Veolia Nuclear Solutions –
Federal Services
120 Technology Dr.
Idaho Falls, ID 83401
Prepared for:
Idaho National Laboratory –
Battelle Energy Alliance
Contract No. 00226967

Sheep Fire Ecological Resources Post-Fire Recovery Plan

Amy D. Forman, Jackie R. Hafla, Sue J. Vilord, Jeremy P. Shive, Kristin N. Kaser,
Quinn R. Shurtliff, Kurt T. Edwards, and Bryan F. Bybee

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EXECUTIVE SUMMARY

A Wildland Fire Management Environmental Assessment was completed for the Idaho National Laboratory (INL) in 2003 in response to the increasing frequency of wildland fires. One requirement of the Assessment was for INL to establish a Wildland Fire Management Committee and one responsibility of the Committee is to determine when the development of a post-fire recovery plan for fires larger than 100 ac (40 ha) is warranted. Following the 2019 Sheep Fire, INL's Wildland Fire Management Committee determined that a post-fire recovery plan should be developed to address impacts of fire suppression activities and the potential effects of the fire on native species recovery and associated wildlife habitat within the burned area. Committee members expressed an interest in a plan where implementation is phased over five years and in a plan that is flexible, where specific actions can be implemented individually depending on specific resource concerns and funding availability.

The lightning-caused Sheep Fire started on July 22, 2019 in a remote region of the INL Site east of T-4 and south of T-9. The INL Site Fire Department and Bureau of Land Management responded under a unified command employing multiple fire suppression strategies. At the time of initial response, the fire was approximately 2,000 ac (809 ha) in size but quadrupled overnight and moved towards the southwest. Redflag and thunderstorm warnings were posted on July 23 and 24 as winds increased and relative humidity remained low, and the fire expanded to over 80,000 ac (32,375 ha). Minimal fire activity was reported on July 25, and the Sheep Fire was 100% contained by the afternoon of July 26. The initial Sheep Fire boundary was created by the Bureau of Land Management and estimated the burned area to be approximately 112,107 ac (45,368 ha). The Environmental Surveillance, Education and Research Program later used high resolution satellite imagery collected after the fire to delineate the Sheep Fire burned area and, for post-fire recovery planning purposes, reduced the burned area estimate to approximately 99,839 ac (40,403 ha).

The fire impacted a variety of ecological resources including 21 different soils types, nine vegetation classes, and numerous wildlife species, including greater sage-grouse, which is designated as Species of Greatest Conservation Need by the State of Idaho. This plan discusses the potential risks of the Sheep Fire to ecological resources and challenges to the natural recovery of those resources. The Wildland Fire Management Committee can use this information to evaluate and prioritize specific fire recovery actions. Treatment options for improving post-fire recovery are included as well as the steps necessary to implement those options.

Natural resource recovery issues were organized into four objectives. Those objectives are listed here, along with and the information that should be considered for developing treatment actions:

1) Soil stabilization for erosion and weed control immediately post-fire,

- Characterize the amount/severity of direct soil disturbance and prioritize restoration activities
- Recontour containment lines and seed direct soil disturbance with a native grass mix
- Sign and/or barricade the containment lines to prevent traffic
- Monitor and spray containment lines for weeds
- Assess any soil disturbance associated with powerline repair and restore accordingly

2) Cheatgrass and noxious weed control within the larger burned area,

- Identify areas that may benefit from cheatgrass treatment
- Apply a pre-emergent herbicide to selected areas at greatest risk for cheatgrass dominance
- Conduct a weed inventory and treat noxious weeds

3) Native herbaceous recovery, and

- Rest the allotment portion of the burn area for at least two growing seasons
- Identify locations of potentially poor native herbaceous recovery
- Plant native perennial grasses in areas with poor native recovery

4) Sagebrush habitat restoration.

- Prioritize areas that would benefit from planting sagebrush
- Evaluate planting options
- Coordinate a local seed collection effort
- Locate available seed that may be appropriate for use on the INL Site
- Aerially plant sagebrush seed in high priority areas
- Plant sagebrush seedlings strategically to address specific areas where accelerated recovery would be beneficial to habitat recovery

Based on stakeholder input, the U.S. Department of Energy decided to pursue aerial sagebrush seeding on portions on the Sheep Fire during the winter of 2019/2020. The Environmental Surveillance, Education, and Research Program provided logistical support for this effort and the U.S. Fish and Wildlife Service, the Bureau of Land Management, and the Idaho Office of Species Conservation helped with seed acquisition. Two areas within the footprint of the Sheep Fire were proposed for aerial sagebrush seeding including a 12,521 ac (5,067 ha) area within the Sage-grouse Conservation Area and a second area, which is 11,828 ac (4,787 ha) and is outside of, but adjacent to the Sage-grouse Conservation Area. Habitat for sagebrush obligates would benefit from aerial seeding in both areas, and recent telemetry data from other agencies suggest they are important wintering habitat for greater sage-grouse.

To identify areas that may need to be treated and to evaluate the outcome of any treatments that are implemented, an effective monitoring plan should be designed and implemented. Effective monitoring plans are those that establish a process to collect, analyze, and use data to track the status of the natural resources of interest and interpret the effectiveness of any implemented actions or treatments against benchmarks developed to evaluate success. Appropriate monitoring methods may include remote sensing using satellite or airborne-based imagery and field-based rapid assessment techniques. Ideally, monitoring results will be used within an adaptive management framework so that previous results inform future decisions.

ACKNOWLEDGMENTS

We would like to thank our agency stakeholders from the U.S. Fish and Wildlife Service, Bureau of Land Management, U.S. Geological Survey, Idaho Department of Fish and Game, and Idaho Office of Species Conservation. Representatives from each of these agencies were very generous in sharing their time, expertise, and experiences with sagebrush steppe post-fire recovery. Eric Gosswiller described the Sheep Fire and John Koudelka acquired the post-fire imagery. Brande Hendricks provided document layout and formatting. Alana Jensen designed the cover. Bill Doering provided an initial review. The final review team included Betsy Holmes, Charles Ljungberg, Eric Gosswiller, and John Irving. Their thoughtful reviews substantially improved the final document.

RECOMMENDED CITATION

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ACRONYMS

BLM	Bureau of Land Management
CCA	Candidate Conservation Agreement
CRMO	Cultural Resources Management Office
DOE	U.S. Department of Energy
EA	Environmental Assessment
ESER	Environmental Surveillance, Education and Research
GIS	Geographic Information System
GPS	Global Positioning System
INL	Idaho National Laboratory
NERP	National Environmental Research Park
SGCA	Sage-grouse Conservation Area
SGCN	Species of Greatest Conservation Need
USFWS	U.S. Fish and Wildlife Service

1.0 BACKGROUND

1.1 Purpose and Scope

Prior to 1994, large wildland fires were relatively infrequent on the Idaho National Laboratory (INL) Site (Anderson et al. 1996). Over the past 25 years, however, several large wildland fires have occurred (Forman and Hafla 2018). As fires began to increase in size and frequency, the INL implemented the "Balanced Fire Protection Approach" alternative in the Wildland Fire Management Environmental Assessment (EA), which established a Wildland Fire Management Committee (DOE 2003). One function of the Wildland Fire Management Committee is to determine when development of a post-fire recovery plan for wildland fires larger than 100 ac (40 ha) may be necessary to address potential wildland fire impacts (INL 2017). In the case of the 2019 Sheep Fire, the INL's Wildland Fire Management Committee determined that a post-fire recovery plan should be developed to address impacts of fire suppression activities and the potential effects of the fire on native species recovery and associated wildlife habitat within the burned area.

Members of the Wildland Fire Management Committee requested a recovery plan that is adaptable and provides a phased approach that can be implemented over five years. They emphasized the importance of including a monitoring plan that is appropriate for identifying areas of greatest risk for poor recovery, as well as assessing the success of post-fire treatments. An effective monitoring plan would also provide the basis for adaptive management decisions to guide treatment activities each year. Additionally, Committee members expressed an interest in a plan that is flexible, where specific recommendations can be implemented individually depending on specific resource concerns and funding availability.

The post-fire recovery options described in this plan integrate input from INL Site contractors, agency partners, stakeholders, and research scientists. Contributions from these various groups were solicited in Wildland Fire Management Committee meetings, agency and stakeholder meetings, and from individual experts. The plan includes four primary natural resource recovery objectives and several options for developing specific actions to improve natural resource recovery. The sections of the report containing considerations for improving post-fire recovery provide a suggested framework for performing a restoration action and an estimated cost for each restoration action. The Wildland Fire Management Committee can use this information to evaluate and prioritize specific fire recovery actions. Specific project planning, site selection, National Environmental Policy Act analysis, and cost scheduling will still be necessary at the time a restoration action is initiated.

1.1.1 Applicable INL Ecological Resource Guidance

There are several INL-specific National Environmental Policy Act analyses, interagency agreements, guidance documents, and charters that provide direction as to how ecological resources should be managed on the INL Site and information as to how to prioritize those management activities. The most important of those documents, as they pertain to the Sheep Fire Recovery Plan are briefly discussed here:

Wildland Fire Management Environmental Assessment

Pre-fire activities aimed at reducing the risk of wildland fire ignition and spread, and post-fire activities intended to stabilize soils, minimize further impact to cultural resources, and recover ecological resources are addressed in the INL Site's Wildland Fire Management EA. The Wildland Fire Management EA was prepared in response to a Department of Energy (DOE) complex-wide review of fire safety programs and related emergency management capabilities in 2000 (DOE 2003). DOE considered four alternative wildland fire management strategies in the EA and selected a modified Alternative 2, Balanced Fire Protection Approach. DOE approved the EA and prepared a Finding of No Significant Impact in 2003.

The Wildland Fire Management EA recognizes that protecting human life and public safety are top priorities of INL's fire management strategy. Protection of physical assets and infrastructure are also among the most important of the listed fire management goals. Additional goals identified in the EA include complying with air and water resource regulations, minimizing and documenting impacts to cultural resources, and protecting or mitigating impacts to ecological resources. The EA discusses the importance of sagebrush steppe habitat at the INL Site and makes several recommendations for minimizing impacts to sagebrush steppe for pre-fire activities (e.g., establishing defensible space), during fire suppression activities (e.g., blading containment lines), and for post-fire activities (e.g., soil stabilization and site restoration). Restoration recommendations that pertain to this plan include post-fire stabilization activities like seeding containment lines and habitat improvement activities like controlling noxious weeds and reestablishing native vegetation to reduce recovery timelines (DOE 2003).

Candidate Conservation Agreement for Greater Sage-Grouse

Due to concerns over the steady decline in Greater Sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) populations and the potential listing under the Endangered Species Act, DOE and the U.S. Fish and Wildlife Service (USFWS) have entered into a Candidate Conservation Agreement (CCA) (DOE-ID and USFWS 2014). The primary purpose of this agreement is to conserve sage-grouse populations and their habitats on the INL Site so that should a listing be considered in the future, potential impacts to the INL Site mission and operations could be properly managed. As part of the CCA, population and habitat "triggers" were identified, which if tripped would initiate an automatic response by USFWS and DOE. The CCA established the Sage-grouse Conservation Area (SGCA) that limits infrastructure development and human disturbance in approximately 68% of remaining sagebrush-dominated communities. Leks protected by the SGCA support an estimated 74% of the sage-grouse that breed on the INL Site. The CCA also identifies potential threats to sage-grouse survival and establishes conservation measures that can be used to mitigate threats. The loss of sagebrush cover resulting from wildland fire is considered a major threat to the persistence of sage-grouse (Connelly et al. 2011). Therefore, the CCA identifies several conservation measures that can be taken to reduce impacts to sage-grouse habitat from wildfire or hasten sagebrush reestablishment in burned areas.

Revegetation Guidance

Revegetation at the INL Site is completed in accordance with the INL Revegetation Guide (INL 2012). The purpose of the Guide is to provide revegetation strategies for hastening the establishment of desired plant communities, to minimize erosion of disturbed soils, and to prevent weed invasions. The use of native species is strongly encouraged, as is the use of a species mix containing adequate diversity of growth forms and root profiles. The Guide also provides recommendations for seed bed preparation, soil amendments, planting strategies, weed control, optimal planting timeframes, and post-planting techniques for improving establishment. Recommendations from the Guide are generally tailored to each project, depending on the site's condition and the goal of the revegetation effort. Any revegetation recommendations made to improve post-fire vegetation recovery should be consistent with INL Revegetation Guide.

Weed Management Plan

Federal agencies are required to develop management programs for controlling undesirable plants on federal lands. The INL's Sitewide Noxious Weed Management Plan (INL 2013) focuses on noxious weed control to the extent practical and within Administration budgetary limits. The Plan recognizes that preventing encroachment and revegetation with native species in degraded areas are the best long-term strategies for noxious weed control. Also discussed in the Plan are tactics to minimize noxious weed spread, methods for inventory and mapping, techniques for controlling noxious weeds, and monitoring for treatment effectiveness. Because weed management is also a post-fire concern, the Sitewide Noxious Weed Management Plan will be used to guide weed control efforts where appropriate.

Comprehensive Land Use and Environmental Stewardship Report

Though not specifically an ecological resource guidance document, the Idaho National Laboratory Comprehensive Land Use and Environmental Stewardship Report (INL 2016) summarizes strategic planning decisions about future land use and infrastructure development. Therefore, post-fire recovery recommendations should be compatible with anticipated land use at the INL Site. Current operations and those forecasted to occur within the next ten to twenty years are primarily limited to current facility boundaries. Some facilities are projected to expand, while others will continue to contract with continued cleanup and decommissioning. There are also several projects in progress or proposed to begin within the next five years that were not captured in the most recent Comprehensive Land Use Report and some of those projects have been sited in more remote areas. These facilities and infrastructure upgrades should be considered in post-fire recovery planning as well.

National Environmental Research Park

The National Environmental Research Park (NERP) program was established in response to recommendations from citizens, scientists, and members of congress to set aside land for ecosystem preservation and study. The INL Site was designated as a NERP in 1975 and the objectives of the Idaho NERP are to: 1) Preserve the area as a representative example of a cool-temperate desert scrub biome, 2) Develop a regional reference data archive of the sagebrush steppe ecosystem, 3) Provide training and education opportunities for environmental scientists and students, and 4) Develop ecosystem models which can predict the effect of proposed activities (Blew et al. 2010). Since its establishment, the Idaho NERP has facilitated research for numerous scientists across a broad range of topics. Active research projects include: studies of ants and their associated invertebrate communities (ESER 2019), movement and behavior of pregnant Great Basin rattlesnakes (*Crotalus oreganus lutosus*) and their offspring (ESER 2019), and characterization of nesting habitat and invertebrate resources for sage-grouse. The goals and objectives of the Idaho NERP, including the unique opportunities it affords to researchers, should be considered in post-fire recovery actions.

1.2 Summary of the Sheep Fire

The Sheep Fire was reported the afternoon of July 22, 2019. The lightning caused fire started east of T-4 and south of T-9 in a remote region of the INL Site; it was approximately 2,000 ac (809 ha) acres when the INL Fire Department responded and it continued to burn to the south and west, affecting an additional 6,500 ac (2,630) ha) overnight. A red flag warning was in effect for thunderstorm activity throughout the day on July 23. At approximately 6:00 a.m., winds picked up from the northeast and a large column began to form. The fire became plume dominated with extreme behavior and made a significant run to the southwest. A mid-morning reconnaissance flight confirmed the fire had expanded to over 80,000 ac (32,375 ha). Crews initiated backfiring operations from the intersection of Jefferson and Portland working both to the north and east. Red flag conditions continued through July 24 for high winds and low relative humidity. Containment was estimated at 60% by the end of the day. Minimal fire activity was reported on July 25, and the Sheep Fire was 100% contained by the afternoon of July 26.

The INL Fire Department and Bureau of Land Management (BLM) responded to the Sheep Fire under a unified command. Fire suppression strategies included establishing containment lines using dozers and support engines, fire retardant drops with air tankers, backfiring operations from strategic anchor points, and cold trailing tactics. Damage to INL property was limited to signs, some incidental storage on the pad behind PBF-623, and 12 INL distribution poles. Rocky Mountain Power lost 46 structures with 100 poles on the Montana line. No buildings were affected and there were no reported injuries.

The initial boundary for the Sheep Fire was produced by the BLM from limited field data and some additional data provided from the INL Site. However, experience with other recent large fires suggests the actual burned area boundary typically differs from the generalized boundary created immediately post-fire. To assist with post-fire evaluation and mapping, high resolution commercial satellite imagery was acquired on September 15, 2019 by Digital Globe's GeoEye-1 sensor. The GeoEye-1 sensor collects four spectral bands in the visible and near-infrared region of the electromagnetic spectrum with 2 m resolution, and a panchromatic band with 0.5 m resolution. Digital Globe delivered raw and processed imagery data products that were radiometrically corrected, pan-sharpened, orthorectified, and georeferenced for easy integration into a Geographic Information System (GIS). Using the imagery as a basemap, a GIS Analyst manually delineated the burned area at a 1:6,000 scale.

The Sheep Fire burned in a very patchy manner across the landscape leaving numerous unburned islands of vegetation within the burned area footprint. There are regions where nearly all vegetation was removed down to the soil and the resulting landscape looks devoid of vegetation. There are other areas, particularly in the northeast region of the fire, where there was complete burn within a matrix of distinct unburned patches. The southern region of the Sheep Fire looked very uncharacteristic of a complete burn in the imagery and could almost be interpreted as a mixture of burned and unburned vegetation. However, ground observations verified there is some partially burned, charred and heat-killed vegetation within this area.

Mapping results indicate the Sheep Fire burned approximately 99,839 ac (40,403 ha) of vegetation which is a reduction from the initial estimate of 112,107 ac (45,368 ha) using the original BLM boundary (Figure 1-1). It should be noted there were many unburned patches of vegetation not delineated which suggests the mapping result is still an overestimate of the actual burned area. The Sheep Fire burned through a region of the INL Site that has experienced numerous fires in the past, and only on the west side of the fire were there large stands of vegetation present that had not been burned previously. Approximately 74.6% of the area burned in the Sheep Fire has been burned at least once since 1994, while some areas have burned up to four times (Figure 1-1).

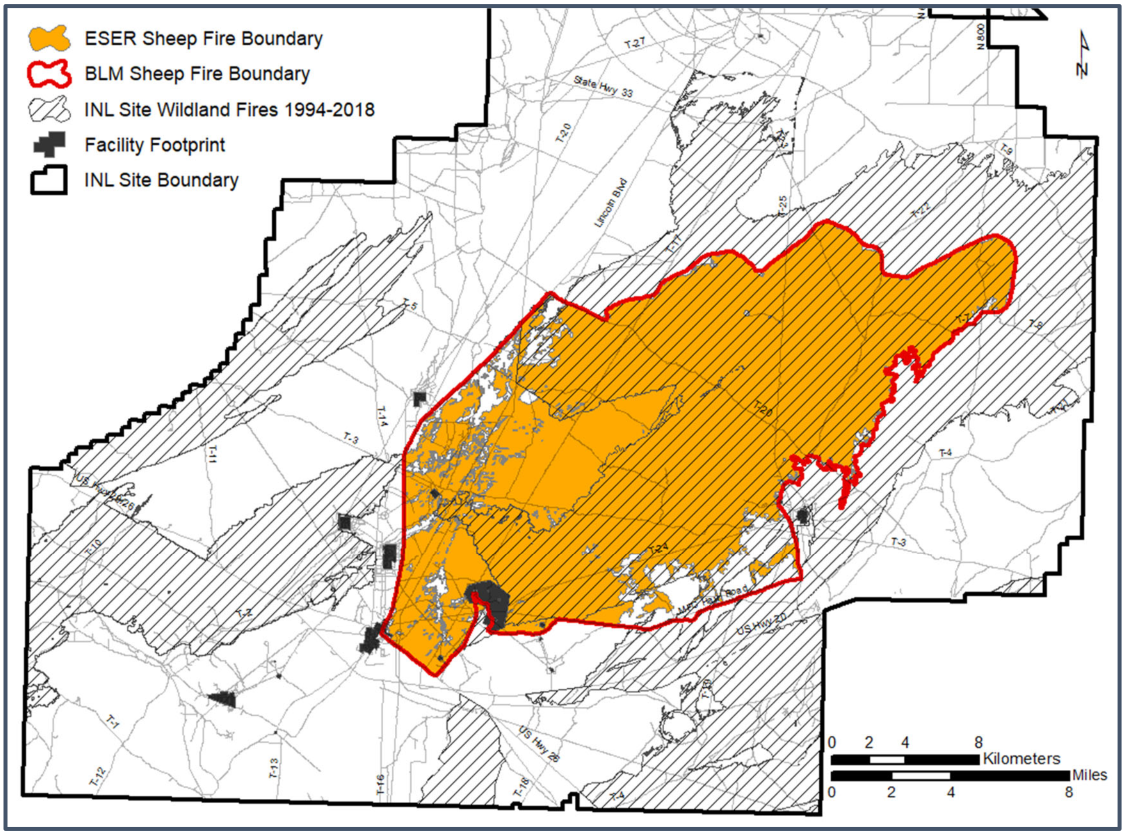

Figure 1-1. The 2019 Sheep Fire on the Idaho National Laboratory Site shown with all major wildland fires since 1994.

1.3 Ecological Resources Affected by the Sheep Fire

1.3.1 Soils

The soils in the area affected by the Sheep Fire are generally described as sand to moderately coarse substrate over basalt. They range from shallow to deep (<20" to >60") with slopes ranging from 0-20%. Olson et al. (1995) mapped the soils in area affected by the Sheep Fire as primarily 5 types: Malm-Bondfarm-Matheson complex, 2 to 8% slopes, Coffee-Nargon-Atom complex, 2 to 12% slopes, Typic Torrifluvents, Grassy Butte-Rock outcrop complex, and Aecet-rock outcrop complex. These five soil types cover approximately 86% of the area burned in the Sheep Fire. Malm-Bondfarm-Matheson singularly accounts for 58% of the total area burned. In its entirety, 21 different soil types were encompassed by the general Sheep Fire perimeter boundary (Figure 1-2).

The Malm-Bondfarm-Matheson complex and the Coffee-Nargon-Atom complex are typical in Idaho for basalt plains with elevations ranging from 4,500 to 5,500 ft (1,372 to 1,676 m), and slopes ranging from 2 to 12%. They are moderately to well drained sandy loam or loess over bedrock/basalt and are typically dominated by sagebrush habitat types. Both soil complexes have a high hazard of soil blowing (wind erosion). The high hazard of soil blowing imparts certain limitations to use of these soils (Olson et al. 1995). They are generally not well suited to mechanical rangeland management treatments, including seeding. These soils are classified as Land Capability Class VIIe and have very severe limitations that make them unsuitable for cultivation due to erosion and have impaired trafficability. This becomes an important consideration for restoration or long-term erosion control measures.

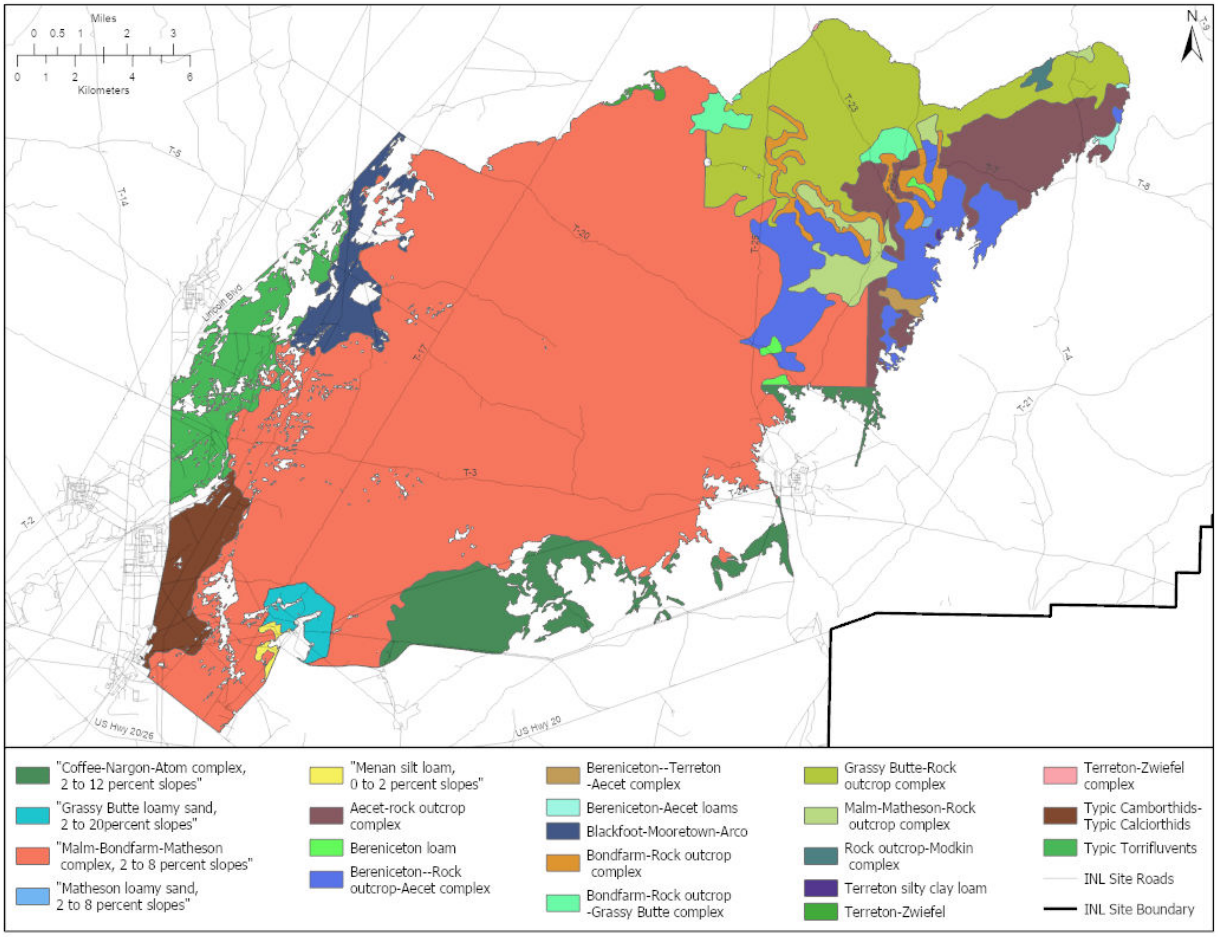

Figure 1-2. Soils in the area impacted by the 2019 Sheep Fire on the Idaho National Laboratory Site.

1.3.2 Vegetation

Spatial Distribution of Plant Communities

An update to the INL Site plant community classification and vegetation map was recently completed and published before the Sheep Fire (Shive et al. 2019). The new vegetation map shows the pre-fire vegetation classes present within the Sheep Fire burned area. Understanding the pre-fire vegetation composition and distribution gives insight into the plant communities likely to reestablish and assist in identifying areas that may need active restoration due to an abundance of non-native species.

There were nine vegetation classes mapped within the Sheep Fire boundary including three shrubland, two shrub grassland, and four grassland classes (Figure 1-3). The majority of area burned was assigned to the Green Rabbitbrush / Thickspike Wheatgrass Shrub Grassland and Needle and Thread Grassland class where 56,402 ac (22,825 ha) was lost (Table 1-1). This class is composed of native grass and shrub species commonly observed on the INL Site following fire in areas previously dominated by sagebrush. The second most common vegetation class within the Sheep Fire was the Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland with 22,510 ac (9,109 ha) burned (Table 1-1). This class distribution was constrained to area that had not burned prior to the Sheep Fire. The Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland vegetation class is also one of three classes that are combined to represent general sagebrush habitat for sage-grouse.

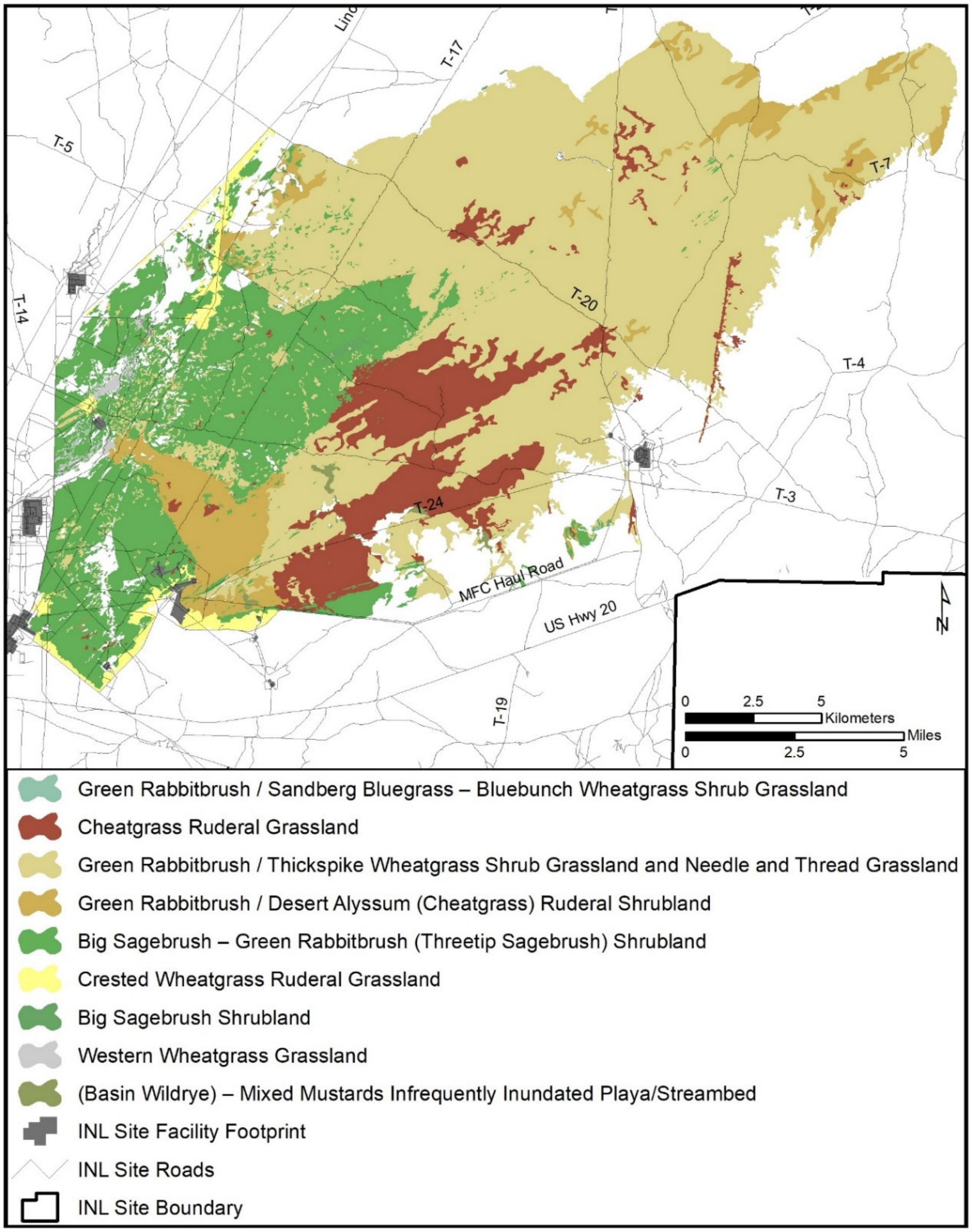

Figure 1-3. Vegetation classes burned in the 2019 Sheep Fire. The most recent Idaho National Laboratory Site vegetation map (Shive et al. 2019) was clipped to the Sheep Fire boundary to estimate area burned for each class.

Table 1-1. The Idaho National Laboratory Site vegetation class area burned in the 2019 Sheep Fire.

Vegetation Class	Area Burned (ac)	Area Burned (ha)
Green Rabbitbrush / Sandberg Bluegrass – Bluebunch Wheatgrass Shrub Grassland	13	5
Cheatgrass Ruderal Grassland	10,741	4,347
Green Rabbitbrush / Thickspike Wheatgrass Shrub Grassland and Needle and Thread Grassland	56,402	22,825
Green Rabbitbrush / Desert Alyssum (Cheatgrass) Ruderal Shrubland	7,036	2,847
Big Sagebrush – Green Rabbitbrush (Threetip Sagebrush) Shrubland	22,510	9,109
Crested Wheatgrass Ruderal Grassland	1,881	761
Big Sagebrush Shrubland	153	62
Western Wheatgrass Grassland	471	191
(Basin Wildrye) – Mixed Mustards Infrequently Inundated Playa/Streambed	384	155

Ecological Condition of Vegetation

The pre-fire condition of vegetation in the area affected by the Sheep Fire ranged from nearly pristine to severely degraded. Approximately 80% of burned area was dominated by native species and was characterized as fair to good ecological condition prior to the Sheep Fire and the remaining 20% of the burned area was dominated by cheatgrass or other non-native species, a sign of poor condition. Plant communities in relatively good pre-fire ecological condition included mature big sagebrush (*Artemisia tridentata*) shrublands that have not recently burned and plant communities that had previously burned and had naturally recovered to a mix of green rabbitbrush (*Chrysothamnus viscidiflorus*) shrublands and native grasslands. Dominant and co-dominant native perennial grasses in areas of good ecological condition that were affected by the Sheep Fire included the bunchgrasses needle-and-thread (*Hesperostipa comata*), Indian ricegrass (*Achnatherum hymenoides*), bottlebrush squirreltail (*Elymus elymoides*), and the rhizomatous grass, thickspike wheatgrass (*Elymus lanceolatus*). Native forbs were abundant and diverse in many pre-fire plant communities. Some of the most frequently occurring species included: tapertip hawksbeard (*Crepis acuminata*), shaggy fleabane (*Erigeron pumilus*), Hood's phlox (*Phlox hoodii*), flatspine stickseed (*Lappula occidentalis*), and western tansymustard (*Descurainia pinnata*). See Shive at al. (2019) for quantitative summaries and a more thorough description of these native plant communities.

Degraded communities that were present prior to the Sheep Fire were characterized by an abundance of non-native annual species. They tend to occur in areas with recurring disturbance such as low-lying topography that experience occasional flooding, basalt outcroppings with thin unstable soils, and areas that have burned previously. Several non-native species from the mustard family, as well as Russian thistle (*Salsola kali*) and saltlover (*Halogeton glomeratus*) generally dominated low-lying areas in poor ecological condition. Areas dominated or co-dominated by cheatgrass (*Bromus tectorum*) occurred most often on basalt outcroppings and in previous burn scars. However, not all previously burned areas were dominated by cheatgrass. Poor condition cheatgrass-dominated communities ranged from vegetation characterized by cheatgrass monocultures to communities with substantial cover from native grasses and/or green rabbitbrush (Shive et al. 2019).

Of the vegetative community types that were burned in the Sheep Fire, sagebrush shrublands were the most stable. Total annual cover fluctuated the least and cover from annual weeds, including cheatgrass was generally the lowest in this vegetation type (Shurtliff et al. 2019). Annual vegetation cover fluctuations were greater in grasslands and cover from native, perennial grasses has been near the upper end of its historical range of variability over the past few years (Shurtliff et al. 2019). Cheatgrass cover has increased notably and has also been relatively high in post-fire plant communities over the past three years (Shurtliff et al. 2019), though long-term vegetation data sets suggest cheatgrass cover trends are reversable and large fluctuations may be becoming more typical over the span of a decade (Forman and Hafla 2018). Cover from Russian thistle and saltlover fluctuate over time, but do not appear to be increasing substantially; their distribution tends to be restricted to disturbed soils and low-lying topography. Much of the annual variability associated with herbaceous species, both native and introduced, is likely related to total annual precipitation and seasonal timing of precipitation events (Forman and Hafla 2018, Shurtliff et al. 2019).

1.3.3 Wildlife

Numerous wildlife species depend upon the local high desert ecosystem: five species of fish, 48 mammal species, 200 bird species, one amphibian species, 10 reptile species (Vilord, In Preparation), and more than 1,240 invertebrate species (Hampton 2005) have been documented on the INL Site. Many mammal, bird, reptile, and invertebrates were likely affected by the Sheep Fire. This may include the federally listed threatened species yellow-billed cuckoo (*Coccyzus americanus*), and the federally protected bald (*Haliaeetus leucocephalus*) and golden eagle (*Aquila chrysaetos*).

Of the species documented on the INL Site, nine bird and six mammal species are listed as Species of Greatest Conservation Need (SGCN) by the State of Idaho (IDFG 2017; Table 1-2), the majority of which are considered sagebrush obligates, meaning that they rely on sagebrush for survival. Sagebrush obligates listed as SGCN include sage-grouse, sage thrasher (*Oreoscoptes montanus*), sagebrush sparrow (*Artemisiospiza nevadensis*), ferruginous hawk (*Buteo regalis*), burrowing owl (*Athene cunicularia*), long-billed curlew (*Numenius americanus*), and pygmy rabbit. Other common or abundant sagebrush obligate species that have been documented on the INL include: Brewer's sparrow (*Spizella breweri*), loggerhead shrike (*Lanius ludovicianus*), northern sagebrush lizard (*Sceloporus graciosus*) and sagebrush vole (*Lagurus curtatus*). Most of the sagebrush obligates were likely present in the 22,510 ac (9,109 ha) of sagebrush habitat that burned during the Sheep Fire.

Other common resident species on the INL Site that were likely affected by the fire include: elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), pronghorn antelope (*Antilocapra americana*), coyote (*Canis latrans*), yellow bellied marmot (*Marmota flaviventris*), Ord's kangaroo rat (*Dipodomys ordii*), black-tailed jackrabbit (*Lepus californicus*), badger (*Taxidea taxus*), horned lark (*Eremophila alpestris*), western meadowlark (*Sturnella neglecta*), mourning dove (*Zenaida macroura*), vesper sparrow (*Pooecetes gramineus*), common raven (*Corvus corax*), short-horned lizard (*Phrynosoma douglassi*), Great Basin rattlesnake, and gopher snake (*Pituophis catenifer*) and many others. Habitats for many of these species consist of both sagebrush and grasslands that that were present prior to the Sheep Fire.

Table 1-2. Idaho Species of Greatest Conservation Need that have been documented on the Idaho National Laboratory Site.

Common Name	Scientific Name	Ranking*
Burrowing Owl	*Athene cunicularia*	Tier 2
Common Nighthawk	*Chordeiles minor*	Tier 3
Ferruginous Hawk	*Buteo regalis*	Tier 2
Grasshopper Sparrow	*Ammodramus savannarum*	Tier 3
Greater Sage-Grouse	*Centrocercus urophasianus*	Tier 1
Long-billed Curlew	*Numenius americanus*	Tier 2
Sage Thrasher	*Oreoscoptes montanus*	Tier 2
Sagebrush Sparrow	*Artemisiospiza nevadensis*	Tier 2
Short-eared Owl	*Asio flammeus*	Tier 3
Bighorn Sheep	*Ovis canadensis*	Tier 2
Hoary Bat	*Lasiurus cinereus*	Tier 2
Little Brown Myotis	*Myotis lucifugus*	Tier 3
Pygmy Rabbit	*Brachylagus idahoensis*	Tier 2
Townsend's Big-eared Bat	*Corynorhinus townsendii*	Tier 3
Western Small-footed Myotis	*Myotis ciliolabrum*	Tier 3

*Tier 1 SGCN is the highest priority for the State Wildlife Action Plan and represents species with the most critical conservation needs (i.e., an early-warning list of taxa that may be heading toward the need for Endangered Species Act listing).

*Tier 2 SGCN are secondary in priority and represents species with high conservation needs— that is, species with longer-term vulnerabilities or patterns suggesting management intervention is needed but not necessarily facing imminent extinction or having the highest management profile.

*Tier 3 SGCN includes a suite of species that do not meet the above tier criteria, yet still have conservation needs. In general, these species are relatively more common, but commonness is not the sole criterion and often these species have either declining trends range wide or are lacking in information.

Sage-Grouse and the Sage-Grouse Conservation Area

There are three active sage-grouse leks within the Sheep Fire boundary (Figure 1-4). In 2019, an average of 16 males were observed using each of these leks. Additionally, researchers from University of Idaho located four sage-grouse nests also within the area directly impacted by the Sheep Fire.

Within the SGCA approximately 11,747 ac (4754 ha) of vegetation burned representing 11.8% of the total burned area (Figure 1-4). The only sagebrush habitat lost within the SGCA were a few unburned patches of sagebrush within the 2010 Jefferson Fire boundary totaling 5.7 ac (2.3 ha).

The sagebrush habitat outside of the SGCA is considered a conservation bank of habitat that could be used to replace area or redefine the SGCA in the event a large fire removes a significant portion of sagebrush within the currently defined boundary (DOE-ID and USFWS 2014). Prior to the Sheep Fire, the total area of sagebrush habitat bank was 95,735 ac (38,743 ha). The Sheep Fire burned 25,703 ac (10,401.7 ha) of sagebrush habitat thus reducing the bank by 28.6% (Figure 1-4).

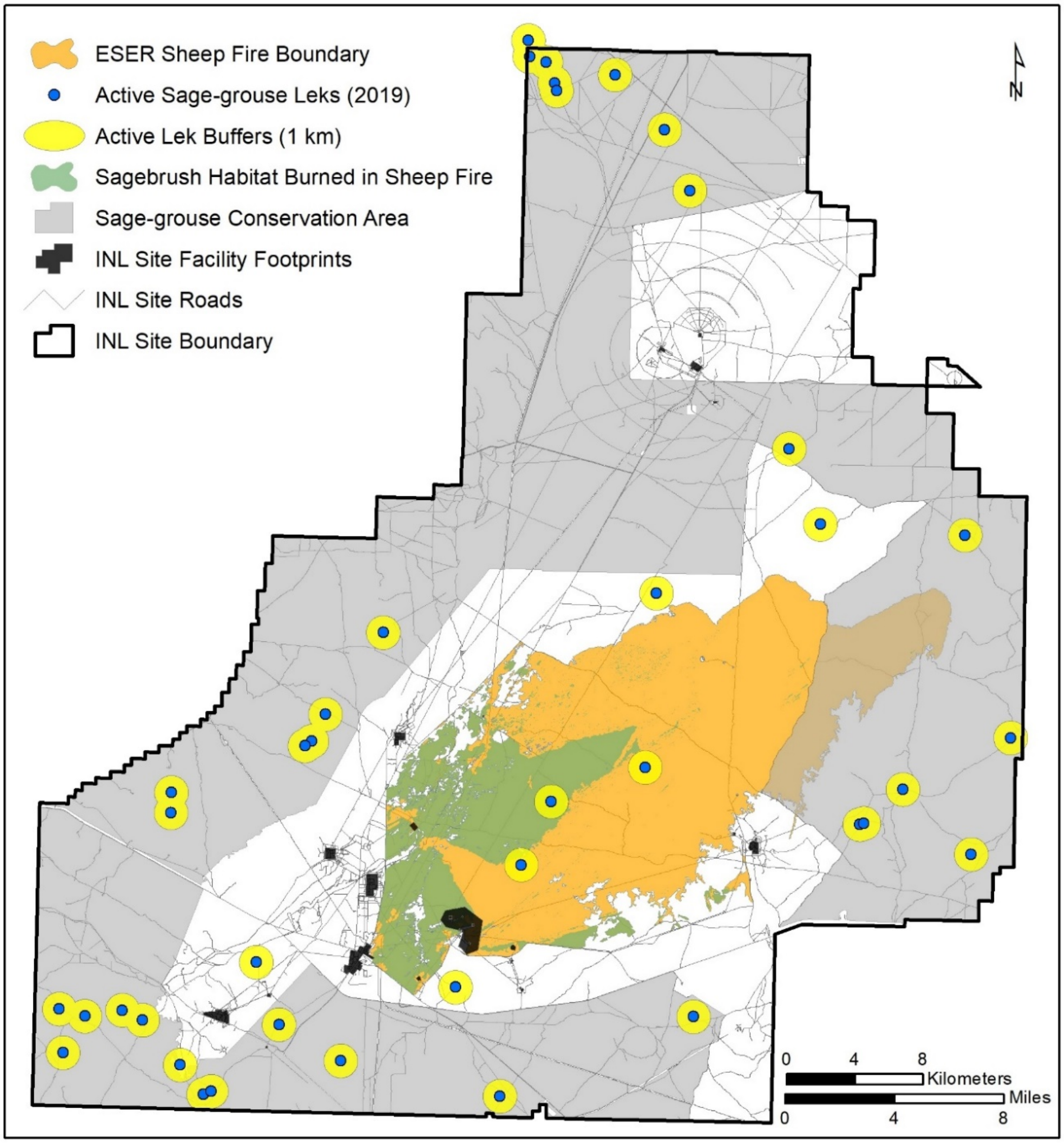

Figure 1-4. Distribution of active sage-grouse leks, sagebrush habitat burned in the Sheep Fire, and the Sage-grouse Conservation Area boundary on the Idaho National Laboratory Site.

2.0 NATURAL RESOURCE RECOVERY OBJECTIVES

2.1 Soil Stabilization for Erosion and Weed Control

Soil stabilization is often the first recovery objective for natural resources to be addressed post-fire. Erosion, primarily from wind, can move large volumes of soil in a relatively short post-fire timeframe (Sankey et al. 2012). Soil disturbance in the area affected by the Sheep Fire may result in a direct loss of existing native vegetation and will provide opportunities for invasive and other non-native plants to become established. Management actions such as re-grading of the containment lines and preventing vehicle traffic on the disturbed soils can reduce the efforts required for revegetation and weed management. Because of the high hazard for wind erosion in these soils, fugitive dust and blowing sand can be expected and may cause potential off-site impacts downwind of disturbed areas. It is also likely that areas within the fire footprint will erode and down-cut under certain types of precipitation events such as those associated with significant thunderstorms and rain-on-snow events. Instances of needed road repair such as gravel or grading on T-roads impacted by blowing soil and surface water may also result from post-fire erosion.

2.1.1 Summary of Risks to Natural Resources from Exposed Soils

There are four primary concerns related to soil erosion that may necessitate stabilization after a wildland fire on the INL Site. The first three concerns are the effects of fugitive dust on INL Site operations, the effects soil loss may have on the recovery of native plant communities, and the encroachment of undesirable species in areas where soils and related nutrients have been redistributed. These concerns stem from wind erosion and loss of soil immediately after vegetation has been removed from a burned area. The remaining concern is associated with the increased risk of creating corridors of weed invasion where vegetation was removed during firefighting activities. Potential issues related to native vegetation recovery and post-fire weed encroachment into burned areas will be addressed under subsequent natural resource recovery objectives. This section will focus on the immediate effects of post-fire wind erosion on INL Site operations and the risk of weed invasion in soils disturbed by firefighting activities.

Burned areas on the INL Site experience substantial movement of soil up to six months post-fire (e.g., Sankey et al. 2010). This soil movement has resulted in concerns for INL Site employee safety. Concerns range from poor air quality to reduced visibility. Increased post-fire soil movement also increases the costs associated with mitigating the effects of dust on INL facility operations. Examples may include increased frequency for changing air filters in buildings, increased need for road maintenance, and providing additional personal protective equipment for personnel working in or around the burned area.

Because of the concerns associated with air quality and its effects on operations at the INL Site, previous attempts have been made to stabilize soils using revegetation via drill-seeding immediately post-fire (Blew and Jones 1998). However, seeding in late summer or early fall does not effectively reduce erosion as seed from the cool season grasses predominant on the INL Site do not germinate well under hot, dry conditions. Optimal germination conditions generally occur during spring in the sagebrush steppe of the Upper Snake River Plain, at which time re-sprouting native perennials would also be emerging. Sankey et al. (2009) reported little soil erosion following spring emergence of herbaceous vegetation and they concluded that seeding for wind erosion control purposes would be of little utility. For this reason, there are no specific recommendations included in this plan for planting outside of the containment lines to managing the effects of soil movement on INL operations. Measures to best address health and safety concerns should be considered at each of the facilities potentially affected until spring emergence curtails erosion. The Wildland Fire Management EA recommends soil tackifier, mulch, water cannon and/or snow fence (DOE 2003).

Containment lines used to break up fuel continuity can result in large linear footprints of exposed soil. These exposed soils generally have reduced recovery of native, perennial species when compared to adjacent burned areas without mechanical soil disturbance. Additionally, disturbed soils are often dominated by non-native, weedy species (Blew et al. 2003). Containment lines pose a concern to post-fire recovery because they contribute to habitat fragmentation and they create corridors for weed encroachment much the same as roads (Halford 2003). Cheatgrass is particularly well-adapted to establishing on disturbed soils and can have significant impacts on native habitats at the INL Site.

Several federal agencies currently recommend reseeding containment lines to reduce the potential risk of weed encroachment and to minimize the potential impacts from habitat fragmentation.

2.1.2 Considerations for Improving Post-Fire Recovery of Exposed Soils

The following components should be considered during the process of developing specific actions for addressing soil stabilization for erosion and weed control.

Characterize the of Amount/Severity of Direct Soil Disturbance and Prioritize Restoration Activities

The Wildland Fire Management EA (DOE 2003) makes the recommendation to "evaluate the necessity to revegetate all or portions of the areas impacted by fire suppression activities." The INL Fire Department provided the Wildland Fire Management Committee a map showing a preliminary evaluation of the extent and location of containment lines from Sheep Fire (Figure 2-1). Estimates of direct soil disturbance related to fire suppression activities on the Sheep Fire were amended by the INL Site Cultural Resources Management Office (CRMO) based on field reconnaissance. The CRMO estimated 80 miles (128 km) of soil disturbance from dozer line, hand line, new access track, damaged access road and an additional 11 acres (4.5 ha) of soil disturbance associated with staging areas (Henrikson and Pink 2019). They also acknowledge that these metrics likely underestimate the total extent of soil disturbance because of known gaps in Global Positioning System (GPS) data from INL dozers and other heavy equipment. High resolution imagery of the Sheep Fire suggests that soil disturbance is apparent beyond the dozer lines initially reported by the INL Fire Department.

The first step towards restoring soils disturbed during fire suppression activities is identifying the extent of impacted area. High resolution imagery can be used to delineate several types of soil disturbance including containment lines, new two-track access roads, damage to existing two-track roads, and staging/laydown areas. Additional field-based data collected during surveys conducted by the CRMO would also be useful for characterizing disturbed areas.

In addition to determining the spatial extent of soil disturbance, it is important to quantify the severity of soil disturbance and to prioritize restoration activities accordingly. Areas impacted by more severe disturbance may be a higher restoration priority than areas with less severe disturbance. For example, containment lines where vegetation was completely removed, and only exposed mineral soil remains aren't likely to recover well naturally because they lack nutrients, organic substrate and intact root masses from which natives can resprout. Therefore, containment lines with more severe disturbance may be a higher restoration priority than containment lines where only surface vegetation was removed and at least some vertically distributed soil properties and root masses from native perennial species remain intact.

Some additional factors that should be considered when prioritizing restoration measures in areas affected by fire suppression activities are access, proximity to sagebrush habitat, and locations of known weed infestations. Restoration activities may not be appropriate in cases where accessing the area has the potential to cause additional damage that outweighs the potential benefit of restoration. A desire to limit the risk of non-native species encroachment in disturbed soils adjacent to good condition habitat may be a prioritizing factor, as may stabilizing soils adjacent to weed infestations to increased resistance to encroachment. Finally, administrative restrictions like those associated with cultural resource sites and areas with unexploded ordnance should be avoided as potential treatment areas are prioritized.

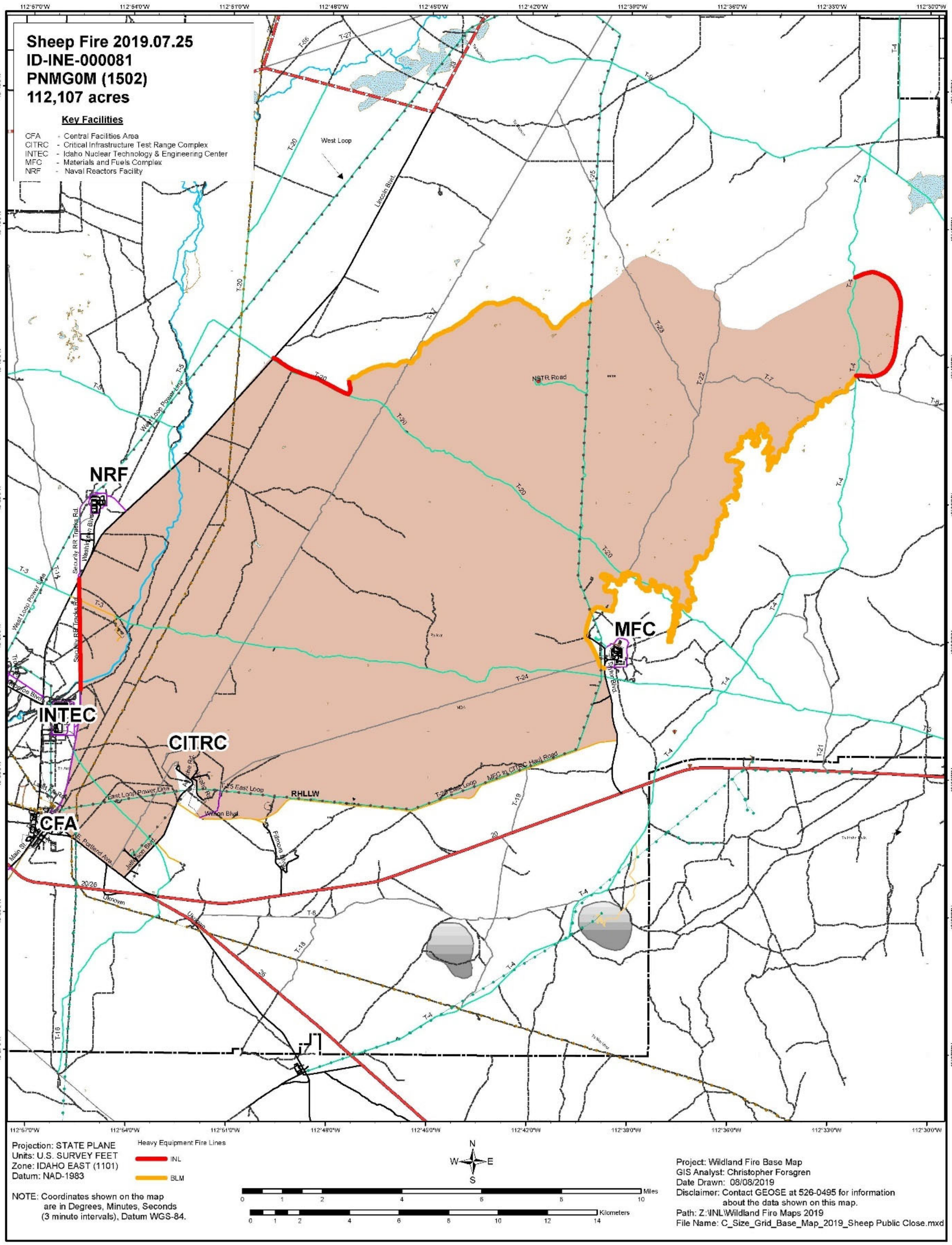

Figure 2-1. Initial map of containment lines from fire suppression activities associated with the Sheep Fire. Data were provided by the Idaho National Laboratory Fire Department.

Recontour Containment Lines and Seed Direct Soil Disturbance with Native Grass Mix

Once containment lines have been identified and prioritized for restoration, the highest priority areas should be recontoured and planted with a native grass mix. Ideally, containment lines should be recontoured prior to demobilization of the heavy equipment used for fire suppression efforts (INL 2017). Because there were concerns over creating additional damage to cultural resource sites, containment lines were not recontoured immediately after the Sheep Fire. Therefore, recontouring and planting of prioritized containment lines should proceed as soon as cultural resource concerns have been addressed. If time and/or resources are limited, containment lines may be prioritized for restoration according to the criteria discussed in the section above.

There is no advantage to making the re-graded lines conform to a certain construction specification. In fact, it is much better for revegetation if they are imperfect and thereby provide favorable microsites for re-sprouting plants or sprouting seeds. In many cases, minimizing additional disturbance is preferable to achieving ideal contours. Planting during the recontouring process also eliminates additional visits to the containment lines and limits traffic on the already disturbed areas. Minimization of disturbance is key to successful revegetation because it also limits soil compaction and risk of introducing non-native species.

The INL Site Revegetation Guide (INL 2012) recommends mechanical planting with a drill on disturbed soils. However, it may not be possible or feasible to pull a drill behind a dozer or other heavy equipment available during the effort to recontour the containment lines. Applying seed to the soil surface via hand or mechanical spreader (broadcast seeding) is another option discussed the Revegetation Guide (INL 2012). Establishing seed to soil contact is the single most important aspect of ensuring a successful reseeding effort. If seed is broadcast on the soil surface, a modified sheep's foot roller, a roll of tires, or the addition of mulch could help to improve soil contact.

A combination of native grasses is often recommended for reseeding containment lines on the INL Site. Native grass seed is produced commercially and can be much easier and less expensive to procure quickly than seed for native shrubs like big sagebrush or green rabbitbrush. Grass seed is also easier to plant with conventional methods, like a drill. There are locally appropriate cultivars for many grass species and planting a diverse mix of species increases revegetation success. If seed from common shrubs can be reasonably obtained, it would improve the diversity of the mix. Forbs are not recommended at this time because the available cultivars appear to be genetically distinct from populations native to the local area. A combination of species provided in Table 2-1 would be suitable for most soil types in the area affected by the Sheep Fire. Application rates should be calculated according to the INL Revegetation Guide (INL 2012).

Table 2-1. Species recommended for seeding containment lines created during the Idaho National Laboratory Site Sheep Fire suppression effort.

Scientific Name	Common Name
Poa secunda	Sandberg bluegrass
Elymus elymoides	bottlebrush squirreltail
Elymus lanceolatus	thickspike wheatgrass
Pascopyrum smithii	western wheatgrass
Achnatherum hymenoides	Indian ricegrass
Chrysothamnus viscidiflorus	green rabbitbrush
Artemisia tridentata ssp. *wyomingensis*	Wyoming big sagebrush

If efforts to recontour and reseed containment lines are not completed during the fall following the fire, any remaining prioritized areas should be reevaluated prior to resuming work the following year. Containment lines with less severe soil disturbance may begin to experience natural regrowth in the spring. If establishing species are abundant and desirable, additional work on the containment line may cause more damage than any possible benefit derived from recontouring. Areas that have been reseeded, and areas where reseeding was not determined to be a priority, should both be monitored for poor recovery (see Section 3.2.1 for monitoring guidance).

Sign and/or Barricade the Containment Lines to Prevent Traffic

On previous wildland fires, continued use of the containment lines by vehicles, up to several years post-fire, was noted (Blew et al. 2010). Continued use of containment lines as roads is detrimental to both natural recovery and to active restoration efforts. Traffic on containment lines also reinforces habitat fragmentation and potential weed vectors created by those lines. Therefore, once the need to access the containment lines to support immediate recontouring and revegetation efforts has been addressed, barriers should be added to all containment lines where they bisect roads to prevent vehicular travel on the recovering lines. This can either be done with signage, jersey barriers, or simply with T-posts placed close enough together to deter traffic. A brief memo reminding all fieldworkers to avoid vehicle travel on containment lines prior to the 2020 field season may also be helpful.

Monitor and Spray Containment Lines for Weeds

Because containment lines are a direct effect of the firefighting effort, noxious weeds that appear in the disturbed areas following fire must be managed. Noxious weed management is covered in the INL's Sitewide Noxious Weed Management Plan (INL 2013) and is outlined in Section 1.1.1. Spraying or hand pulling weeds on containment lines during the recontouring and reseeding efforts would be efficient and would help prevent further spreading of weeds during restoration activities.

Revisiting high risk areas at least once annually to assess non-native plant establishment is recommended. If infestations are discovered, they should be reported and treated as quickly as possible. These areas should then become high priority for future monitoring to prevent additional impact to the recovery of native species. After initial weed control efforts, coinciding with recontouring and reseeding, are addressed, annual noxious weed surveys on containment lines could be integrated into an annual monitoring plan designed to address noxious weeds across the entire area burned by the Sheep Fire (see Section 3.1.3 for monitoring guidance).

Assess Any Soil Disturbance Associated with Powerline Repair and Restore Accordingly

Soil disturbances caused by infrastructure repair could increase the amount of human caused damage after a fire. Because repairs related to public safety and infrastructure are a time sensitive priority after a fire, an assessment of potential damage prior to the initiation of repairs are not often completed. This assessment is likely to occur after the fact and mitigative measures will only be considered if the damage is considered severe enough to warrant additional revegetation. One example may be excessive soil disturbance that removes re-sprouting perennials species.

The power poles that were replaced immediately after the fire should be revisited to determine if there were any associated areas with excessive disturbance that may require revegetation to stabilize the soil. Because the powerline repair work on the Montana line was completed within the public utility right-of-way, any need for restoration in this area would have to be addressed in collaboration with Rocky Mountain Power, including NEPA documentation and cultural resource assessments. It is notable that many INL poles were previously treated with fire retardant material, which saved the cost of replacing those structures, and as the cost of mitigating any damage associated with repairing those structures.

2.2 Cheatgrass and Noxious Weed Control

The risk of increased pressure by non-native species is a critical post-fire concern and reducing that risk is an important natural resource recovery objective. Currently, there are 13 documented noxious weeds species widely distributed on the INL Site (Hafla 2004). There are also several other non-native species of concern (not classified as noxious) that are widely distributed across the INL Site. These are frequently encountered, and are known to form large, degraded stands on the Site (Shive et al. 2019). These species include cheatgrass, crested wheatgrass (*Agropyron cristatum*), and a number of introduced, annual forbs including saltlover, Russian thistle, desert alyssum (*Alyssum desertorum*), kochia (*Bassia scoparia*), and various mustards (*Sisybruim* spp. and *Descurainia* spp.). To successfully address the risks to sagebrush habitat recovery posed by non-native species, control strategies for all noxious weeds and other undesirable non-native should be addressed as an integral component of the fire recovery plan.

2.2.1 Summary of Risks to Natural Resources from Weeds

Risk of Cheatgrass Spread and Increased Dominance

Cheatgrass often functions as a winter annual, where it can germinate in late fall or very early spring. It will then sit dormant until it can take advantage of favorable early season growing conditions, which gives it a competitive advantage over natives that germinate or emerge later in the growing season. The impacts of cheatgrass invasion and the resulting change in fire cycles on sagebrush steppe ecosystems across the western United States have been well-documented. Burned areas are less resistant to invasion and are at greater risk for shifts toward cheatgrass dominance than areas that have not recently burned (Chambers et al. 2013). Plant communities that have become dominated by cheatgrass post-fire signify a serious decline in ecological condition because cheatgrass fragments sagebrush steppe and generally reduces habitat value (Knick and Rotenberry 1997), it can drastically impact ecosystem function (Norton et al. 2004), and it further alters the historical fire cycle (Knick 1999).

Previous fire recovery plans for the INL Site didn't specifically address the risk of increased cheatgrass dominance in post-fire plant communities (e.g., Blew et al. 2010). Prior to the Jefferson Fire, cheatgrass was documented to be widely distributed across the INL Site, but it typically occurred at very low densities that weren't considered a threat to post-fire recovery of good condition sagebrush steppe habitat (Forman et al. 2010). Since that time, cheatgrass abundance has begun exhibiting larger fluctuations from one time period to another (Forman and Hafla 2018), and in some recent data sets these fluctuations have generally been trending upward (Shurtliff et al. 2019). Over the last several years, cheatgrass has also become much more abundant in post-fire plant communities than in sagebrush-dominated shrublands that have not burned in recorded history (Shurtliff et al. 2019). Coincident with increases in abundance are notable increases in the distribution of cheatgrass-dominated plant communities across the INL Site, as documented by the differences in distribution of cheatgrass vegetation classes between the two most recent mapping efforts (Shive et al. 2011, Shive et al. 2019). Nearly all the increase in the distribution of the cheatgrass-dominated vegetation class was in post-fire plant communities. Because of these increases in both cheatgrass abundance and distribution across the INL Site over the past decade, it is now an important consideration for post-fire vegetation management.

Importance of Noxious Weed Management

According to Executive Order 13751 (2016) "Invasive species means, with regard to a particular ecosystem, a non-native organism whose introduction causes or is likely to cause economic or environmental harm or harm to human, animal or plant health". The Plant Protection Act [7 U.S.C. §7702 (2000)] defines a noxious weed as "Any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment."

Noxious weeds and other invasive plants are one of the largest disruptors of ecosystem function. Their vigorous growth and prolific reproductive capabilities cause changes in soil chemistry, hydrological conditions, and fire regimes that favor their growth and spread and impede natural succession. Native vegetation does not have the ability to compete with these aggressive species, resulting in a change of native plant communities, a reduction in biodiversity, and habitat degradation. Forage production is also diminished for all classes of herbivores and habitats for small birds and mammals are reduced, making rangelands unusable for wildlife and livestock. Noxious weeds are also a factor for Threatened or Endangered species as it is estimated that approximately 42% of these species are at risk due to non-native, invasive species (Pimentel et al. 2005). The longer the presence of noxious/invasive species is overlooked, the harder and more expensive it is to control them.

2.2.2 Considerations for Improving Post-Fire Recovery by Limiting Weed Spread

The following components should be considered during the process of developing specific actions for addressing cheatgrass and noxious weed control.

Identify Areas that May Benefit from Cheatgrass Treatment

The INL Site vegetation map was recently updated (Shive et al. 2019), and the map class distribution within the Sheep Fire showed two degraded vegetation classes where non-native annual grasses were dominant or were a significant understory component in shrublands (Figure 2-2). The Cheatgrass Ruderal Grassland class had a notable increase in mapped area compared to the previous INL Site vegetation map (Shive et al. 2011) suggesting it is becoming more common and may continue to expand in spatial distribution. The Green Rabbitbrush / Desert Alyssum (Cheatgrass) Ruderal Shrubland is a map class that is commonly found in regions that have been burned and sagebrush has been removed. The understory contains undesirable species, and the Green Rabbitbrush / Desert Alyssum (Cheatgrass) Ruderal Shrubland can be viewed as a transition class that is shifting towards the Cheatgrass Ruderal Grassland if control measures are not implemented or natural processes do not promote an increase in native species cover.

Both classes are recognizable in aerial imagery due to the characteristic reddish color of cheatgrass once it has senesced. While there is overlap between how these two classes appear in imagery, they can be distinguished from one another by considering the red color brightness and whether the distribution appears patchy with shrub structure present, or if it resembles a monoculture with little variability that is most common in the Cheatgrass Ruderal Grassland class. Despite the capability to identify and map these two classes at appropriate scales, there will always be the potential to have localized patches of vegetation that differ from the map class designation. There is also the possibility that natural processes and abiotic factors, such as the timing of precipitation, could help reduce densities of annual grasses and potentially change the distribution of these classes over time.

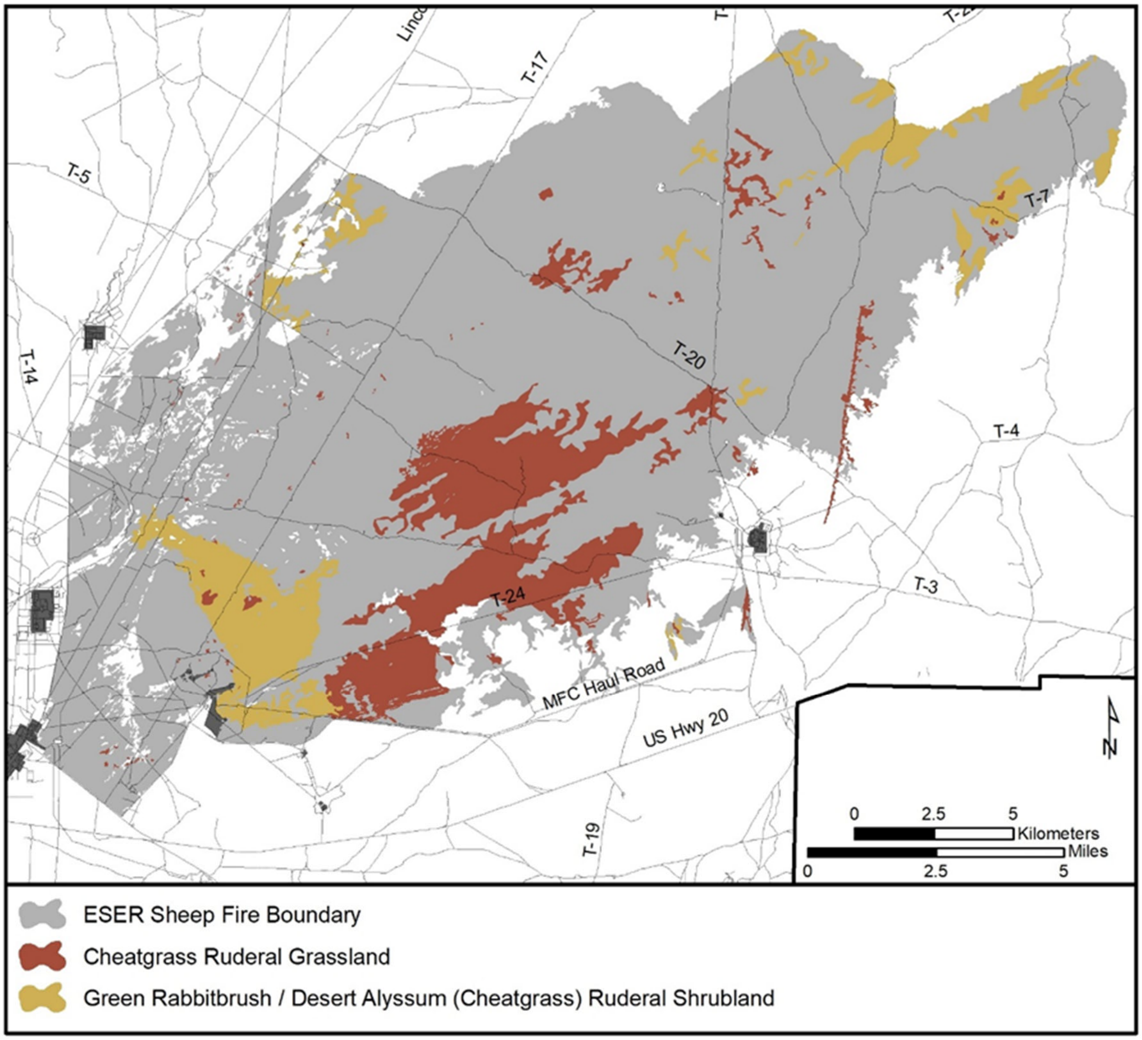

Figure 2-2. Selected Idaho National Laboratory Site vegetation map class distribution within the 2019 Sheep Fire. These two classes represent degraded conditions and would be candidate areas for post-fire treatment options.

As part of an integrated post-fire recovery plan for the Sheep Fire, prioritization of areas for cheatgrass treatment should begin by identifying areas already known to be dominated by cheatgrass prior to the Sheep Fire through the most recent mapping effort. These areas should then be visited and evaluated to verify that current conditions are still appropriate for treatment. Areas that would be considered optimal for treatment are characterized by high cheatgrass cover and relatively homogenous and contiguous distribution over a large spatial extent. Communities may retain some native herbaceous species, but native grasses and forbs would generally contribute less than half of the total cover of the vascular vegetation. Areas with a substantial resprouting shrub component would be a lower priority than areas lacking shrubs entirely, but they should be monitored for changes in condition (see Section 3.1.2 for monitoring guidance).

Apply a Pre-emergent Herbicide to Selected Areas at Greatest Risk for Cheatgrass Dominance

Several herbicides have been used in sagebrush steppe to control cheatgrass and have achieved various levels of success. Imazapic is a pre-emergent chemical herbicide that is commonly used for cheatgrass control across the arid West; it is becoming an agency standard and, when used correctly, it can reduce cheatgrass effectively in the short term (Applestein et al. 2018). Weed-suppressive bacteria have also been considered as an option for cheatgrass control on the INL Site. However, at the time of publication, there were no commercially available sources for these bacteria and results of recent studies have failed to confirm their efficacy (Lazarus and Germino 2019). Cultural practices, like hand-pulling, mowing, and disking, substantially increase the likelihood of successful control, especially when combined with chemical herbicides.

The use of Plateau® or Panoramic® 2SL (Imazapic) is a reasonable approach to cheatgrass control; however, there are additional chemical herbicides that should be considered. Local agencies have recently reported high success rates in controlling cheatgrass using Esplanade® 200 SC (Indaziflam). This herbicide is a pre-emergent herbicide which is best applied during the late fall, winter or spring shortly after a fire; it is most effective when the thatch layer has been reduced, but it should not be applied before soils have stabilized to prevent down-wind movement. This timing also protects established grasses, forbs and shrubs since they are not actively growing. Precipitation is needed to activate the herbicide, but it should not be applied during heavy rain events nor to frozen or snow-covered ground. Esplanade® 200 SC has minimal post emergent activity and generally does not control weeds that have emerged. A labeled post emergent grass and broadleaf herbicide, such as Lambient®, should be mixed with Esplanade 200 SC to control winter annual weeds that may already be growing, such as cheatgrass. As always, this product should be applied as specified on the label. The benefits of Esplanade® are:

- Selectively controls cheatgrass and 74 broadleaf weeds including saltlover and Russian thistle
- Established native grasses and forbs are not harmed
- Reports of residual control range from 8 months to 3 years
- Unique mode of action to help manage herbicide resistance
- Odorless and non-staining to surfaces
- Minimal PPE requirements when compared to traditional IVM herbicides
- Low use rates
- Fewer applications required results in reduced costs
- Not a federally restricted-use pesticide
- Is already included on the INL Site list of approved chemicals.

Both Imazapic and Indaziflam are noted to be most effective when good soil contact can be achieved. Therefore, at least a portion of the prioritized treatment area should be sprayed as soon as soils have stabilized post-fire. It will not likely be feasible to treat all at-risk areas within that time frame and some areas may still benefit from chemical application up to several years post-fire. A phased implementation approach would allow for ongoing cheatgrass treatment. Data from the INL Site suggest that cheatgrass abundance may remain relatively low for several years post-fire before beginning to increase (Forman et al. 2013,Taylor et al. 2014); this allows some lag time during which cheatgrass treatment may be effective in at-risk areas and chemical effectiveness doesn't appear to decrease until cheatgrass cover reaches about 40% absolute cover (Applestein et al. 2018). Treated areas should be monitored and evaluated to determine if additional actions are needed (see Section 3.2.1 for monitoring guidance).

Conduct a Weed Inventory and Treat Noxious Weeds

Noxious weed species that have been documented within the area affected by the Sheep Fire, and are of greatest concern, are thistles, knapweeds, and Rush skeletonweed (*Chondrilla juncea*); however, all weeds identified in Table 2-2 should be inventoried and treated in order to prevent a serious infestation. A noxious weed survey typically includes surveying the target area and documenting the presence of individual weeds or larger infestations of weeds. Weeds should be treated at the time of survey using chemical herbicides or other appropriate control methods. Large infestations with degraded native communities should also be considered for revegetation after noxious weeds have been controlled as that is the most effective long-term control strategy (see Section 2.3.2). Noxious weed surveys should begin on the burned area during late spring/summer 2020 and continue for several years post-fire. This consideration is independent of the recommendation to survey and control weeds on containment lines. As such, it may be evaluated separately, but both weed control efforts may eventually be combined for efficiency. All treatments should be implemented following the guidance provided in the INL Site Noxious Weed Management Plan (INL 2013). Section 3.1.3 provides additional detail about noxious weed surveys and monitoring.

Table 2-2. List of Noxious and Invasive Weeds on the INL Site, Control Methods and Timing of Treatment.

Common Name (Scientific Name)	Difficulty of Control	Administrative Control	Mechanical Control	Best time to apply Chemical Control
Black Henbane *(Hyoscyamus niger)*	Easy	None	Pulling, digging, or mowing repeatedly	Spring
Canada Thistle *(Cirsium arvense)*	Moderate to Difficult	None	Mowing every 3-4 weeks	Spring and Fall
Field Bindweed (*Convolvulus arvensis*)	Easy	None	Tilling, every 3 weeks for 2 years.	Late Spring through Fall
Hoary Alyssum (*Berteroa incana*)	Easy	Establish healthy competitive vegetation	Pulling, digging, tilling	Spring
Spotted Knapweed (*Centaurea stoebe*)	Moderate	Establish healthy competitive vegetation	Mowing, pulling, tilling,	Spring and Fall
Russian Knapweed (*Acroptilon repens*)	Moderate			
Leafy Spurge (*Euphorbia esula)*	Moderate to Difficult	Establish healthy competitive vegetation, targeted grazing	Not recommended	When in flower
Musk Thistle (*Carduus nutans*)	Easy	Establish healthy competitive vegetation	Digging or pulling to remove root crown 2-4" beneath soil, mowing repeated every 3-4 weeks	Rosette stage
Bull Thistle (*Cirsium vulgare*)	Easy			
Scotch Thistle (*Onopordum acanthium*)	Easy			
Whitetop/Hoary Cress (*Lepidium draba*)	Moderate	Manage for grassland health	Hand-hoeing 4-week intervals	Spring
Rush Skeletonweed (*Chondrilla juncea*)	Difficult	Manage for healthy natural vegetation	Not recommended	Rosette Stage (Fall and Early Spring)
Puncture Vine (*Tribulus terrestris*)	Easy	Establish healthy competitive vegetation, 4-6" mulch	Hand-pulling, shallow tilling	Post emergence (prior to seed production)

Common Name (Scientific Name)	Difficulty of Control	Administrative Control	Mechanical Control	Best time to apply Chemical Control
Cheatgrass* (*Bromus tectorum*)	Difficult	Establish healthy competitive vegetation	Hand pull or hoe small patches	Fall to early spring
Crested Wheatgrass* (*Agropyron cristatum*)	Difficult (need to use two or more control methods)	None. Do not seed with this species.	Mowing prior to seed production (5cm or lower)	When flowering but before they go to seed (typically 8-15 cm tall)
Saltlover (*Halogeton glomeratus*)	Easy	Reduce soil disturbance and establish healthy native vegetation	Tilling and seeding with native species	Early-Summer
Russian Thistle** (*Salsola kali*)	Difficult	Reduce soil disturbance and establish healthy native vegetation	Mowing prior to seed production	Pre-emergent on bare soil (prior to seed germination) Post-emergent (early seedling stage)
Desert Alyssum (*Alyssum desertorum*)	Easy	Reduce soil disturbance and establish healthy native vegetation	Mowing prior to flowering	Late fall or early spring prior to seed production
Kochia** (*Bassia scoparia*)	Difficult	Reduce soil disturbance and establish healthy native vegetation	Light tillage when very young (fall or early spring)	As soon as temps remain above 55°F for a few days
Various Mustards (*Sisybruim* spp. And *Descurainia* spp.)	Easy	Establish healthy competitive vegetation	Mowing prior to seed production	Late fall to early spring while in rosette stage

*not on the State noxious weed list, however an invasive introduced species of concern on the INL Site.

** these species are known to develop herbicide-resistant biotypes. Avoid repeated use of a single use herbicide or herbicides that have the same mode of action.

2.3 Facilitation of Native Herbaceous Recovery

Improving recovery of native herbaceous vegetation post-fire was identified as a natural resource recovery objective for several reasons. A healthy and diverse herbaceous layer can impart resilience to a plant community, which can improve natural recovery after a disturbance like wildland fire or in response to an abiotic stressor like drought. Resistance to weed invasions and infestations is generally much better in vegetation with an abundant native perennial component, and habitat for taxa ranging from plants and invertebrates to birds and mammals is improved by a healthy herbaceous stratum. Habitat benefits of an herbaceous layer in good ecological condition can include: concealment, ameliorated microclimate conditions, improved forage, and improved prey resources.

2.3.1 Summary of Risks to Natural Resources from Poor Native Herbaceous Recovery

Herbaceous Recovery in Good Condition Plant Communities

Until the last few decades, vegetation across on the INL Site was thought to be in generally good ecological condition. Good condition sagebrush steppe plant communities are characterized by a diversity of native species and are not highly impacted by introduced grasses and forbs. They tend to be more stable in terms of total vegetative cover (Anderson and Inouye 2001) and retain spatial nutrient patterns typical of desert ecosystems (Halvorson et al. 1994). Sagebrush steppe that is in good ecological condition is resilient in response to environmental stressors and is resistant to invasion by non-natives (Chambers et al. 2014).

Although ecological condition has declined in some plant communities on the INL Site over the past ten to twenty years, native vegetation still dominates much of the area (Shive et al. 2019). Roughly 80% of the area burned by the Sheep Fire was mapped as plant communities dominated by native species prior to the fire (Table 1-1). Studies of post-fire dynamics on the INL Site and across the region indicate that except for sagebrush, post-fire species composition closely resembles pre-fire composition (Ratzlaff and Anderson 1995, Blew and Forman 2010) and communities that were in good ecological condition prior to fire will recover to good condition communities within a few years post-fire (Blew et al. 2010). For this reason, areas dominated by native species before the Sheep Fire aren't a top priority for active restoration. These areas should continue to be monitored, however, because they do have a greater abundance of non-natives and are likely not in as good of ecological condition as they were historically, leaving them at greater risk for undesirable non-natives to invade and dominate.

Potential Challenges for Herbaceous Recovery in Poor Condition Communities

Vegetation in about 20% of the area affected by the Sheep Fire was dominated by non-natives or was characterized by a shrub overstory with a degraded herbaceous stratum (Figure 2-2). Treatments to help control cheatgrass are recommended in many of these areas. In some instances, areas treated to control cheatgrass may have enough remnant perennial, herbaceous natives remaining that reducing cheatgrass abundance for a few years may allow the natives to recover sufficiently and improve the recovery trajectory of the area. Other areas, where the abundance of native species is particularly low, may require reseeding with native perennial species to improve ecological condition. Reestablishing natives in a vegetation community that is strongly dominated by invasive species is the best long-term solution for increasing the future resilience of the plant community and for improving local habitat conditions.

2.3.2 Considerations for Improving Post-Fire Recovery of Native Herbaceous Vegetation

The following components should be considered during the process of developing specific actions to help native herbaceous recovery.

Rest the Allotment Portion of the Burn Area for at Least Two Growing Seasons

The BLM administers several grazing allotments that extend onto the boundaries of the INL Site. Approximately 22,595 ac (9,144 ha) of the easternmost portion of the area affected by the Sheep Fire are in the Twin Buttes Allotment. Livestock grazing can negatively impact recovering herbaceous communities by damaging recovering herbaceous species and increasing the risk of spread and dominance of undesirable non-natives. Livestock closure of the burned area of the Twin Buttes allotment is appropriate to facilitate soil stabilization and natural vegetation recovery. BLM generally communicates closures to the affected permittees through modifications to grazing permits. The duration of the closure is at the discretion of the BLM, but locally, they often allow for at least two-post fire growing seasons, or until recovery objectives for the area have been met (see Section 3.3.1 for a general discussion of recovery objectives). Although the Wildland Fire Management Committee doesn't have authority over BLM grazing policy, they may consider allotment rest while planning other restoration strategies. For example, grazing exclusion will be important to allow for vegetation establishment in areas that have been seeded.

Identify Locations of Potentially Poor Native Herbaceous Recovery

Some of the areas at high risk for cheatgrass dominance are also likely at risk for poor native herbaceous recovery (see Section 2.2.2 for a discussion of areas at risk for cheatgrass dominance). As part of an integrated post-fire recovery plan for the Sheep Fire, prioritization of areas for planting native, herbaceous species should begin by identifying areas already known to have degraded understories prior to the fire through the most recent mapping effort (Figure 2-2). These areas should be visited and evaluated to verify that current conditions still justify planting. Areas that would be considered optimal for planting retain few native herbaceous species; natives would generally contribute far less than half of the total cover of the vascular vegetation. Areas where soils are not conducive to planting and the probability of successful establishment is low should be deprioritized. If cheatgrass is dominant in the area, it should be treated prior to planting (see Section 2.2.2). Some areas with high cheatgrass abundance may retain enough native species that cheatgrass control alone will boost native recovery. Mechanical planting of these areas is not advised as it may damage root systems of recovering plants; however, they should be monitored for changes in condition (see Section 3.1.2 for monitoring guidance).

Plant Native Perennial Grasses in Areas with Poor Native Recovery

Areas that have been evaluated and determined to be a high priority for planting should first be treated for cheatgrass, if applicable, and then planted with a native grass mix. Revegetation should be implemented according to the INL Revegetation Guide (INL 2012). Appropriate planting techniques may include using a mechanical drill, broadcasting, or broadcasting followed by imprinting with a roller. A combination of the native grasses provided in Table 2-1 is suitable for most locations within the Sheep Fire. Additional treatments like fertilizer, mulch, and supplemental water may help increase the success of the planting. The highest priority areas should be planted in October of 2020. Areas that have been planted should be monitored for several years; however, it can take a few years for a planting to show progress, so the decision to replant should be delayed long enough to determine that it is indeed necessary (see Section 3.1.2 for monitoring guidance).

2.4 Sagebrush Habitat Restoration

Sagebrush is an essential component of the cold desert ecosystem of the Upper Snake River Plain, which makes hastening its return after a wildland fire a valuable natural resource recovery objective. Big sagebrush has been described as a foundation species, or a species that has disproportionate influence on other species and provides stabilizing effects on ecosystem processes (Prevey et al. 2010). Following wildland fire, sagebrush does not resprout; it must reestablish from seed. It can take from 50 to 120 years for it to return to pre-burn cover levels (Baker 2006). Seed availability is generally considered a limiting factor for recovery (Young and Evans 1989, Meyer 1994) and unfavorable microclimatic conditions may be a primary factor constraining natural sagebrush reestablishment on the INL Site (Forman et al. 2013). Overcoming these limitations to natural recovery by implementing assisted recovery techniques may be necessary to address the large tracts of sagebrush habitat lost to wildland fire on the INL Site over the past 25 years.

2.4.1 Summary of Risks to Natural Resources from Sagebrush Habitat Loss

Loss and Fragmentation of Sagebrush Habitat

In the arid west, food, cover and water resources are distributed unequally across the landscape. This is a primary characteristic of sagebrush steppe where many obligate species have evolved to require very large areas of intact habitat to meet their seasonal and annual resource needs. The loss of sagebrush habitats can have an acute impact on wildlife. There are hundreds of birds, mammals, reptiles and amphibians that depend on sagebrush as well as many unique insects, spiders, plants and lichens that are closely associated with the sagebrush community and utilize it in a variety of ways during various seasons. Species such as sage-grouse and pygmy rabbit depend on relatively large expanses of sagebrush-dominated shrub steppe and are entirely dependent on sagebrush habitats for successful reproduction and winter survival (Connelly et al. 2004). Songbirds rely on it for nesting and escape cover, and various small mammals use it as shelter and travel corridors.

The INL Site is a critical breeding bird area, primarily due to the large amounts of undisturbed sagebrush communities (National Audubon Society 2013). The Site has long been known as a vital area for several sagebrush obligate species such as the sage-grouse, sagebrush sparrow, sage thrasher, Brewer's sparrow and pronghorn antelope. Big sagebrush is one of the most important vegetation communities on the INL Site and is recognized as the major component of sagebrush habitat for greater sage-grouse described in the CCA (DOE and USFWS 2014).

Habitat fragmentation refers to the breaking apart of a large expanse of continuous habitat into smaller distinct patches, isolated from each other by a matrix of habitats unlike the original (Wilcove et al. 1986), resulting in the decrease in the amount of habitat, increase in the number of habitat patches, decrease in the size of habitat patches and increase in isolation of patches (Fahrig 2003). Habitat fragmentation can also alter the natural disturbance regimes and the function of ecosystems (Caling and Adams 1999). When combined, these impacts can have detrimental effects on the distribution and abundance of individual species (Saunders et al. 1991) especially those who are considered habitat obligate species (Braun et al. 1976; Rotenberry and Wiens 1980).

When sagebrush steppe habitats are fragmented from fire, road creation, livestock grazing, agriculture, urban development or other methods, populations of sagebrush obligate species decline due to the reduction of suitable habitat (Temple and Cary 1988) or because of lower reproduction or higher mortality in remaining habitats (Porneluzi et al. 1993). Other effects of habitat fragmentation that lead to species declines after habitats are fragmented include changes in microclimates (e.g., light, temperature, wind, humidity; [Reed et al. 1996; Shelhas and Greenberg 1996; Ewers and Banks-Leite 2013]) and an increase of edge effects such as predation (Chalfoun et al. 2002), or brood parasitism (Belthoff and Rideout 2000).

For some species, habitat fragmentation isolates or separates populations as they refuse or are unable to cross barriers such as roads or containment lines. A network of roads or containment lines fragments the population even further than the actual loss of habitat (Noss 1996). For example, fragmentation of sagebrush communities poses a threat to populations of pygmy rabbits because pygmy rabbits are reluctant to cross areas where sagebrush is removed or between sagebrush areas that are bisected by a road (Lawes et al. 2012). Maintaining large, uninterrupted tracts of sagebrush habitat is critically important for so many species and is the reason sagebrush habitat restoration is becoming an important post-fire consideration across the West and on the INL Site.

Challenges Associated with Sagebrush Restoration

Restoration of native plant communities, particularly sagebrush steppe, can be difficult under even ideal conditions, but the harsh climate of the arid high desert in the intermountain west poses additional challenges. Sagebrush communities are particularly low in moisture, have numerous invasive species that exploit local conditions, may be difficult to access, have low/poor soil nutrition, and may be subject to several additional conditions that vary spatially and temporally (i.e., grazing, wind, etc.). There are a number of approaches for reestablishing sagebrush, but success is variable and is often dependent of factors outside of human control. The primary factor regulating the potential success of sagebrush restoration is the timing and amount of precipitation. Some options for sagebrush revegetation include aerial application of seed, hand distribution of seed, use of a rangeland drill to plant seed, and manually planting seedlings. Each method may be successful; however, success is consistently greater with locally collected seed.

Deploying well-adapted and ecologically appropriate plant materials is a core component of successful restoration projects (Bower et al. 2014). Collecting locally adapted seed can substantially increase the long-term success of a planting. Identifying appropriate seed consists of more than finding the same subspecies and may be more specific than finding seed from the same provisional seed zone (Bower et al. 2014). Seed and seedlings from climate zones inconsistent with the restoration area may result in shrubs that appear similar to local stock at the beginning of a planting but deteriorate in condition or fail to continue reproducing over time. Survival of plant material derived from colder sites is generally better than survival of plant material derived from warmer sites (Chaney et al. 2017). However, common garden studies show that the greatest survival occurs with plants from locally collected seed, where temperature and aridity are similar (Germino et al. 2019).

Planting seedlings, rather than drilling or broadcasting sagebrush seeds is typically more successful because seed germination and establishment are dependent on specific weather events, including timing and amount of precipitation and microtopography of the planting location (Young et al. 1990, Boudell et al. 2002). The suite of environmental conditions that can facilitate successful germination of seed and establishment of new plants fluctuates from year to year (Colket 2003; Forman et al. 2013), and in many years, few or no seeds may germinate and survive the summer (Brabec et al. 2015). Survivorship of seedlings is consistently higher than seeding options as plants already have a root mass and can reasonably survive more adverse conditions. The primary drawback of planting seedlings is the limited amount of area that can be covered. Much larger extents can be addressed with seeding, and aerial seeding in particular. Although a review of sagebrush seeding efforts across the Great Basin indicated relatively low success rates (Lysne 2004), seeding success may be improved by considering several landscape variables in the restoration strategy (Germino et al. 2018).

Studies from the INL Site do not provide any evidence for competitive exclusion of sagebrush by native, perennial grasses (Anderson and Inouye 2001) and sagebrush were found to germinate in mature stands nearly every year, even with a robust herbaceous layer (Forman et al. 2013). However, some restoration literature suggests that established herbaceous communities could limit sagebrush establishment from seed (Schuman et al. 1998) and this concern should be considered in determining which planting technique to use at various stages of restoration. Aerial seeding or seeding with a rangeland drill may be more successful immediately post-fire, especially during the first growing season when the ground is mostly bare and soil to seed contact would be greatest. Seeding using a rangeland drill may also be less damaging to existing plants prior to the first growing season, but soil disturbance may also increase the risk of infestations of non-native species.

2.4.2 Considerations for Improving Post-Fire Recovery of Sagebrush Habitat

The following components should be considered during the process of developing specific actions for addressing sagebrush habitat restoration.

Prioritize Areas that Would Benefit from Planting Sagebrush

Locations impacted by the Sheep Fire which have the greatest potential to return to sagebrush habitat should be considered a priority for planting. Areas most desirable for sagebrush planting consist of perennial grasslands and green rabbitbrush shrublands that were previously known to contain sagebrush habitat, and where noxious or invasive vegetative species have not become established. Vegetative areas that are not likely to transition or recover to sagebrush habitat (e.g., salt desert shrub), non-native grasslands or areas mapped as degraded should not be considered until the poor condition of those sites has been addressed. Priority should be given to areas within 5 km of a sage-grouse lek that will increase nesting habitat, and which can be easily accessed without damage to surviving native, perennial vegetation or culturally sensitive resources. Future land use plans for the INL Site should be considered so that sagebrush isn't planted in an area designated for development (INL 2016) and unexploded ordnance restricted areas or culturally sensitive areas should also be avoided.

Sagebrush habitat restoration is one way that DOE can avoid tripping a sage-grouse habitat trigger or is an approach that can be used as mitigation once a trigger is tripped. In 2014, DOE identified an area of the INL Site that incorporated most of the active sage-grouse leks, including a 1 km (0.6 mi) radius around each to protect nesting habitat, and established a SGCA (DOE and USFWS 2014). Due to the importance of the SGCA for nesting sage-grouse and other sagebrush obligates, areas within the SGCA have been identified and prioritized for yearly planting of sagebrush seedlings. In response to wildland fire, priority restoration areas from within the SGCA can also be used to target appropriate sagebrush planting sites.

Evaluate Planting Options

To increase the likelihood of success for sagebrush planting, multiple planting techniques should be considered, and some techniques may be more useful at certain times in post-fire recovery than others. For the Sheep Fire, aerial seeding may be appropriate immediately post-fire and seedlings grown from container stock may be more effective in subsequent years. Seed is typically applied on snow using a helicopter in January or February and could be applied as early as the first winter post-fire. Seedlings must be grown in the greenhouse as bareroot or container stock. Container stock have generally been found to survive well on the INL Site (Shurtliff et al. 2019), but the earliest optimal planting window for seedlings that have been grown post-fire is in October after the first post-fire growing season.

Mechanical seeding or broadcast seeding may be viable options, but both tend to be more successful when seed is pressed into the ground for better contact. Seeding with a rangeland drill should be restricted to areas where native herbaceous recovery is poor to avoid damaging recovering grasses and forbs. Aerial and mechanical seeding can both feasibly cover much larger areas than seedlings, but they require much more seed and establishment is typically lower. Any seeding that requires off-road travel, especially with a tractor, rangeland drill, or roller should be reviewed by the CRMO during project planning.

Coordinate a Local Seed Collection Effort

The INL Wildland Fire Management EA (DOE 2003) and the INL Revegetation Guide (INL 2012) both encourage using locally adapted seed for sagebrush reestablishment. Short-term germination and establishment, and long-term viability are both typically greater for seed that is genetically like stands lost in a wildland fire (Meyer and Monson 1992; Germino et al. 2019). Options for collecting local sagebrush seed may include using available internal resources, coordinating an outreach program, or tasking a commercial vendor. If the amount of seed necessary to support sagebrush planting is limited to approximately 200 lbs. bulk or less, INL or Environmental Surveillance, Education and Research (ESER) programs could collect seed and have it processed at the U.S. Forest Service Region 6 Seed Extractory.

If larger amounts of seed are required, as with aerial seeding, INL could engage local outreach service programs like the Master Naturalists or Idaho Fish and Game volunteers to coordinate a seed collection effort. Several commercial seed vendors will also perform custom seed collections at specified locations. These latter two options may be more logistically feasible on BLM lands adjacent to the Site but will require applying for a BLM seed collection permit. Sagebrush seed ripens in late-October to early-

November in the Upper Snake River Plain, so local seed collections would have to be planned within a few months post-fire for seed or seedlings to be planted the next year. Seed should be collected for as many years as necessary to meet natural resource recovery objectives.

Locate Available Seed that May be Appropriate for Use on the INL Site

Local seed collections may not be feasible in the seed-ripening timeframe (late-October to early-November) following the Sheep Fire. Alternative options may include sourcing seed available from commercial vendors or coordinating seed acquisition through the BLM seed warehouse. Several commercial vendors stock sagebrush seed from previous years' collections. There can be a lot of variability in seed quality among vendors and these differences are often related to the cleaning and storage processes for sagebrush seed. Care should be taken to select a vendor who is cleaning and storing seed appropriately to increase the likelihood that seeds acquired through that vendor have relatively high purity and good viability.

Many of the same vendors also supply seed to the BLM seed warehouse and DOE may be able to purchase seed from the warehouse. Seed from the warehouse is typically well-documented in terms of source location and must meet minimum purity standards. Seed acquired from the warehouse should be selected from collections as close to the INL Site as possible. At a minimum, seed should come from the same provisional seed zone as the INL Site, as seed from sites with similar temperature regimes and aridity should perform better than seed from elsewhere. Seed begins to lose viability as it ages, so seed should be no more than two seasons old for optimal germination and establishment.

Aerially Plant Sagebrush Seed in High Priority Areas

DOE and agency partners decided to pursue aerial seeding on portions on the Sheep Fire during the winter of 2019/2020. Two areas within the footprint of Sheep Fire were proposed for aerial sagebrush seeding. The area identified to be the highest priority was 12,521 ac (5,067 ha) within the SGCA (Figure 2.-3). A second area, which is 11,828 ac (4,787 ha) and is outside of, but adjacent to the SGCA was also selected for seeding These areas have been identified as having a good potential for providing seasonal habitat for sagebrush obligates and, given recent telemetry data from other agencies, could provide critical wintering habitat for sage-grouse lekking north of the INL Site.

DOE, the Idaho Fish and Game Department, the Idaho Office of Species Conservation, and the USFWS purchased approximately 8,000 lbs. (3,629 kg) of bulk sagebrush seed from the BLM seed warehouse. In addition to coordinating the seed purchase, BLM provided an additional 1,600 lbs. (726 kg) of seed at no cost to DOE through an excess property transfer. The seed will be applied aerially with a helicopter in January or February of 2020; the exact timing will be dependent on weather conditions. Optimally, sagebrush seed is applied on fresh snow, but conditions must also allow for safe operation of the aircraft. The target planting area will be seeded in strips so that about ¼ of the total acreage, or about 6,260 ac (2,533 ha) is seeded. All operations associated with the aerial seeding effort will be required to be compliant with DOE, INL, and ESER aviation procedures, including health and safety requirements, and overflight notifications. The aerial seedings should be monitored for sagebrush establishment (see Section 3.2.1 for monitoring guidance). If seedings are not meeting recovery objectives, they could be reseeded, or other approaches to reestablishing sagebrush, like planting seedlings could be considered.

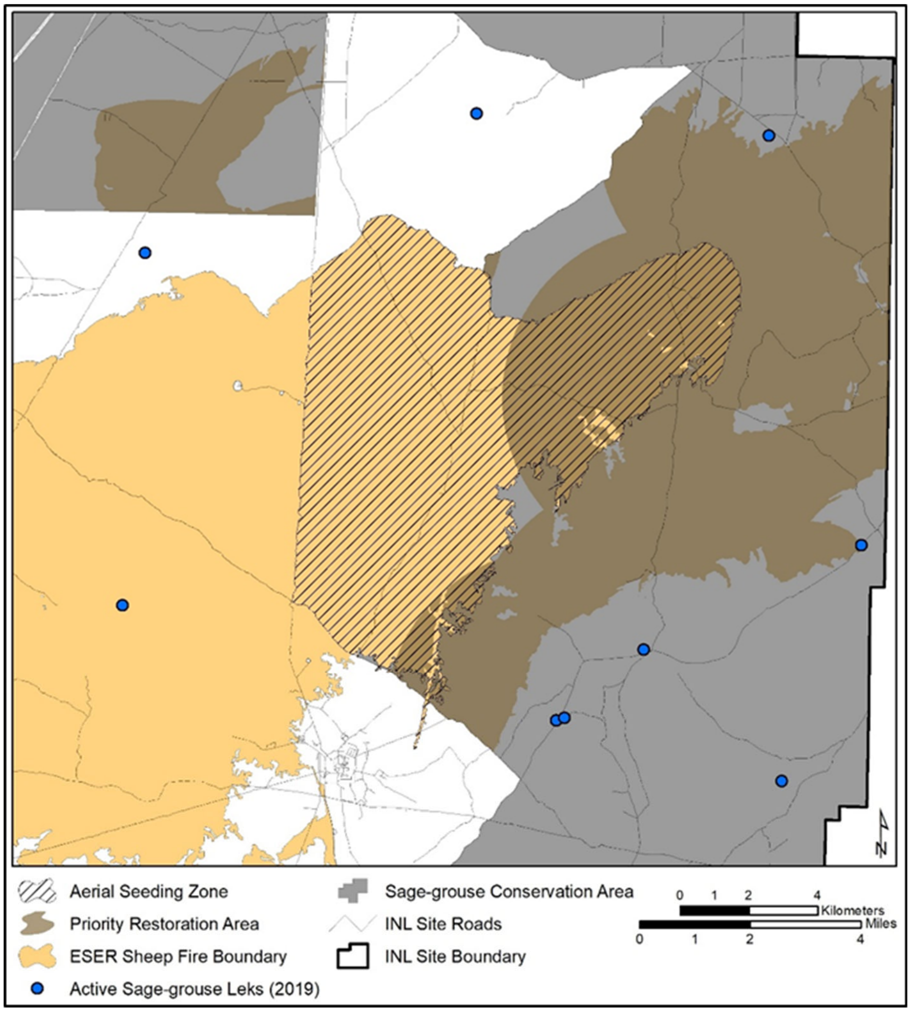

Figure 2-3. Proposed aerial sagebrush seeding zone within the 2019 Sheep Fire on the Idaho National Laboratory Site.

Plant Sagebrush Seedlings Strategically to Address Specific Areas Where Accelerated Recovery Would be Beneficial to Habitat Recovery

While the potential success of sagebrush seedings may be highly variable and difficult to predict from one year to another, results of planting sagebrush seedlings are more consistent and reliable. Installation of healthy seedlings may also reduce the recovery time for sagebrush in the areas they are planted. Seedling plantings require less sagebrush seed, but involve more labor and specialized greenhouse facilities, which also make them more expensive than aerial or mechanical seeding. For this reason, seedlings should be considered an integral part of the Sheep Fire sagebrush recovery strategy, but they should be placed strategically where they can provide the greatest habitat benefit. Seedlings should be used where they can improve high priority habitat and/or habitat connectivity; the CCA for sage-grouse (DOE 2014) provides additional information about how these areas may be identified and prioritized. They should also be considered in areas where risk of poor natural recovery is high and where conditions are unfavorable for sagebrush establishment from seed.

There are several regional greenhouses that specialize in growing sagebrush seedlings. Ideally, the grower would be provided with seed collected from the INL Site. The ESER Program has some local seed available for growing seedlings; it is currently stored with U.S. Forest Service Region 6 Seed

Extractory. Alternately seed could be procured from a commercial vendor or directly from a native greenhouse, based on the stock they have available. As discussed above, the more local the seed source, the greater likelihood of long-term sagebrush establishment and persistence. If local seed is used, seedlings should be ordered during the late-winter to early-spring of 2020 and the resulting seedlings should be planted in October. A subset of high priority areas could be planted every year until those priority restoration areas best suited to seedling plantings have been addressed. Monitoring of seedling survivorship would help verify that the seed, greenhouse, and planting techniques used are effective (see Section 3.2.1 for monitoring guidance).

3.0 MONITORING

Effective monitoring plans are those that establish a process to collect, analyze, and use data to track the status of the natural resources of interest and the effectiveness of any implemented actions. This two-pronged approach allows a project team to answer two fundamental questions:

1) are natural resource recovery objectives being met through natural recovery processes, and

2) if actions are taken to assist natural recovery processes, are the actions effective?

If a project team regularly collects and evaluates data designed to answer these two questions, it will be well-positioned to quickly adjust its approach if results do not occur as expected, which is the foundation for adaptive management.

The first step to developing a targeted and cost-effective monitoring plan is to clearly outline how recovery status and treatment effectiveness will be defined and how adaptive management principles will be applied in response to deviations from recovery objectives. Potential monitoring approaches will then be addressed in two sections, one for assessing areas at risk of poor natural recovery, and one for evaluating efficacy of treatments in areas that have received active restoration.

3.1 Measures of Success and Adaptive Management Responses

3.1.1 Benchmarks Against Which to Evaluate Success

The primary purpose of monitoring is to detect measurable changes in condition and progress towards meeting clearly defined natural resource management objectives. Before determining if assisted recovery is required and prior to initiating a treatment, a project team should outline its assumptions about what a successful outcome would look like. This outline should include defining measurable benchmarks and expected timeframes so the project team and other stakeholders will have a realistic understanding of when they can expect to see short- and long-term results. The benchmarks defined in a monitoring plan should be realistic, logical, and simple as these benchmarks will ultimately help guide decisions about whether further treatment should be considered.

Many agencies use a benchmark for native, perennial herbaceous vegetation of 70% of pre-fire or reference site cover. In other words, if the cover of native herbaceous species at the location of consideration is at least 70% of the pre-fire cover of those species, the benchmark for the site has been met, and no further action is required. A common benchmark for cheatgrass is that it remains lower than pre-fire cover, and the benchmark for noxious weeds is typically that they are no longer detectable in regular surveys. Benchmarks for aerial sagebrush plantings are often a certain number of established seedlings per unit area and a common benchmark for sagebrush seedling planting is at least 50% survival.

3.1.2 Adaptive Management Responses

Ecological communities are complex, and natural resource professionals often face uncertainties about which strategies will best contribute to achieving restoration goals following a large disruptive event such as wildfire. An adaptive management framework is a common, practical methodology that can be applied to post-fire recovery to determine if a restoration action is necessary to meet natural resource recovery goals. If an action is taken, adaptive management can also be used to address uncertainty associated with potential outcomes of a strategy or to adjust a strategy if it is not meeting restoration goals.

The first step in adaptive management is to identify the restoration issues and summarize the current knowledge base (Rist et al. 2013). Section 2.0 provides this information and offers the Wildland Fire Management Committee multiple considerations that can be used, either individually or as a combination to achieve the desired objectives or goals. Systematic monitoring is also a key feature of any adaptive management framework (Meretsky and Fischman 2014). To determine whether the condition of a specific area warrants active restoration and to determine the success of any post-fire restoration actions, monitoring should be conducted, and results compared to predetermined benchmarks, as discussed above. Monitoring results should be used to regularly assess whether recovery goals are being met within the expected timeframe and to adjust actions and expectations accordingly.

3.2 Areas at Risk of Not Recovering Naturally

3.2.1 Cheatgrass Monitoring with Imagery

Cheatgrass monitoring should begin in areas at risk of becoming dominated during the first growing season post-fire such as the approximately 10,700 ac (4,300 ha) that were dominated by cheatgrass before the Sheep Fire. Monitoring should continue for several years, as post-fire cheatgrass response has been shown to be delayed in some vegetation types on the INL Site. Cheatgrass has a unique spectral response pattern throughout the growing season that allows it to be detected in imagery easier than most native grasses. This species produces considerable above-ground biomass early in the season before most native species, and then abruptly senesces where it appears reddish-purple while most native species are still green. The distinct visual difference between cheatgrass and native grasses makes it a good candidate to be monitored with remote sensing imaging technology.

Remote sensing technology has the advantage of more efficiently monitoring large areas where traditional ground-based surveys would require much greater effort and cost. One consideration for image acquisition is whether to use satellite-based sensors or airborne sensors to collect imagery for monitoring purposes. Satellite sensors acquire imagery on a fixed return cycle of varying intervals. Because satellites are constrained to acquiring images within specific windows, the flexibility to task a sensor for unplanned data collection may be limited, or the cost associated with tasking a sensor may increase the overall cost of imagery. In the case of the Sheep Fire, post-fire assessments were completed using high resolution commercial satellite imagery and similar imagery would be also appropriate for cheatgrass monitoring.

Airborne sensors have the flexibility to fly on specific days and to avoid cloud cover by postponing flights until appropriate conditions occur. Commercial airborne acquisitions require advance notice for project/flight planning, and costs can increase substantially based on the number of standby days, which are dependent on weather conditions. The INL Site has access to airborne drones with imaging capabilities that can take advantage of deployment flexibility while largely eliminating the standby and ferrying costs for fixed-wing airborne data collections. There are also statewide aerial acquisitions collected periodically through the U.S. Department of Agriculture's National Agricultural Imaging Program.

The National Agricultural Imaging Program collects high resolution, multispectral imagery across the State of Idaho every two years and has been used to produce the two most recent vegetation maps for the INL Site. The data are collected over a period of weeks, depending on weather conditions, during the late summer. The imagery is then provided to the public at no cost, typically the following late winter/early spring. National Agricultural Imaging Program imagery could be used to support post-fire restoration monitoring depending on the monitoring goals, the timing of imagery required to address those goals, and the accuracy required.

Each of the imagery options would require some effort by a remote sensing/GIS analyst to analyze and process the data to assess cheatgrass status and inform treatment prioritization. Manual delineations in a GIS can provide the most spatially accurate results, however this method is influenced by the experience of the GIS analyst and can take more processing time than automated methods. Because cheatgrass has a unique spectral signature, automated methods, such as supervised image classification, could also be successful minimizing the time an analyst needs to process imagery and provides an unbiased repeatable method for continued monitoring through time.

3.2.2 Cheatgrass and Native Herbaceous Monitoring with Rapid Assessment Techniques

Field-based rapid assessment techniques provide simple field methods that collect useful data on measurable vegetation attributes to evaluate specific areas. While remote sensing techniques can provide a great overview of cheatgrass status across the entire area affected by the Sheep Fire, finer-scale data will be required to evaluate the need for treatment at specific locations. Areas of poor native herbaceous recovery aren't as readily identified in imagery, so field-based techniques will be required to determine if planting is warranted in those at-risk locations as well.

Qualitative plot assessments are techniques designed to evaluate the remaining plant community composition to identify changes in cheatgrass or native component abundance in the herbaceous stratum. Methods appropriate for monitoring cheatgrass and native herbaceous species include photoplots combined with density frames, basic species lists, and a quick ocular estimate for rank abundance of species on a set scale. Implementing a monitoring plan targeting cheatgrass changes and poor native recovery should begin summer of 2020 and supported annually if pre-defined recovery objectives are not being met. If available, pre-fire data documenting herbaceous conditions are useful to establish a baseline or known levels of herbaceous composition to assist in meeting certain recovery objectives. If cheatgrass begins to dominate the herbaceous stratum, herbicide treatment may be indicated. If native species decline, planting may be necessary.

3.2.3 Noxious Weed Surveys

Surveys should be routinely conducted within areas impacted by the Sheep Fire to determine the presence, relative abundance and distribution of noxious weeds or invasive introduced species of concern. Priority for noxious weed surveys should be directed toward containment lines and those surveys should begin during the fall of 2019; the rest of the burned area should be surveyed beginning late spring of 2020. Ground-based survey methods are most effective and should be conducted when plants are flowering. However, not all species flower at the same time; therefore, multiple surveys may be required for effective control. Ground-based weed surveys consist of traveling through an area on foot, ATV, or other vehicle and recording findings on a standardized form, topographic map or aerial photo, and GPS unit. Data to be collected should include:

- Observation Date
- Species name (Scientific and Common)
- GPS location (point)
- GPS the area of the infestation (polygon)
- Density or Abundance
- Photographs of plant to help with proper identification and
- Photographs of the landscape to show abundance

3.3 Efficacy of Planting and/or Herbicide Treatment

3.3.1 Rapid Assessment Techniques for Treatment Monitoring

This plan contains several treatment options for meeting natural resource recovery objectives after the Sheep Fire. Many of the treatment options discussed above include application of chemical herbicides for cheatgrass or noxious weed control and planting native herbaceous species or sagebrush. An effective approach to adaptive management requires monitoring of these treatments to determine whether they were effective, if they should be repeated, or if an alternate approach to meet recovery objectives should be considered. Potential monitoring approaches to the most frequently discussed treatments are included here.

Native Grass Recovery on Containment Lines
After containment lines have been reseeded with a native grass mix, it is appropriate to begin monitoring the results of the reseeding effort after the first growing season. The use of field-based rapid assessment techniques supports monitoring methods that are simple and easy to employ in the field. Native grass recovery on containment lines should be monitored by appropriate methods to evaluate changes in the plant composition to meet recovery objectives. Suggested methods include photoplots, abundance ranking, presence/absence of species of interest, density frames, and a basic species list. Before work begins, a baseline should be established against which to measure change within vegetation composition as it may take several years for native grasses to meet recovery objectives.

Cheatgrass Abundance in Areas Treated with Chemical Herbicide
Once a treatment is prescribed to control cheatgrass, the next consideration is to select an appropriate monitoring plan to determine whether restoration or control actions are having any measurable effect on reducing cheatgrass density and distribution. To determine whether the spatial extent of cheatgrass dominated areas has been reduced in response to treatment, remote sensing techniques as described above may be employed.

To determine whether treatments have improved vegetation composition at a specific location, field-based rapid assessments should be able to detect directional changes of cheatgrass abundance before and after treatments. Generally, a combination of multiple methods is appropriate for monitoring cheatgrass including photoplots combined with density frames, point intercepts, species lists, and rank abundance. Quantitative data from permanent plots already located in the area may provide absolute cover estimates to reasonably infer directional changes in cheatgrass abundance before and after treatments. An effective cheatgrass treatment monitoring plan should incorporate reasonable replication over an adequate spatial distribution to be able to interpret treatment results confidently within the context of the natural resource recovery objectives.

Sagebrush Establishment in Seeded Areas

A monitoring approach for the aerial seeding effort should include subsampling of an adequate number of locations within seeded strips beginning late-summer of 2020. Much of the initial mortality of seedlings would be expected during the first growing season, so monitoring later in the season will provide a more realistic approximation of initial establishment. Rapid assessments techniques can be used to efficiently estimate sagebrush establishment in seeded areas. Subsample location, plot size, and shape should be considered for best estimating sagebrush establishment. Spatial distribution is also an important consideration for evaluating progress toward natural resource recovery objectives as seeding in some areas may be more successful than others. A monitoring approach for measuring sagebrush planting outcomes may include photo plots, presence/absence detection, or density frames to estimate seedling abundance. Results of seedling establishment monitoring should inform a decision about further restoration efforts as prescribed through an adaptive management framework.

Sagebrush Survivorship in Areas Planted with Seedlings

Seedling plantings are often easiest to assess during the fall and because most of the expected mortality occurs during the first growing season, the most appropriate time to monitor sagebrush seedling survivorship is about one year after planting. Field-based assessments provide an efficient and straightforward option for describing overall sagebrush seedling condition and estimating survivorship. The method currently used for seedling monitoring on the INL Site involves marking a subset of seedlings as they are planted with a sub-meter GPS receiver. The following year, seedling GPS coordinates are relocated, and an observer collects data based on a ranking system to assess seedling vigor. Based on the data, a relative estimate of seedling survivorship can be obtained quickly with minimal effort. The acceptable survivorship results for the sagebrush seedling planting effort, with respect to natural resource recovery objectives should be evaluated against a defined benchmark.

4.0 COST ESTIMATE

The cost table contains coarse cost estimates based on industry average costs for various treatments. It is only intended to provide the Wildland Fire Management Committee a starting point for discussions about how to prioritize the various natural resource recovery options provided in the plan. At the time the plan was finalized, costs were unknown for several line items, especially those with associated with INL contractor labor. The amount of area estimated for treatments were based on arbitrary assumptions for most treatment options, and in many cases represent the minimum amount of area that should receive treatment. The actual amount of area to be treated should be based on the treatment prioritization efforts developed by the Wildland Fire Management Committee based on the information provided in the recovery plan. Because the cost table provides a high-level estimate, administrative and project management costs have not been included. Additional costs associated with NEPA analysis, cultural resource surveys, UXO clearance, or similar associated tasks have not been included. Assumptions about treatment areas and cost calculations are noted below the cost table.

Objective	Action Description			FY19		FY20		FY21		FY22		FY23		
		Unit Type	Unit Cost	QTY	Cost	QTY	Cost	QTY	Cost	QTY	Cost	QTY	Cost	Total Cost
2.1 Soil Stabilization	Native Grass Seed	acres	$171.00	120	$20,520.00									$20,520.00
	Plant Containment Lines	acres	Unknown											$0.00
	Plant Powerline Disturbance	acres	Unknown											$0.00
	Sign Containment Lines	signs	Unknown											$0.00
	Cheatgrass/Noxious Weed Herbicide	gallons	$1,220.00	2.8	$3,416.00									$3,416.00
	Spray Containment Lines	acres	$14.00	60	$840.00									$840.00
	Total				$24,776.00		0		0		0		0	**$24,776.00**
2.2 Weed Control	Cheatgrass Treatment Herbicide	gallons	$1,220.00			94	$114,680.00	94	$114,680.00	94	$114,680.00			$344,040.00
	Cheatgrass Treatment Application	acres	$14.00			2000	$28,000.00	2000	$28,000.00	2000	$28,000.00			$84,000.00
	Noxious Weed Treatment Herbicide	gallons	$150.00			109	$16,350.00	109	$16,350.00	109	$16,350.00			$49,050.00
	Noxious Weed Survey/Treatment	acres	$5.00			99839	$499,195.00							$499,195.00
	Total				0		$658,225.00		$159,030.00		$159,030.00		0	**$976,285.00**
2.3 Native Herbaceous	Native Grass Seed	acres	$171.00					1000	$171,000.00	1000	$171,000.00	1000	$171,000.00	$513,000.00
	Plant Poorly Recovering Areas	acres	Unknown											
	Total				0		0		$171,000.00		$171,000.00		$171,000.00	**$513,000.00**
2.4 Sagebrush Habitat	Collect Local Seed	bulk lbs	$18.00			8000	$144,000.00	200	$3,600.00	200	$3,600.00	200	$3,600.00	$154,800.00
	Aerial Seeding	acres	$5.50			6260	$34,430.00							$34,430.00
	Seedling Planting	seedlings	$1.50					150000	$225,000.00	150000	$225,000.00	150000	$225,000.00	$675,000.00
	Total				0		$178,430.00		$228,600.00		$228,600.00		$228,600.00	**$864,230.00**
3.0 Monitoring	Cheatgrass Imagery	acres	$0.32					20000	$6,400.00	20000	$6,400.00	20000	$6,400.00	$19,200.00
	Survey Labor	hours	$20.00			480	$9,600.00	640	$12,800.00	640	$12,800.00	640	$12,800.00	$48,000.00
	Survey Equipment/Supplies	total	$2,000.00			1	$2,000.00	0	$0.00	0	$0.00	0	$0.00	$2,000.00
	Survey Mileage	miles	$0.58			1656	$952.20	2208	$1,269.60	2208	$1,269.60	2208	$1,269.60	$4,761.00
	Report Labor	hours	$40.00			120	$4,800.00	160	$6,400.00	160	$6,400.00	160	$6,400.00	$24,000.00
	Total				0		$17,352.20		$26,869.60		$26,869.60		$26,869.60	**$97,961.00**
Total Annual					**$24,776.00**		**$854,007.20**		**$585,499.60**		**$585,499.60**		**$426,469.60**	**$2,476,252.00**

- Seed costs for planting native grass seed is for drill seeding, for broadcast seeding estimated seed cost is $257/ac.
- Costs for chemical herbicide are based on using Indaziflam for cheatgrass control (approximately 6 oz/ac) and Imazapic for noxious weed control (approximately 7 oz/ac).
- Area disturbed by firefighting activities was estimated using 80 mi of containment line with a 12 ft dozer width; the 11 ac associated with staging was also included.
- All the disturbed acreage was included in the estimate for planting with native grass seed.
- About half of the total area of disturbance was assumed to require weed control, primarily for cheatgrass.
- Within the burned area, a total of approximately 18,000 ac are at risk for cheatgrass dominance; the cost estimate assumes only about 2,000 ac will be prioritized for herbicide treatment in each of three consecutive years.
- The assumption for prioritization of replanting native grasses in this cost estimate is 1,000 ac a year in each of three consecutive years.
- The cost estimate associated with the aerial seeding effort includes planting a 25,000 ac prioritized area with 0.5 lbs of pure live seed per acre with strip seeding at a coverage of about ¼ of the total area.
- The cost estimate for sagebrush seedling costs is based on planting 150 seedling/ac across 1,000 ac in each of three consecutive years.
- The estimate for imagery to support cheatgrass monitoring is based on using a satellite-based sensor similar to that which was used for the initial post-fire imagery collection and only includes imaging a subset of the burned area in each of three consecutive years.

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