brush landscape level treatments. Consider that State lands have greater flexibility to try alternative ESR methods relative to Federal lands.

Outreach

Increase public and agency awareness of slickspot peppergrass and its significance (e.g., field reviews, "Adopt-an-EO").

Use citizen scientists (Master Naturalists, native plant enthusiasts, Audubon, etc.) to assist in locating new slickspot peppergrass populations.

Monitoring

Ensure species monitoring is included as a component of project and recovery planning.

Reevaluate HIP monitoring to better measure population numbers and frequency and intensity of exposure to threats.

Adjust slickspot peppergrass monitoring to be more objective-based.

Increase monitoring sample size (e.g., more slick spots and transects) to include additional EOs or greater areas of large EOs.

Monitor slickspot peppergrass (plant numbers, invasive nonnative cover, etc.) inside and outside of fenced treatment areas to ensure results are due to treatments rather than responses to other environmental factors.

Research Needs

Use research (independent researcher or herbicide company) or monitoring to determine herbicide types, application rates, and active ingredients to effectively control cheatgrass while allowing for slickspot peppergrass, biological soil crusts, and native forb persistence/germination. Note that forbs with thinner seed coats had a higher risk of negative impacts from herbicide use as described in a Boise State University study conducted on the Morley Nelson Snake River Birds of Prey National Conservation Area.

Assess the compositional gradient of the transition between degraded nonnative plant dominated areas and relatively intact sagebrush steppe habitat for insect pollinator communities (This is a pending Idaho Army National Guard-funded project).

Encourage generation of reports or provide support for reporting results of pilot cheatgrass reduction/weed control using livestock grazing (particularly when associated with slickspot peppergrass EOs) on nonfederal lands for future consideration of similar grazing treatments across all land ownerships.

Development

Work with County Commissioners to include EO/LEPA conservation in county municipal land use planning efforts, such as the Ada and Elmore County Comprehensive Plans.

Craft trusts or conservation easements to maintain privately-owned rangelands as undeveloped.

Recreation

Restrict public access to high value slickspot peppergrass sites such as the Orchard Combat Training Center's Bravo area (EO 27).

Redirect recreational use to ensure the public has a place to recreate in non-slickspot peppergrass areas. (Recreational use can increase nitrogen levels, which in turn can increase cheatgrass cover.)

Place educational signage for public in logical locations to provide information while reducing vandalism risks.

Focus enforcement of OHV, dumping, and recreational shooting regulations within and adjacent to EOs.

Improper Livestock Grazing

Restrict large areas important to slickspot peppergrass from livestock grazing and consolidate grazing in areas of lower value to slickspot peppergrass. Avoid managing all areas for all uses.

Increase flexibility/adaptability of permitted livestock grazing on public lands to address wildfire, invasive plants, and slickspot peppergrass conservation. Focus on desired outcome for habitat condition as opposed to current focus on inflexible rules that may not benefit slickspot peppergrass and its habitat. Focus on desired habitat condition would require a high level policy change regarding how BLM traditionally has addressed permitted livestock grazing.

Appropriateness of Existing Conservation Measures

Ensure allotment-specific slickspot peppergrass conservation measures are crafted for allotments that contain slickspot peppergrass in all pastures (such as allotments in the Jarbidge Field Office) to provide a balance between risks of trampling impacts to slickspot peppergrass and the need to reduce fine fuels/enhance rangeland health. Consider modification of conservation measures in the current BLM – Fish and Wildlife Service Conservation Agreement to allow for Jarbidge Field Office and Boise District allotment grazing flexibility.

Consider modification of fenced slickspot peppergrass areas where sites may contain higher weed cover and reduced numbers of slickspot peppergrass plants than areas outside the fence. An example was brought forth from the Jarbidge Field Office.

Consider modification of CCA conservation measures prohibiting herbicide spraying within 10 feet of slick spots as this practice results in creation of "doughnuts" of cheatgrass in untreated buffers surrounding slick spots (this was observed on BLM Big Fire ESR treatments in Foothills geographic area).

Identify existing conservation measures with limited effectiveness for current and future slickspot peppergrass conservation.

Consider modification of existing conservation measures to allow flexibility to use livestock for reduction of fine fuels, reducing future wildfire risks to slickspot peppergrass.