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Hanford Site Post-Fire Vegetation Monitoring Report for Calendar Year 2023

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract 89303320DEM000031

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Hanford Site Post-Fire Vegetation Monitoring Report for Calendar Year 2023

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1.0 Introduction

The Hanford Site is comprised of an expanse of shrub-steppe habitats that provide exceptional value to plants and animals located on the Hanford Site and in the surrounding greater Columbia Basin. The greatest threat to this habitat is fire-related conversion to a cheatgrass-dominated monoculture. To decrease future fire risk and to disrupt the positive feedback cycle between cheatgrass and fire, land managers can make efforts to restore native vegetation following a fire. The goal of this report is to summarize fires and fire monitoring efforts that occurred in 2023 and analyze vegetation recovery post-fire in both restored and unrestored areas to inform future post-fire response actions.

1.1 Background

The Hanford Site consists of 1,425 km^2 (550 mi^2) of land that has been closed to the public since the 1940s. Though sections of the Hanford Site have been developed, it contains one of the last remaining continuous stretches of shrub-steppe in the Columbia Basin. This stretch of land provides habitat for endangered, threatened, and rare species of plants and animals, and acts as a refuge for species that rely on shrub steppe to survive. Though the habitat on the Hanford Site is not heavily threatened by development like other areas of the Columbia Basin, fire presents a threat to the integrity of the ecosystem. As fires become more frequent and intense in shrub-steppe areas, planning post-fire restoration and monitoring has increased in importance and is a crucial management tool in retaining shrub-steppe ecosystems.

High-quality sagebrush (*Artemisia tridentata*) communities have a perennial herbaceous understory, typically bunchgrass species such as bluebunch wheatgrass (*Psuedoroegnaria spicata*) and needle-and-thread grass *(Hesperostipa comata*) (HNF-61417). Spacing between individual perennial bunchgrasses creates gaps in fuel availability that reduce fire efficiency and prevent fires from spreading over large areas (Whisenant 1990). The extent of high-quality sagebrush communities is declining, both at Hanford and throughout the Columbia Basin (Bakker et al. 2011). A significant contributor to this decline is the introduction of invasive annual grasses and subsequent reduction in the fire-return interval, causing increased fire frequency and intensity (Whisenant 1990). Cheatgrass (*Bromus tectorum*) is the most prominent annual grass that has invaded much of the arid west and contributes heavily to increasing fires (Whisenant 1990).

Along with the introduction of European settlers to the west came the invasion of non-native plant species, some capable of outcompeting and displacing native species (Klemmedson and Smith 1964), which are referred to as invasive species. One of the most habitat-altering and widespread invasive plant species in the shrub-steppe ecosystem is cheatgrass, which was first found in the Pacific Northwest in 1889 (Colorado State University and University of Wyoming 2013). The range of cheatgrass now extends through all 50 states and has become the dominant annual grass in much of the Columbia Basin and Great Basin, with an estimated annual spread rate of 14% (USDA 2019, Colorado State University and University of Wyoming 2013). Cheatgrass is a winter annual that germinates before the majority of the native grasses, giving it a

competitive advantage in securing water and space resources. It does not exhibit the same spacing as bunchgrasses and will blanket the understory, resulting in a large amount of continuous biomass that acts as fuel, increasing the frequency, duration, and intensity of wildfires (Knapp 1996, Whisenant 1990). Once burned, cheatgrass survives in the seed bank and recolonizes the area, often outcompeting native plants at the Hanford Site (Humphrey and Schupp 2001). As Colorado State University and University of Wyoming (2013) describes:

> *Since the invasive can outcompete native seedlings at a disturbed site, fire can lead to a positive feedback cycle of increased fire frequency and increased dominance of cheatgrass.*

Wildfire has been a significant driver in changing vegetation cover throughout the Hanford Site (HNF-61417). Historically, shrub-steppe habitat in the western United States experienced fire approximately every 32 to 70 years (Wright et al. 1979). The majority of the Hanford Site has burned at least once in the last 40 years, some areas as many as seven times as of 2022 (Figure 1). Sagebrush shrubs are slow to reestablish in areas that have burned multiple times, resulting in not only a loss of native understory plants to cheatgrass after fire but also a loss of the dominant overstory shrub. Recovery of sagebrush canopy cover after a fire has been estimated to take over 100 years in the shrub-steppe environment (Cooper 2007). As of 2017, areas containing cheatgrass as a dominant component of the understory encompass approximately 65% of the Hanford Site (HNF-61417). The extensive cover of cheatgrass and associated increase in fire frequency amplifies the chance of future fires and threatens the longevity of the shrub-steppe habitat at the Hanford Site.

1.2 Purpose and Need

Without intervention and active management, cheatgrass fires result in a reduction of total plant diversity and can result in the complete loss of the sagebrush overstory (Colorado State University and University of Wyoming 2013, Bakker et al. 2011). Ecological systems are a coarse scale vegetation unit used to categorize general vegetation patterns on a landscape level (Rocchio and Crawford 2015). The Inter-Mountain Basins Big Sagebrush Steppe ecological system is considered imperiled, and the Inter-Mountain Basins Semi-Desert Shrub-Steppe and Inter-Mountain Basins Active and Stabilized Dune ecological systems are considered critically imperiled in Washington State (Rocchio and Crawford 2015). These three systems make up the majority of the Hanford Site (Figure 2) that is not already converted to invasive annual grassland, and fire poses a major risk to the stability of the native vegetative communities in these areas (HNF-61417).

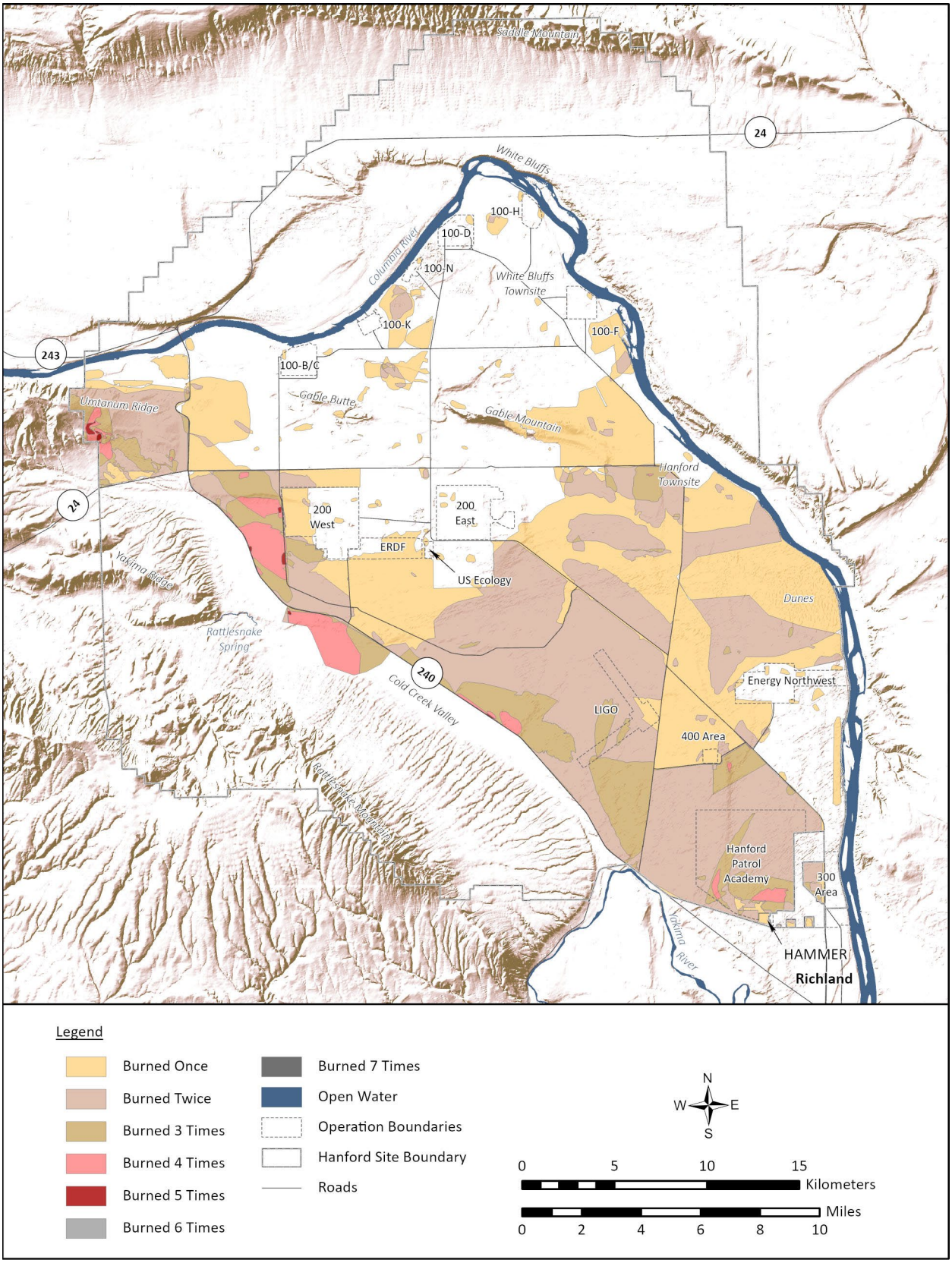

Figure 1. Hanford Site Fire Frequency from 1974 to 2023

To decrease future fire risk and to disrupt the positive feedback cycle between cheatgrass and fire, land managers can make efforts to restore native vegetation following a fire. Restoration post-fire is thought to be advantageous; immediately following a fire cheatgrass seeds are temporarily reduced in the seed bank (Humphrey and Schupp 2001). This temporary reduction in cheatgrass dominance would give native plants a chance to establish; however, studies have shown that in cheatgrass-dominated areas few native seeds make up the seed bank following a fire (less than 4%) (Humphrey and Schupp 2001). This is not sufficient to establish a strong native population, suggesting human intervention may be required.

The Hanford Site lacks sufficient data on post-fire vegetation survival and recovery. Studies have occurred on the neighboring Arid Lands Ecology Reserve measuring the effects of repeated fire on vegetation monitoring plots and the success of restoration treatments (Bakker et al. 2011). Though similar plots exist on central Hanford, limited monitoring has occurred at these sites.

The purpose of post-fire monitoring is to collect and analyze data on the immediate and long-term effects of fire on plant communities to better understand vegetative succession after fire in different habitat areas of the Hanford Site. Additionally, the effectiveness of post-fire restoration in recently burned areas will be analyzed in this document. These data will be used to better plan and execute future post-fire restoration activities.

The first iteration of this monitoring effort occurred in 2021, where both recently burned and historically burned areas were analyzed to evaluate vegetation recovery. Results from this monitoring effort can be found in HNF-67070, *Hanford Site Post-Fire Vegetation Monitoring Report for Calendar Year 2021*. Monitoring in 2023 built on previous post-fire monitoring and this report summarizes data from ongoing monitoring and new monitoring efforts initiated for fires that occurred in 2023.

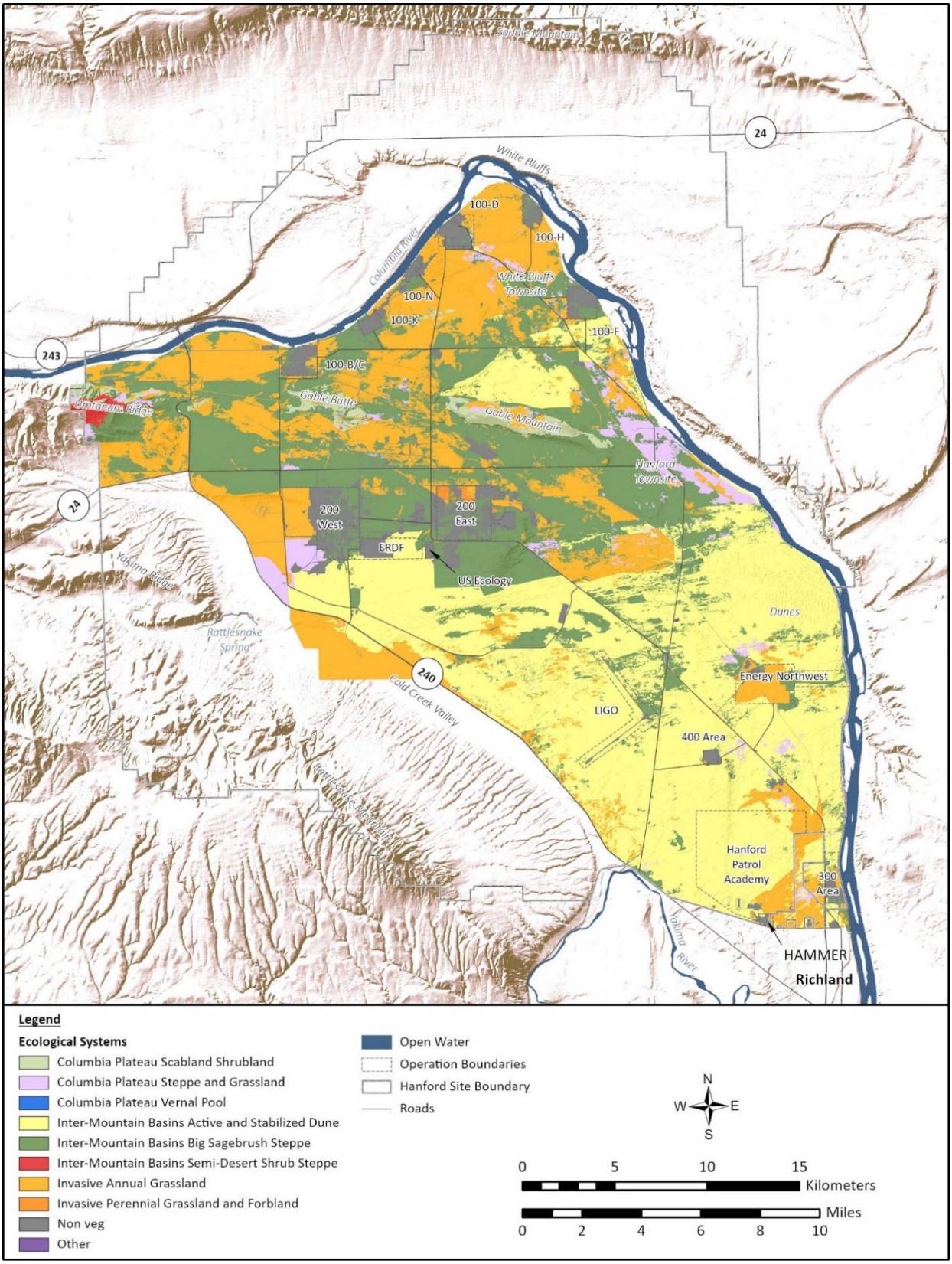

Figure 2. Ecological Systems of the Hanford Site

1.3 Regulatory Drivers

1.3.1 Federal Laws and Policy

The U.S. Department of Energy, Richland Operations Office (DOE-RL) conducts ecological monitoring on the Hanford Site to collect and track data needed to ensure DOE-RL compliance with an array of laws and policies. Ecological monitoring data provide baseline information about the plants, animals, and habitats under DOE-RL stewardship required for decision making under the *National Environmental Policy Act of 1969* and the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*.

The Federal Wildland Fire Policy (FWFP) requires burned areas to be assessed to determine appropriate rehabilitation and restoration activities and requires those activities to be evaluated to assess their effectiveness (DOI 2009). Additionally, this policy emphasizes prevention, which includes mitigating risks and losses to ecosystems (DOI 2009). Though this policy applies to federal agencies governed by the U.S. Department of the Interior, aligning Hanford Site strategies with the requirements set forward within the FWFP will better align the Hanford Site's fire management strategy with that of neighboring U.S. Fish and Wildlife Service land. This monitoring effort both assesses burned areas and evaluates the effectiveness of restoration activities, aligning Hanford Site environmental stewardship with the FWFP.

1.3.2 Hanford Site Management Guidance

DOE/RL 96-32, *Hanford Site Biological Resources Management Plan*, (BRMP) is identified by DOE/EIS-0222-SA-01, *Hanford Comprehensive Land-Use Plan*, (CLUP) as the primary implementation control for managing and protecting natural resources on the Hanford Site. According to Section 1.4.1 of the CLUP, the BRMP provides a mechanism for ensuring compliance with laws protecting biological resources; provides a framework for ensuring that appropriate biological resource goals, objectives, and tools are in place to make DOE-RL an effective steward of the Hanford biological resources; and implements an ecosystem management approach for biological resources on the Hanford Site. The BRMP provides a comprehensive direction that specifies DOE-RL biological resource policies, goals, and objectives.

Section 5.1.3 of the BRMP describes Fire Management practices at the Hanford Site as:

> *Burned area replanting will be considered on a case-by-case basis. Determining if replanting is needed depends on the site, pre-existing plant community, characteristics of the wildfire, level of damage sustained by native vegetation, and likelihood the burned area will further degrade if restoration actions are not performed.*

The monitoring effort described in this document evaluated the level of damage sustained by native vegetation and provides data regarding vegetation recovery in both the short- and long-term. It also supports current biological resources management activities and falls under the guidance of the BRMP.

1.4 Goals and Objectives

The specific objectives of this monitoring report are to:

- Evaluate the extent, intensity, and damage of new fires on the Hanford Site
- Provide third-year data on the Gable Mountain post-fire restoration
- Evaluate the impacts of post-fire restoration actions in the Gable Mountain Area
- Recommend actions to improve post-fire vegetation management
- Provide management recommendations for fires that occurred in 2023

This monitoring report is the third report in a multi-year effort to analyze short- and long-term vegetation recovery after fire on the Hanford Site. The results of this effort will help inform future post-fire management activities and provide crucial data on the natural recovery of Hanford Site habitats after fire.

1.5 Scope of Monitoring Report

The remaining sections of this monitoring report cover the following topics:

- **Section 2** provides background on the large fire that occurred on Gable Mountain in 2020, as well as restoration efforts that occurred and ongoing monitoring. The methods used in short- and long-term post-fire monitoring and the results of 2023 monitoring are described. The overall implications for post-fire vegetation recovery on the Hanford Site are also discussed.

- **Section 3** provides background information on the Route 11A fire that occurred in 2023, as well as pre-burn and post-burn assessments and management recommendations.

- **Section 4** provides background information on the Gable Butte fire that occurred in 2023, as well as pre-burn and post-burn assessments and management recommendations.

- **Section 5** lists the literature cited throughout this report.

- **Section 6** includes an appendix with a table of the 2023 results for the four Gable Mountain fire areas.

2.0 Gable Mountain Fire

2.1 Background

On May 30, 2020, a 22.3-km^2 (8.6-mi^2) fire occurred on the Hanford Site on Gable Mountain and in the surrounding area (Figure 3). The cause of this fire is believed to be lightning. The fire caused considerable damage, removing the majority of old growth sagebrush overstory on large areas of land and leaving little surviving vegetation. The fire covered both biologically valuable shrub-steppe habitat and culturally significant areas resulting in harm to biological and cultural resources. The decision to restore the burned area with a native seed mix was made based on the ecological and cultural value of the habitat.

The pre-fire vegetation cover types were evaluated to develop appropriate seed mixes for the burned area. Historic vegetation mapping data, field surveys, and photo points were used to determine what plant communities were present in the burned area before the fire. The vegetation mapping data was pulled from the 2017 report HNF-61417, *Upland Vegetation of the Central Hanford Site*, which used both field surveys and aerial photography to determine the primary grass and shrub components of habitats throughout the DOE-RL-managed portion of the Hanford Site. To confirm the vegetation data and to evaluate the surviving vegetative community, post-fire vegetation monitoring occurred in June 2020 once the burned area was safe to enter. In these field surveys, surveyors walked transects throughout the burned area, noted surviving plant species, and distinguished which sections of the burned area were severely impacted by the fire. In October 2020, another survey was conducted that established transects for long-term vegetation monitoring. The details of this survey are described in Section 2.2.1. In addition to the data analysis and post-fire monitoring, historic photo points were evaluated during the June 2020 monitoring to provide additional information on how the vegetative community had changed post-fire. Photo points showed dramatic changes in the landscape (Figure 4).

Based on the collected and existing data on vegetation composition in the burned area, three seed mixes were developed to restore the area. These seed mixes were developed to include the plants dominant in the native environment pre-fire. One seed mix targeted the areas surrounding Gable Mountain with high-density sagebrush cover pre-fire, one targeted the areas surrounding Gable Mountain with low-density or no sagebrush cover pre-fire, and one mix targeted the higher elevation areas that were burned on Gable Mountain. The boundaries of each seed mix are shown in Figure 5. Table 1 describes the species seeded in each mix along with the approximate rate of Pure Live Seed per acre. The seed mixes were made up of locally collected or native-grown grasses; the high-density sagebrush seed mix included sagebrush seed to restore the shrub layer in that area. Seed mix rates were initially calculated by doubling broadcast seeding rates in DOE/RL-2011-116, *Hanford Site Revegetation Manual* due to the expected lowered success with aerial seeding and restrictions on covering the seed with straw or mulch. The actual Pure Live Seed rate per acre was heavily determined by regional seed availability, which resulted in decreases in key species like needle-and-thread grass and increases in available species like sand dropseed (*Sporobolus cryptandrus*) and prairie junegrass (*Koeleria macrantha*). Table 1 shows the actual broadcast seeding rates for each species, some of which are below the rate that was targeted due to the availability of seed at the time of restoration. The three seed mixes were broadcast via helicopter over the entire burned area in January 2021, seven months after the fire had occurred.

The area restored in this effort will be monitored annually for five years to track the recovery of the burned area. The third year of this monitoring was conducted in 2023 and is summarized in Section 4.1 of this

report. The area will then be added to long-term post-fire monitoring as part of Hanford Site post-fire ecological monitoring. The methods used to evaluate post-fire recovery in this area are described in Section 3.0.

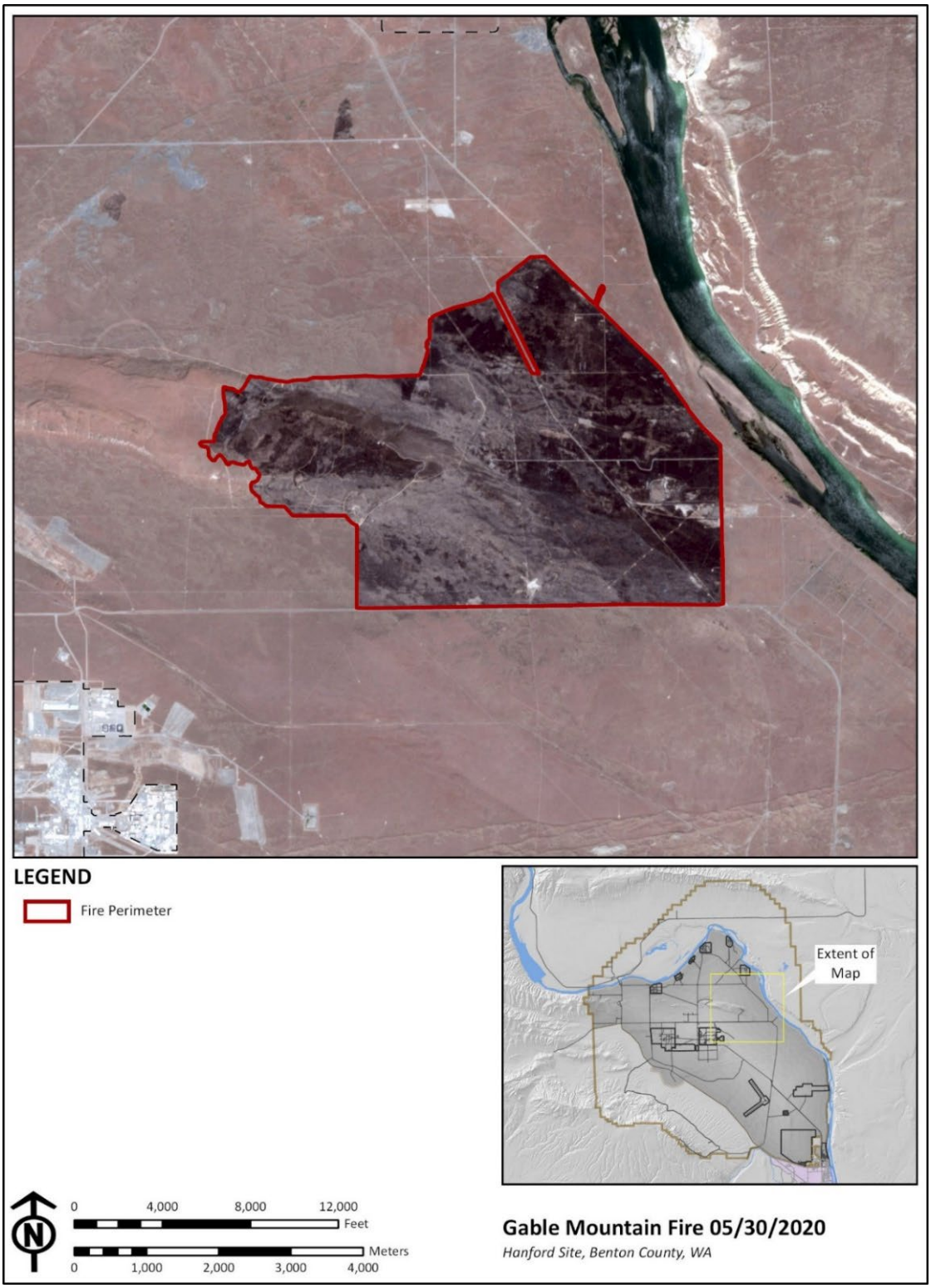

Figure 3. The Area Burned in the Gable Mountain Fire in May 2020

Figure 4. The High-Density Sagebrush Area in 2017 (top) and after the Gable Mountain Fire in 2020 (bottom)

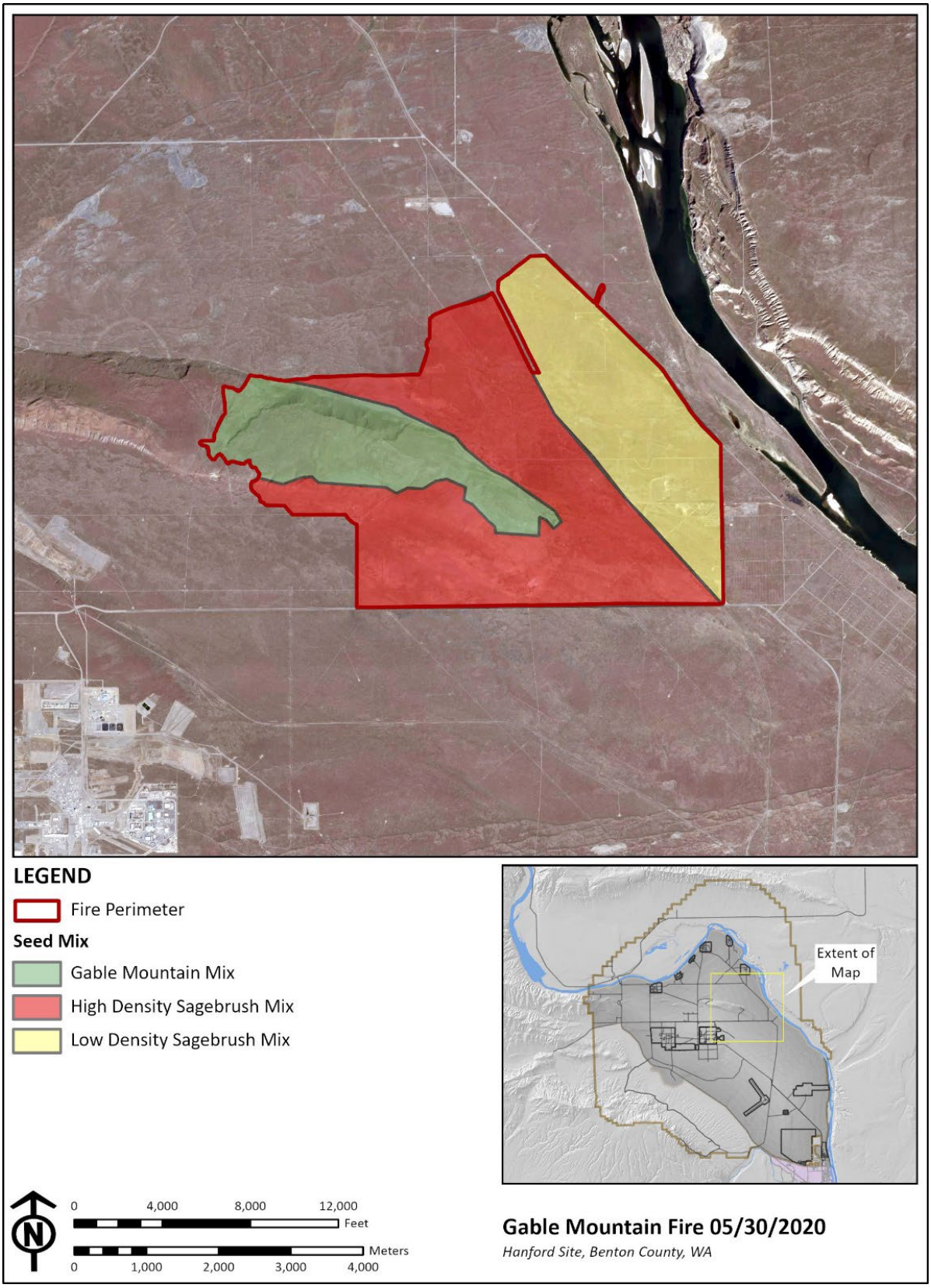

Figure 5. Locations of the Seed Mixes Used in the Gable Mountain Restoration

Table 1. Species in the Seed Mixes Used in the Gable Mountain Restoration.

Common Name	Scientific Name	PLS/Acre
High Density Sagebrush Mix - 3,000 Acres		
Sandberg bluegrass	*Poa secunda*	7.50
Indian ricegrass	*Achnatherum hymenoides*	3.66
Needle-and-thread grass	*Hesperostipa comata*	0.04
Bottlebrush squirreltail	*Elymus elymoides*	1.45
Sand dropseed	*Sporobolus cryptandrus*	0.50
Prairie junegrass	*Koeleria macrantha*	0.95
Big sagebrush	*Artemisia tridentata*	0.24
Low Density Sagebrush Mix - 1,500 Acres		
Sandberg bluegrass	*Poa secunda*	7.17
Indian ricegrass	*Achnatherum hymenoides*	0.67
Bottlebrush squirreltail	*Elymus elymoides*	1.43
Sand dropseed	*Sporobolus cryptandrus*	0.50
Prairie junegrass	*Koeleria macrantha*	0.47
Gable Mountain Mix - 1,000 Acres		
Sandberg bluegrass	*Poa secunda*	4.00
Bluebunch wheatgrass	*Pseudoroegneria spicata*	10.00
Idaho fescue	*Festuca idahoensis*	1.00

2.2 Methods

Monitoring in 2023 was the third year of monitoring for the restored Gable Mountain fire area. The methods used replicated the first-year monitoring methods that were used at the restoration area in 2021.

2.2.1 Short-Term Monitoring

A short-term monitoring strategy was implemented for the Gable Mountain Fire, intended for use in areas burned within the last five years. The goal of short-term monitoring is to collect data on the vegetation recovery of areas after fire and to collect data on the short-term effectiveness of restoration actions. The Gable Mountain fire area was monitored for short-term monitoring in late April and early May 2021, early May 2022, and early May 2023.

To track vegetation recovery after the fire, 15 transects were established throughout distinct habitats within the Gable Mountain fire area in 2020 (Figure 6). These transects will be monitored annually for five years to track vegetation diversity, abundance, and growth. The transect locations were selected to represent habitats throughout the Gable Mountain fire area that were identified using HNF-61417, *Upland Vegetation*

of the Central Hanford Site, along with historic photo-points and results from a post-fire pedestrian survey. The transect locations also represent areas that experienced different levels of fire intensity. Transects were recorded on a global positioning system (GPS) and rebar with flagging tape was placed at the start and end of each transect.

In addition to monitoring the 15 transects established within the burned area, five additional reference transects were established. The goal of establishing reference transects was to evaluate vegetative cover in similar neighboring plant communities that were not affected by the Gable Mountain Fire. The unburned plant population can serve as a basis for comparison as the vegetation in the burned area grows and the community composition develops. Monitoring transects were chosen based on proximity to the burned area, vegetation layer similarity to the burned area according to HNF-61417, and accessibility. The transects were established and monitored using the same methods as the original 15 transects and will be monitored when the burn area transects are monitored, from short-term to long-term monitoring. Reference Area (RA) transects are displayed in Figure 6 with "RA."

Coordinates were recorded at the start and end points of each 100-m (328-ft) transect. A photo-point was established at the starting point of each monitoring transect. Pictures were taken in a clockwise fashion with the first picture facing north and each subsequent picture slightly overlapping the previous. Pictures were taken horizontally with the horizon only visible in the upper 1/8 of the picture.

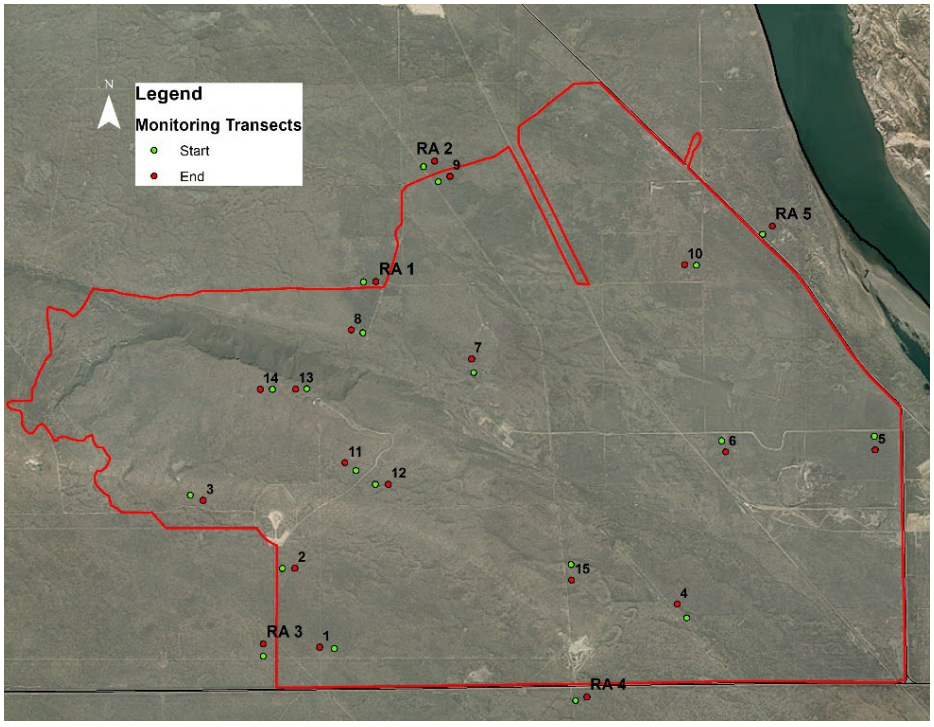

Figure 6. Monitoring Transects for the Gable Mountain fire area Established in 2020.

Plot frame data were taken along each of the transects in May 2023. These data were collected following methods described in the *Steppe Vegetation of Washington* (Daubenmire 1970) and methods used during

post-fire monitoring of BRMP plots that were established in 1996 and used by a variety of groups (Evans and Lih 2005, Bakker et al. 2011). The plot frame transects consist of a 100-m (328-ft) long measuring tape, stretched from the start point to the end point so that it is straight and taut. One 20- by 50-cm (8- by 20-in) plot was placed every 5 m (16 ft) on the right-hand side of the transect with the longest side parallel with the tape for a total of 20 plots per transect. Upon placing the plot frame, each species within the frame was identified and estimates of coverage were made for each species rooted within the area of the frame. Canopy coverage is defined by Daubenmire (1970) as "the percentage of ground surface included in the vertical projection of a polygon drawn about the extremities of the undisturbed foliage of a plant." Coverage was estimated using the following coverage classes: 1 (0-5% cover), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (75-95%), and 6 (95-100%). In addition to plot frames, all plant species observed within 5 m (16 ft) of either side of the transect were recorded. In addition to plant species observed within 5 m (16 ft) of the transects, any classified noxious weeds encountered during the survey were recorded and marked with a GPS point. The noxious weed locations are shared with the Noxious Weed program for treatment planning.

2.3 Results

This section reports third-year monitoring results for the Gable Mountain fire area. Long-term BRMP plot monitoring was not conducted in 2023; the next scheduled BRMP monitoring will occur in 2026. The implications of the Gable Mountain fire area and BRMP plot monitoring results are discussed in Section 5.0.

2.3.1 Gable Mountain fire area

Third-year post-fire monitoring occurred in the Gable Mountain fire area in 2023. This effort measured vegetation on the same 15 transects as 2021 monitoring and replicated the methods used in 2021. First-year monitoring occurred in late April and early May 2021. In 2022, second-year monitoring occurred in early May. In 2023, third-year monitoring occurred in early May to align with the phenology at the time of monitoring in 2021 and 2022.

The 15 monitored transects are categorized into 4 areas: Gable Mountain, High-Density Sagebrush, Low-Density Sagebrush, and RAs. The monitoring transects have been categorized this way to develop a higher-level understanding of habitat recovery within the Gable Mountain burn area. Additionally, it allows analysis of the effectiveness of the three different seed mixes used in the restoration effort. A table of results for each area is included in Appendix A.

2.3.1.1 Gable Mountain Transects

The Gable Mountain transects are all located within the higher elevation section of the burned area, on and around Gable Mountain. This area was distinguished from the rest of the burned area due to the presence of bluebunch wheatgrass as a dominant grass in the understory before the 2020 fire. The north slope of Gable Mountain saw far less fire damage than the south slope and appeared to be the only part of the burned area with a significant population of surviving sagebrush. No transects were established on the north slope of Gable Mountain due to timing and accessibility limitations. Transects 11, 13, and 14 are all within the Gable Mountain Area, with Transect 12 on the boundary between the Gable Mountain Area and the high-density shrub area. Transect 12 was analyzed within the Gable Mountain Area due to the relatively high elevation of the site. Transects 13 and 14 are located on the higher elevation portion of Gable Mountain and Transects 11 and 12 are located on the south slope of the mountain.

The soils in the Gable Mountain Transect area are characterized by lithosols and Kiona silt loam soil. Prior to burning, the lithosols in the high elevation areas and the north slope of Gable Mountain supported sagebrush, spiny hopsage (*Grayia spinosa*), and purple sage (*Salvia dorii*) along with rock buckwheat (*Eriogonum sphaerocephalum*); slender buckwheat (*Eriogonum microthecum*); rubber rabbitbrush (*Ericameria nauseosa*); green rabbitbrush (*Chrysothamnus viscidiflorus*); and a matrix of grasses including bluebunch wheatgrass, needle-and-thread grass, and Sandberg's bluegrass (*Poa secunda*). The south slope supported similar vegetation, with a pattern of increasing cheatgrass and decreasing sagebrush southward.

Monitoring in May 2023 found an overall increase in native and non-native cover with decreases in native cover at some transects. Figure 7 compares native and non-native cover for the four Gable Mountain transects from 2021 to 2023. Across the four transects in the Gable Mountain Area, native cover averaged 16.8% and non-native cover averaged 40.7%. This represents an increase of 2.4% for native cover and 12.2% for non-native cover from 2022. Transect 12 (Figure 8) and 13 (Figure 9) had the highest native cover with 15.8% and 39.9% native cover, respectively. Transect 12 was surrounded by small patches of vegetation that had survived the fire. Both areas appeared to have a lower burn severity immediately after the fire than Transects 11 (Figure 10) and 14 (Figure 11). In May 2023, native cover at Transects 11 (Figure 8) and 14 (Figure 9) was quite low at 4.6% and 6.9%, respectively. Non-native species appear to be recovering faster than native species at transects 11, 12, and 14, but not at transect 13.

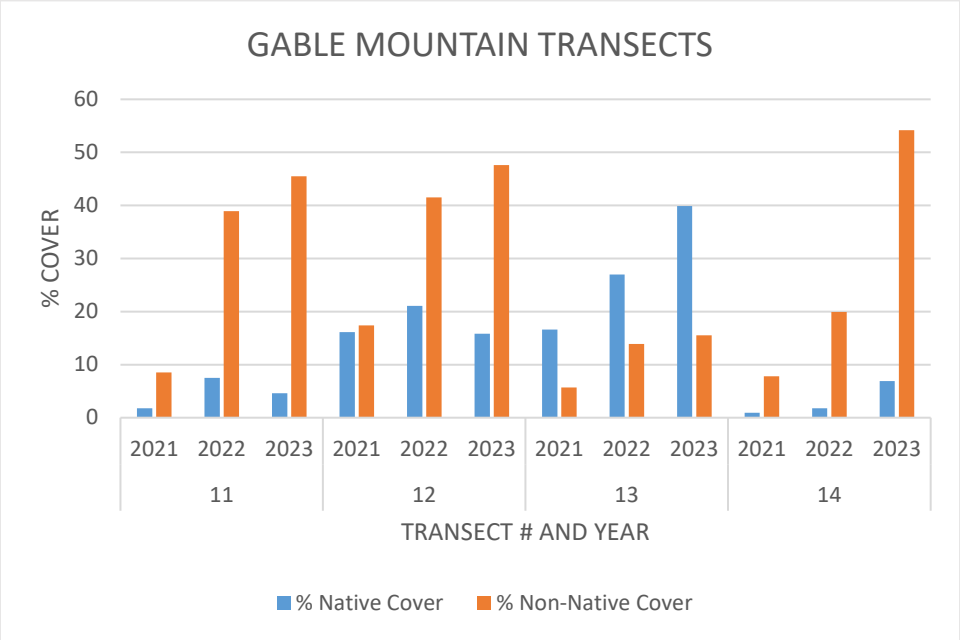

Figure 7. Gable Mountain Transect Results

Sandberg's bluegrass had the highest cover of any native species on average, at 12.6% coverage. This represents a decrease of 16.2% from 2022 levels. Cheatgrass was the dominant non-native species at all transects within this area with an average cover of 31.13%. It was most abundant at transect 14 despite this area possessing less cheatgrass than the south slope of Gable Mountain prior to the burn. The trend of rapidly increasing cheatgrass cover at transect 14 was noted in 2022 and it continued in 2023 with an increase of 17.3% for a total of 42.6% cover. In 2022, a large increase in the cover of tall tumblemustard (*Sisymbrium altissimum*) at all transects was noted. In 2023, the average cover of tall tumblemustard decreased 5.3% for a total of 4.0% cover.

The restoration seed mix for this area included bluebunch wheatgrass as the primary component along with Sandberg's bluegrass and Idaho fescue. Sandberg's bluegrass was detected at all transects in 2023 and appeared to be mostly comprised of individuals that survived the fire along with some seedlings. Bluebunch wheatgrass, a defining species for this area was recorded only at Transect 13, with 0.1% cover. Idaho fescue was not detected at any transects in 2023.

The number of native species found in the Gable Mountain Area in 2021 was 29. In 2022, 42 native species were found. In 2023, 36 native species were found. The decrease in native species could be a result of lower precipitation in 2023, relative to 2022 as many of the species not detected were precipitation-dependent annuals. Further monitoring is necessary to determine if native species diversity will continue trending up. The number of non-native species found in the Gable Mountain Area in 2021 was seven. In 2022 and 2023, 10 non-native species were found. While the percent cover of non-native species is increasing, no new non-native species were observed in 2023.

Figure 8. Transect 12 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

Figure 9. Transect 13 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

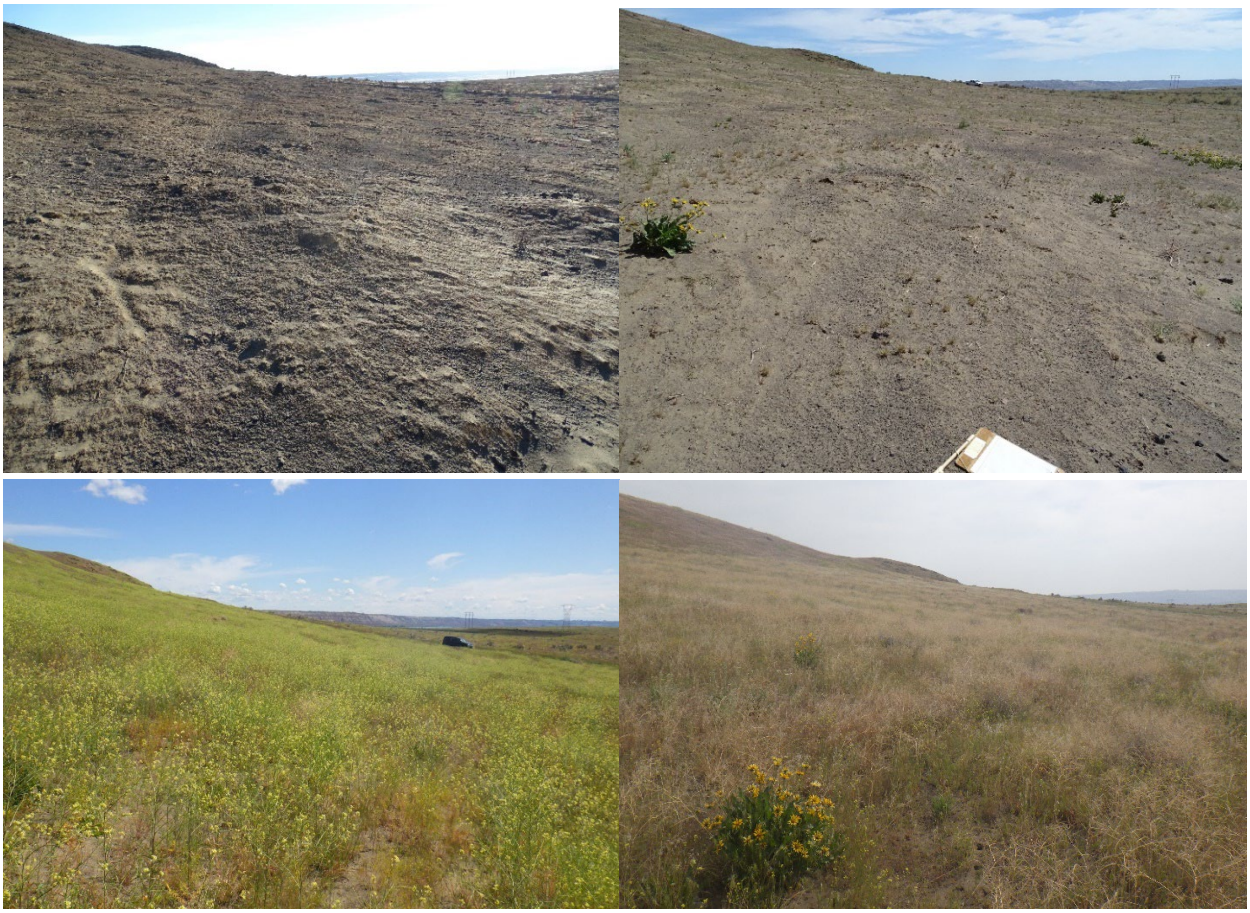

Figure 10. Transect 11 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

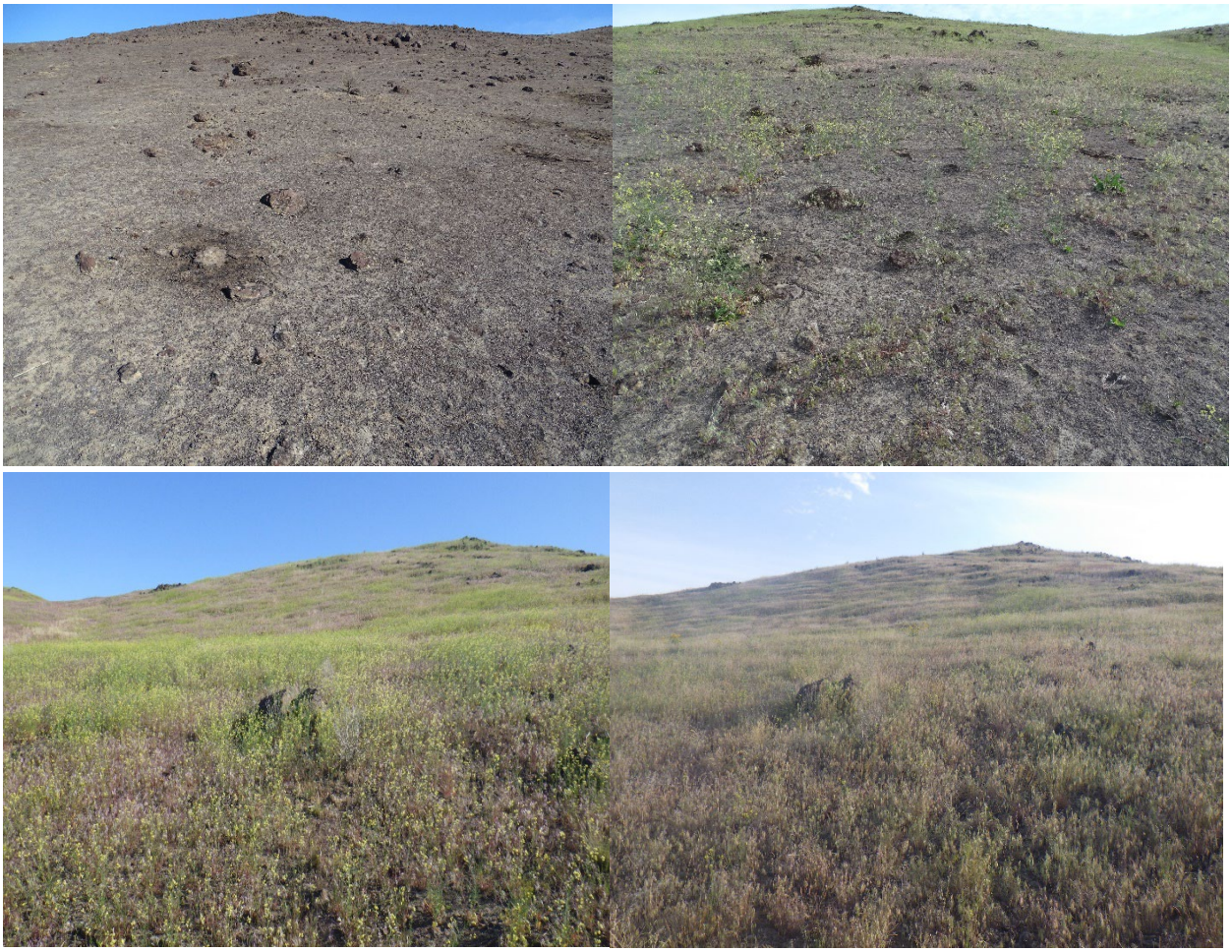

Figure 11. Transect 14 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

2.3.1.2 High-Density Sagebrush Transects

The high-density sagebrush transects are all located within the lower elevation area surrounding Gable Mountain. This area was distinguished from the rest of the burned area due to the presence of a dense sagebrush overstory before the fire. This area included habitat previously designated as an element occurrence by the Washington State Department of Natural Resources Natural Heritage Program due to its high quality, which is where Transect 1 is located. Except for a few patches in this area, the Gable Mountain Fire completely removed the sagebrush overstory. Sagebrush seed was added to the seed mix in this area to account for the loss of sagebrush plants. Transects 1, 2, 3, 4, 7, 8, 9, and 15 are all within the high-density sagebrush area. These transects span a variety of habitats with changing soil types.

The high-density sagebrush area lacks the lithosols and silt loam that characterize the Gable Mountain transect area. Soils in the high-density sagebrush area ranged from Burbank loamy sand to Quincy sand. Prior to burning, the soils in this area supported sagebrush and rabbitbrush species, along with scattered buckwheat species. Grasses found in this area prior to burning included Sandberg's bluegrass, needle-and-

thread grass, and ricegrass (*Achnatherum hymenoides*). Cheatgrass was a dominant component of this area before the fire and likely contributed to the fire having sufficient fuel to completely remove the sagebrush overstory. Sandy habitats within the high-density sagebrush area had less cheatgrass prior to the fire and more patches of surviving vegetation.

Immediate post-fire monitoring in October 2020 showed little to no surviving vegetation on any of the high-density sagebrush transects. There are eight high-density sagebrush transects; Transect 1 (Figure 12), Transect 2 (Figure 13), Transect 3 (Figure 14), Transect 4 (Figure 15), Transect 7 (Figure 16), Transect 8 (Figure 17), Transect 9 (Figure 18), and Transect 15 (Figure 19). The only transect with significant vegetation cover was Transect 4 with a total of 30.9% native cover, where needle-and-thread grass covered approximately 10.2% of the area and Sandberg's bluegrass covered approximately 14.5% of the area. Transect 4 was distinguished from the other transects with active sandy soils, leading to some blowouts and gaps in vegetative cover. Lower cheatgrass coverage before the fire may have led to a lesser burn intensity in this area, resulting in more surviving native grasses.

Figure 12. Transect 1 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

Figure 13. Transect 2 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

Figure 14. Transect 3 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

Figure 15. Transect 4 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

Figure 16. Transect 7 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

Figure 17. Transect 8 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

Figure 18. Transect 9 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

Figure 19. Transect 15 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

Monitoring of high-density sagebrush transects in 2022 measured an increase in both native and non-native cover on average. Monitoring in May 2023 showed native and non-native cover to be quite variable across the eight transects in the high-density sagebrush area, with native cover averaging 16.5% and non-native cover averaging 42.5%. This represents an increase of 3.5% for native cover and 13.1% for non-native cover from 2022 levels. Transect 4 had the highest native cover at 30.9%. Transect 9 had the lowest native coverage, with 1.5% cover. Transect 8 was noted to have very low native cover in 2022 but coverage increased by 8.4% for a total of 10.8% in 2023. These areas saw high burn intensity and had no surviving sagebrush overstory. Cheatgrass was the dominant non-native species at all transects with Transects 9, 1, and 15 having the highest non-native species coverage at 87.8%, 46.4%, and 40.3% coverage, respectively. Figure 20 compares native and non-native cover for the eight High-Density Sagebrush transects from 2021 to 2023.

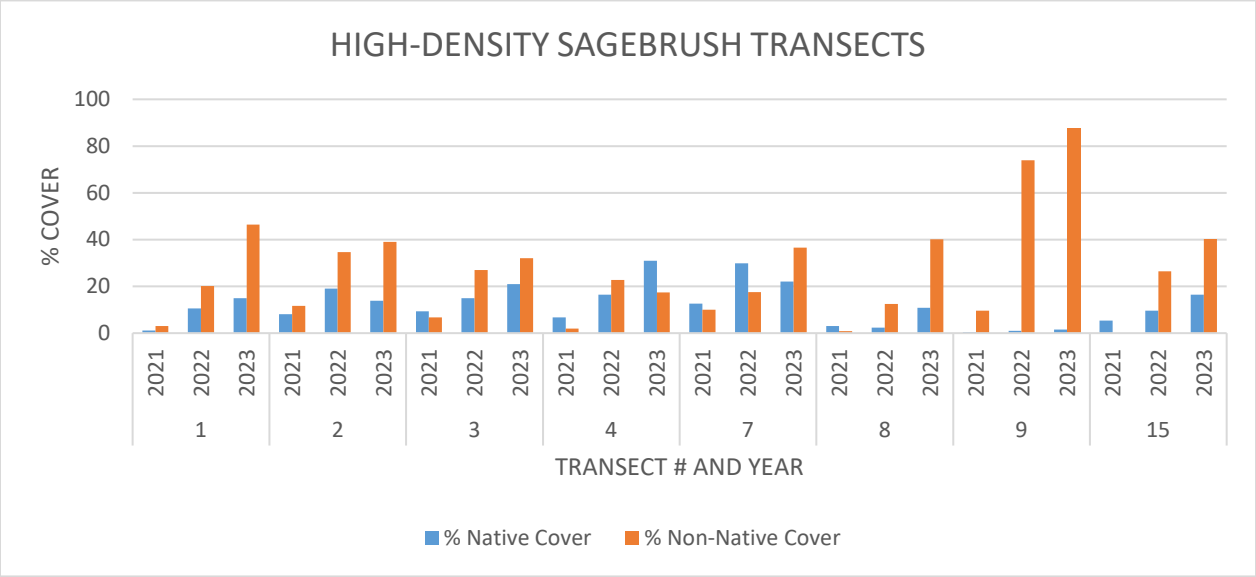

Figure 20. High-Density Sagebrush Transect Results

The species making up the majority of native coverage in this area was Sandberg's bluegrass, with an average cover of 6.69%, followed by slender phlox (*Microsteris gracilis*), with an average cover of 2.15%. Sandberg's bluegrass was the primary component of the restoration seed mix for this area, while slender phlox is a naturally occurring, non-seeded native species. Other seeded bunchgrasses were detected at low cover levels at Transects 3, 4, 7, 8, and 15; whereas in 2021 they were only detected as seedlings at transects 2, 4, and 15. Notably, no sagebrush seedlings were detected at any transects in the high-density transect area or in the entire Gable Mountain burn area in 2021, despite sagebrush seed being included in the high-density sagebrush seed mix. Monitoring in 2023 detected a small number of juvenile sagebrush shrubs at Transects 2, 7, 8, and 9. Cheatgrass had the highest cover on average of any non-native species at 36.23%. Transect 9 had exceptionally high cheatgrass cover at 66.8%.

The number of native species found in the High-Density Sagebrush transect area in 2021 was 37. In 2022, 45 native species were found and in 2023, 38 native plant species were found. The decrease in native species could be a result of lower precipitation in 2023 relative to 2022, as many of the species not detected were precipitation-dependent annuals. Further monitoring is necessary to determine if native species diversity will continue trending up. The number of non-native species found in the Gable Mountain Area in 2021 was five. In 2022, nine non-native species were found, and 10 non-native species were found in 2023. While the percent cover of non-native species is increasing in the area, few new non-native species were observed.

2.3.1.3 Low-Density Sagebrush Transects

The low-density sagebrush transects are all located within the lower elevation area east of the historic railroad track traversing the Gable Mountain fire area. This area is bordered by Route 2 North, which was used as a firebreak during the firefighting process. The low-density sagebrush area was distinguished from the rest of the burned area due to the lack of a sagebrush overstory before the fire and general dominance

of weedy species, including cheatgrass and tall tumblemustard prior to the burn. Transects 5 (Figure 22), 6 (Figure 23), and 10 (Figure 24) are within the low-density sagebrush area.

Figure 21. Transect 5 in October 2020 (top left) and April 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

Figure 22. Transect 6 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

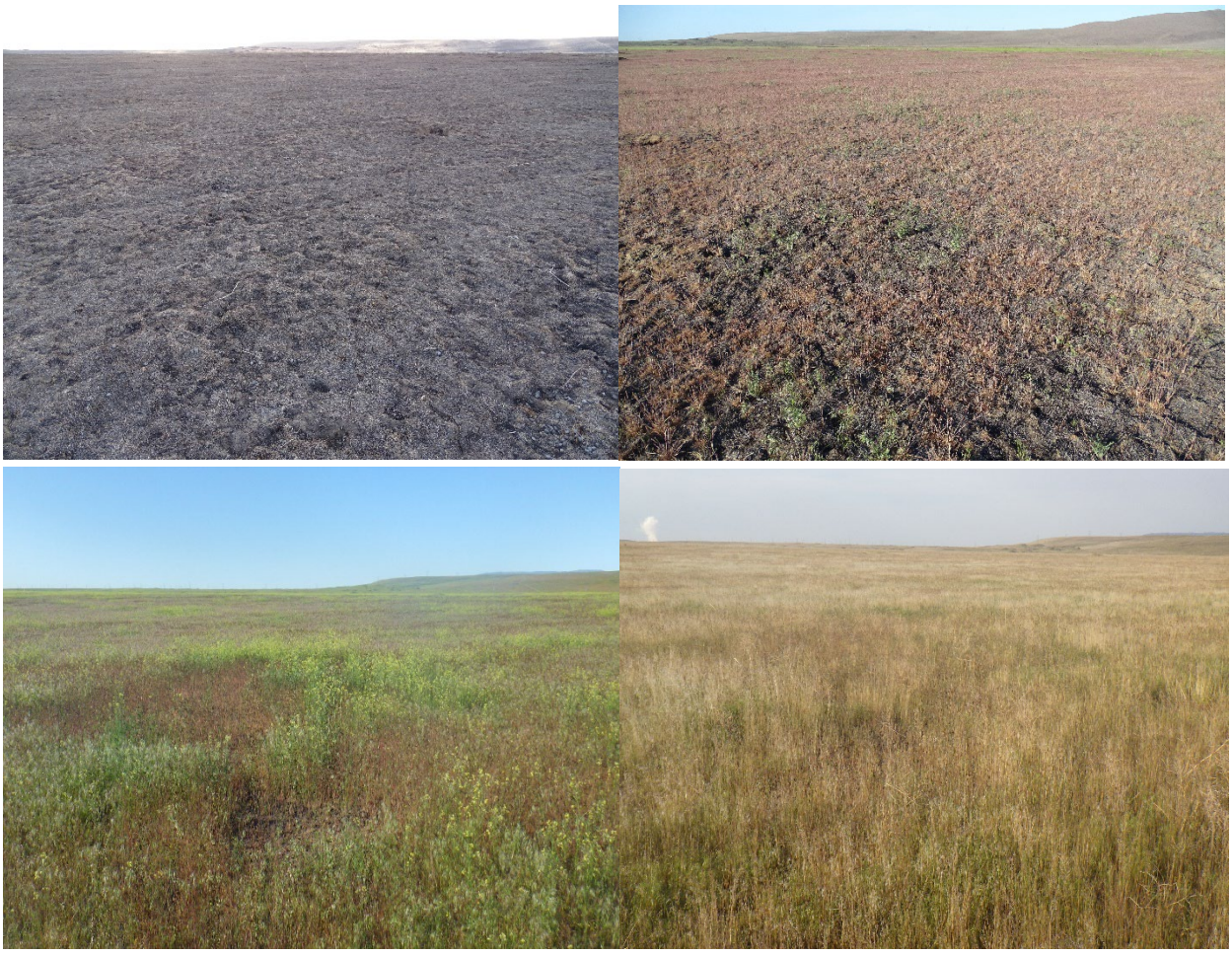

Figure 23. Transect 10 in October 2020 (top left), May 2021 (top right), May 2022 (bottom left), and May 2023 (bottom right)

The low-density sagebrush area contains a range of soil types, including Burbank loamy sand, Quincy sand, and Ephrata sandy loam. Prior to burning, soils in this area supported a grassland community made up of needle-and-thread grass, sand dropseed, Sandberg's bluegrass, and cheatgrass. Cheatgrass was a dominant component of this area before the fire, and large swaths of burned and matted cheatgrass were present throughout this section of the burned area leading to little exposed soil. In addition to the grasses, patches of rabbitbrush characterized the overstory with occasional sagebrush plants along the western boundary of the area.

Immediate post-fire monitoring in October 2020 found little to no surviving vegetation on any of the low-density sagebrush transects. Vegetation began to recover by April and May 2021, and cover continued to increase in 2023.

Native cover in this area was the lowest of the three burned areas, averaging 2.4% across the three lot-density sagebrush transects, representing an increase of 0.9% from 2022. Although native species were sparsely present at transects 5 and 10, no native cover was detected along those transects. Non-native cover

was by far the highest of the three areas, averaging 71.5%, representing an increase of 14.5% from 2022. The dominant non-native species was cheatgrass with an average cover of 41%. In 2022, high coverage of tall tumblemustard was noted, however this decreased 12% in 2023 for a total average cover of 3.4%. Transect 6 had the highest native cover at 7.3%, which consisted mainly of hoary tansyaster (*Dieteria canescens*) and needle-and-thread grass. Figure 24 compares native and non-native cover for the three Low-Density Sagebrush Transects from 2021-2023.

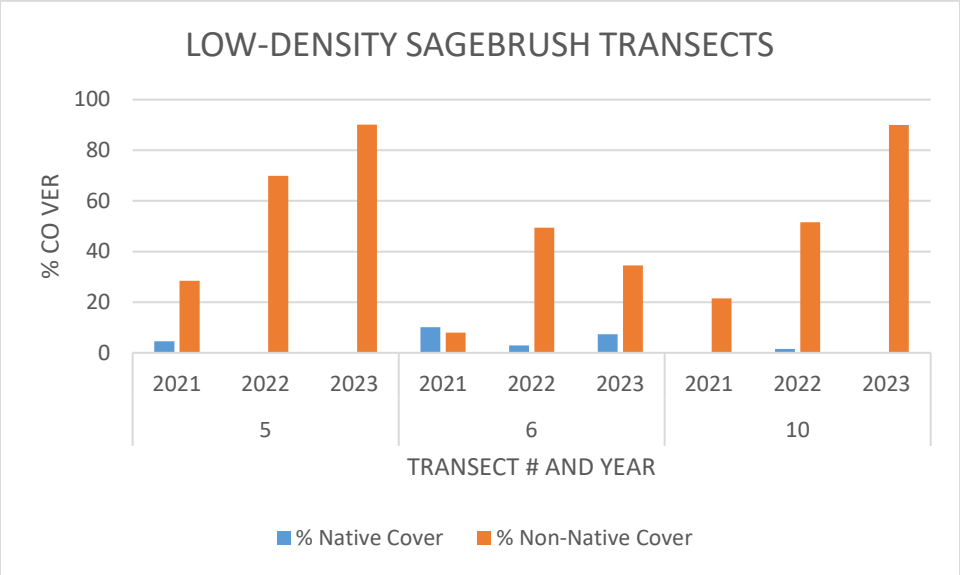

Figure 24. Low-Density Sagebrush Transect Results

The seed restoration mix for this area included Sandberg's bluegrass as the primary component with prairie junegrass, ricegrass, bottlebrush squirreltail (*Elymus elymoides*), and sand dropseed. In 2023, Sandberg's bluegrass was found at low levels at transect 6 and sand dropseed was found at low levels at all three transects. Prairie junegrass was detected in 2021 but has not been observed since. The other seeded species have not been detected.

The number of native species found in the Low-Density Sagebrush Transect area in 2021 was nine. In 2022, 16 native species were found and in 2023, 11 native species were found. The decrease in native species could be a result of lower precipitation in 2023 relative to 2022, as many of the species not detected were precipitation-dependent annuals. Further monitoring is necessary to determine if native species diversity will continue trending up. The number of non-native species found in the Gable Mountain Area in 2021 was eight. In 2022, nine non-native species were found and in 2023, 10 non-native species were found. While the percent cover of non-native species is increasing in the area, few new non-native species were observed.

2.3.1.4 Reference Area (RA) Transects

The RA transects are located around the perimeter of the burned area in sections that resemble the vegetative community within the burned area prior to the fire. The purpose of these transects is to establish what the baseline vegetative community consisted of prior to the fire and to compare how the burned area recovers over time to the vegetative communities in the RA. These areas will be monitored annually to determine if trends observed are unique to areas recovering from fire or if they appear in undisturbed communities as well. Five reference transects were established for this study (depicted as "RA" in Figure 6). Figure 25 compares native and non-native cover for the five RA transects from 2021 to 2023.

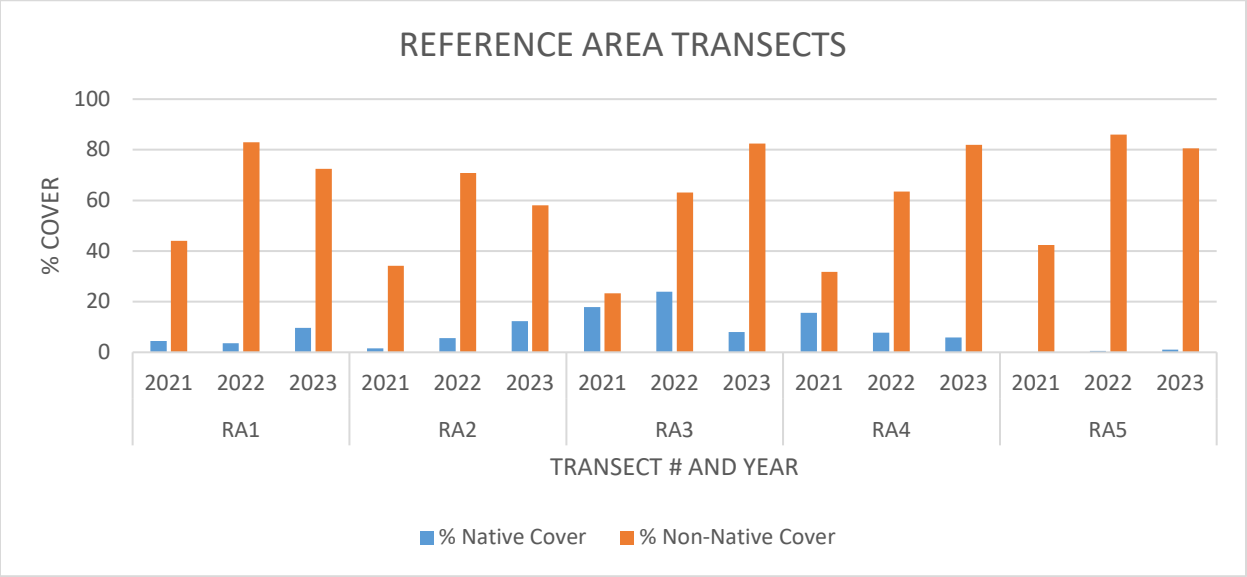

Figure 25. RA Transect Results

RA 1 (Figure 26) is representative of the low-elevation area north of Gable Mountain, where Transect 7 and Transect 8 are located. It is characterized as a mature sagebrush habitat with a highly disturbed understory. In 2023, native cover increased 6% for a total of 9.6%, mainly consisting of big sagebrush and Sandberg's bluegrass. In 2023, non-native cover at RA 1 increased 28.5% for a total of 72.5% cover, nearly completely made up of cheatgrass. Six native plant species and six non-native plant species were found here in 2023.

RA 2 (Figure 27) is representative of the non-native dominated habitat with little overstory that is transitional between the high-density and low-density sagebrush areas of the burned area. It is located near Transect 9; both transects are near a firebreak created during the process of fighting the Gable Mountain Fire. In 2023, native cover increased 6.7% for a total of 12.3%, mainly consisting of Sandberg's bluegrass. Non-native cover at RA 2 decreased 12.8% from 2022 to 58% in 2023, consisting mostly of cheatgrass. Five native plant species and seven non-native plant species were found in 2023.

RA 3 (Figure 28) is located on the west side of the fire boundary and is representative of pre-fire conditions for Transect 1 and Transect 2. RA 3 is within the element occurrence that spanned over Transect 1 prior to the fire. Native cover decreased 15.9% from 2022 to 8% in 2023, mainly consisting of big sagebrush. In

2022 RA 3 had 63.1% non-native cover, with 60.5% of that made up by cheatgrass. In 2023, non-native cover increased 19.4% for a total of 82.5%, mainly consisting of cheatgrass. Twenty-two native plant species and three non-native plant species were found in 2023.

RA 4 (Figure 29) is located south of the fire boundary in an area similar to pre-fire conditions for Transect 15 and Transect 4. In 2023, native cover decreased 2.0% for a total of 5.8%, mainly consisting of Sandberg's bluegrass and big sagebrush. In 2023, non-native cover increased 18.4% for a total of 81.9%, consisting mostly of cheatgrass and jagged chickweed (*Holosteum umbellatum*). Seventeen native plant species and five non-native plant species were found in 2023.

RA 5 (Figure 30) is located on the east side of the fire boundary and is representative of pre-fire conditions for Transect 5, Transect 6, and Transect 10. In 2022, RA 5 had only 0.5% native species cover on the transect, though three native species were observed in the area. In 2023, native cover increased 0.5% for a total 1.0%, consisting of tarweed fiddleneck. In 2023, non-native cover decreased 5.4% for a total of to 80.6%, consisting mostly of cheatgrass. Two native plant species and six non-native plant species were found in 2023.

Figure 26. RA 1 in May 2023. Note the high cheatgrass density in the understory, typical of the RA Transects

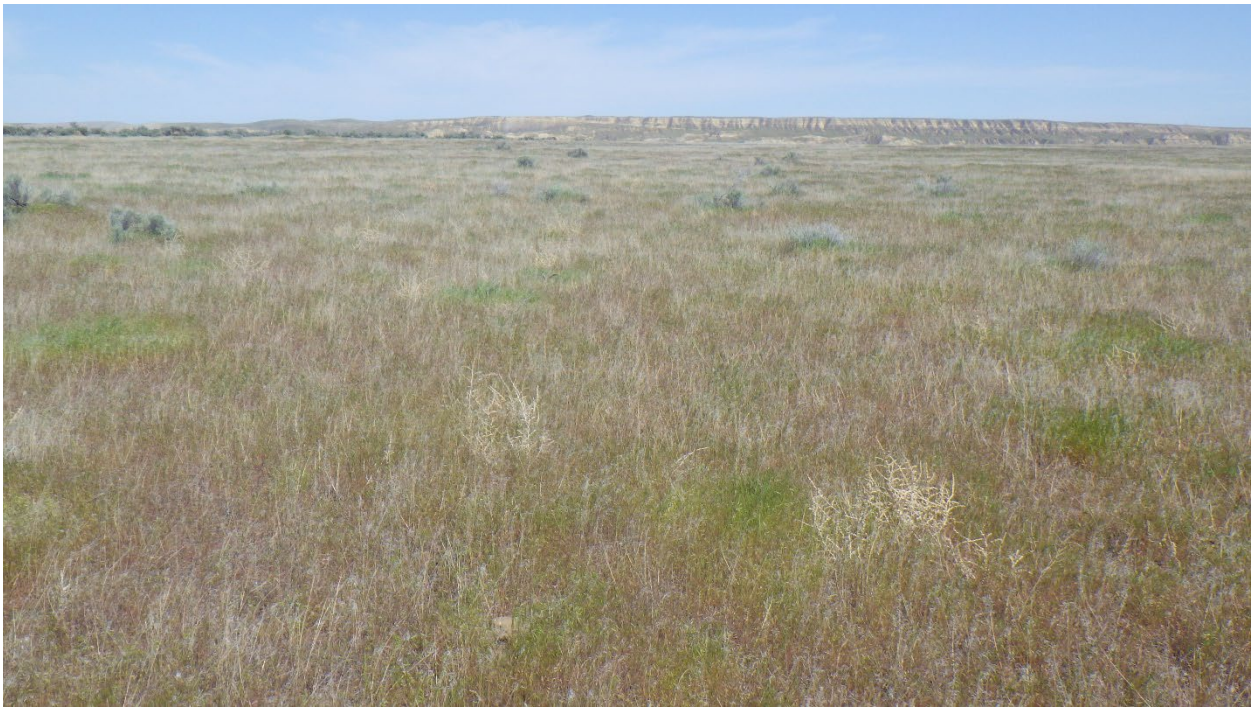

Figure 27. RA 2 in May 2023

Figure 28. RA 3 in May 2023

Figure 29. RA 4 in May 2023

Figure 30. RA 5 in May 2023

2.3.1.5 BRMP Plot 25

BRMP Plot 25 (referred to as BRMP 25) is located in an area classified by HNF-61417 as a big sagebrush/Sandberg's bluegrass – cheatgrass habitat. This plot is included in the Gable Mountain fire area results because it was seeded in the January 2020 restoration effort. This plot was not monitored in 2023 because these plots are on a five-year monitoring schedule; however, the results are included for reference.

It is characterized by having an overstory dominated by sagebrush, with lower coverage of antelope bitterbrush (*Purshia tridentata*) and spiny hopsage interspersed. The understory is co-dominated by Sandberg's bluegrass and cheatgrass, with low coverage of needle-and-thread grass. This classification was done before the area burned in 2020 and stands as a pre-fire representation of the area. The soil in this area is characterized as Burbank loamy sand and Quincy sand. Data from 1996 and 2009 monitoring efforts were evaluated to determine the pre-fire vegetative composition; this plot was monitored in 2021 to determine the post-fire composition. Two BRMP Plot (PC) locations (PC-1 and PC-3) were evaluated for this study. Figure 31 shows the change in vegetative composition over time and Figure 32 shows the change in the dominant grass coverage over time at BRMP 25.

Average native cover in 1996 was 44.1%. This was mainly made up of sagebrush and Sandberg's bluegrass, which were the two main components of the habitat. Bottlebrush squirreltail, long-leaf phlox (*Phlox longifolia*), and small fescue (*Vulpia microstachys*) were other common native species in the plot. Non-native cover averaged 37.3%, with the majority of that coverage coming from cheatgrass. Jagged chickweed and spring draba (*Draba verna*) also contributed to the high non-native coverage. Monitoring in 2009 found 32.6% native cover. Sagebrush and Sandberg's bluegrass still made up the majority of the native cover with forbs like annual Jacob's ladder (*Polemonium micranthum*), long-leaf phlox, and slender phlox also providing coverage. Non-native cover averaged 18.9% and was mainly made up of cheatgrass.

Post-fire monitoring in 2021 found significant decreases in all species. Native cover decreased to 2.6%, with the majority of the native cover coming from Sandberg's bluegrass and needle-and-thread grass. Non-native cover also decreased significantly, averaging only 3.3% after the fire. Cheatgrass made up the majority of the non-native species coverage in 2021. BRMP Plot surveys are planned every five years, therefore, the sites were not surveyed in 2022 or 2023.

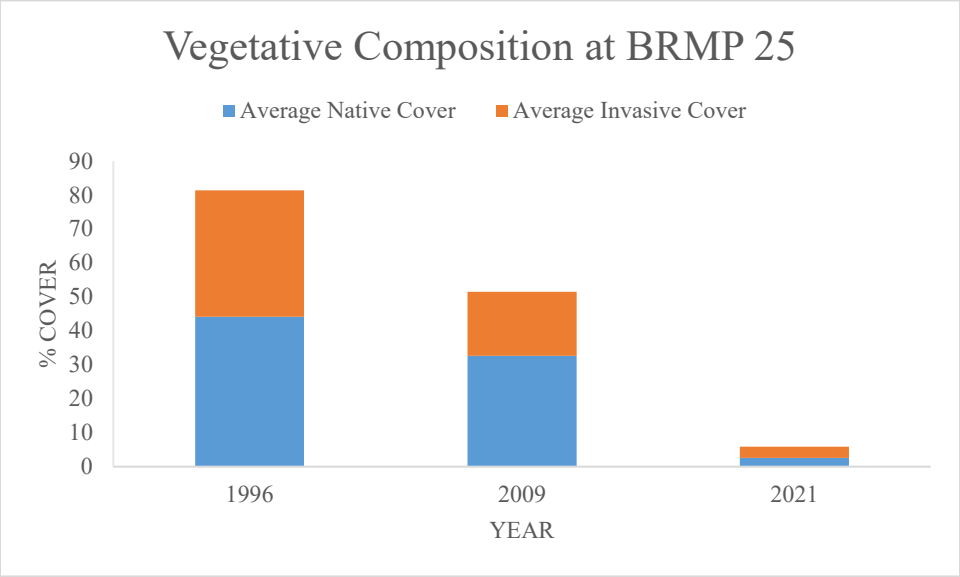

Figure 31. The Average Vegetative Composition at BRMP 25 Over Time

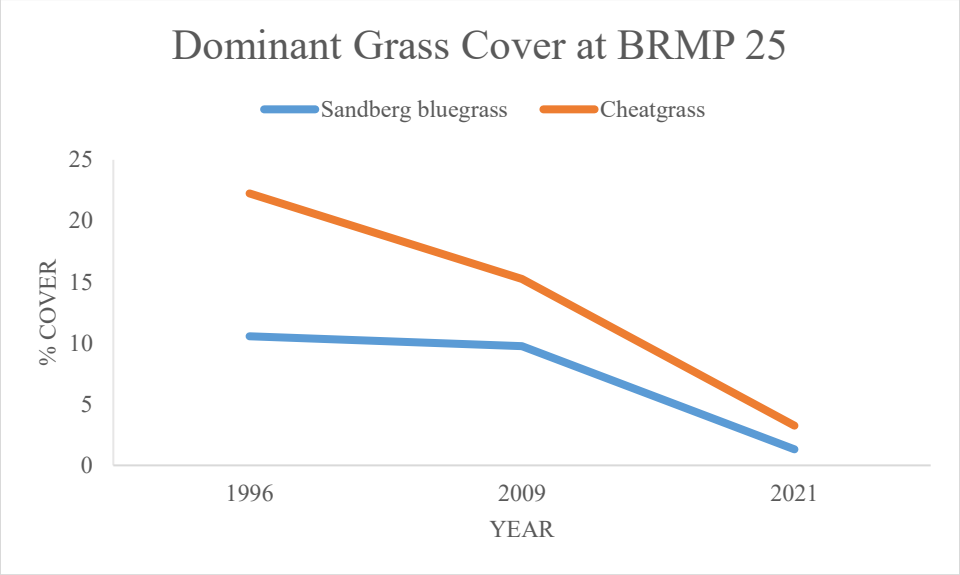

Figure 32. Changes in Dominant Grass Cover at BRMP 15 Over Time

2.3.2 Long-Term BRMP Plot Monitoring

Long-term post-fire monitoring did not occur in 2022 as this monitoring is scheduled to occur every five years; however, the results from previous monitoring are included as reference and they are utilized for drawing conclusions in the discussion. These plots are scheduled to be monitored again in 2026.

Long-term post-fire monitoring occurred at seven BRMP plots in 2021. Six of those plots had burned in the 24 Command Fire in 2000. The BRMP plots selected had all been monitored once prior to the fire and at least once between the fire and the 2021 monitoring effort. The goal of long-term BRMP plot monitoring

in these areas was to evaluate vegetation recovery over time with no post-fire restoration. The seventh plot burned in the Gable Mountain Fire and provides pre-fire vegetation data from 1996 and 2009. Results from BRMP plot monitoring are reported by plot rather than by individual PC locations. BRMP plot monitoring occurred from June 7 to June 10, 2021. BRMP Plot surveys are planned every five years, therefore, the sites were not surveyed in 2022 or 2023.

2.3.2.1 BRMP Plot 2

BRMP Plot 2 (referred to as BRMP 2) is located in an area classified by HNF-61417 as an antelope bitterbrush/Sandberg's bluegrass cheatgrass-dominated habitat with a low cover of antelope bitterbrush, rubber rabbitbrush, and green rabbitbrush in the overstory, as well as Sandberg's bluegrass and cheatgrass co-dominant in the understory along with low coverage of ricegrass and needle-and-thread grass. The soil in this area varies between Quincy sand and Burbank loamy sand. This plot was established and first monitored in 1996, four years prior to the 24 Command Fire. Two PC locations (PC-1 and PC-3) were evaluated for this study. Figure 33 shows the change in vegetative composition over time and Figure 34 shows the change in the dominant grass coverage over time at BRMP 2.

Average native cover at BRMP 2 in 1996 was 25.9%, made up mainly of Sandberg's bluegrass and dune scurfpea (*Ladeania lanceolata*). No shrubs were detected in the overstory in either location in 1996. Non-native species averaged 54.4% cover, with cheatgrass as the dominant non-native species. BRMP 2 was monitored for vegetative cover for a second time in 2009, nine years after the 24 Command Fire. Monitoring in 2009 showed an increase in native species cover, with native cover averaging 30.6%. Sandberg's bluegrass, dune scurfpea, pale-evening primrose (*Oenothera pallida*), hoary tansyaster, and needle-and-thread grass made up the majority of the native cover in 2009. Non-native cover had decreased significantly since 1996 monitoring; in 2009 it averaged 12.8% but was still dominated by cheatgrass.

BRMP 2 was monitored for a third time on June 7, 2021. Average native cover had decreased to 18.7%, below pre-fire levels. Sandberg's bluegrass and dune scurfpea made up the majority of the native cover in the area with tarweed fiddleneck and needle-and-thread grass present as minor components of the understory. Non-native cover had increased to 19.7% since 2009 monitoring but was still significantly less than pre-fire levels. Cheatgrass was the most common non-native species with Russian thistle and tall tumblemustard as minor components of the understory. No shrubs or shrub seedlings were detected on either transect in 2021. BRMP Plot surveys are planned every five years, therefore, the sites were not surveyed in 2022 or 2023.

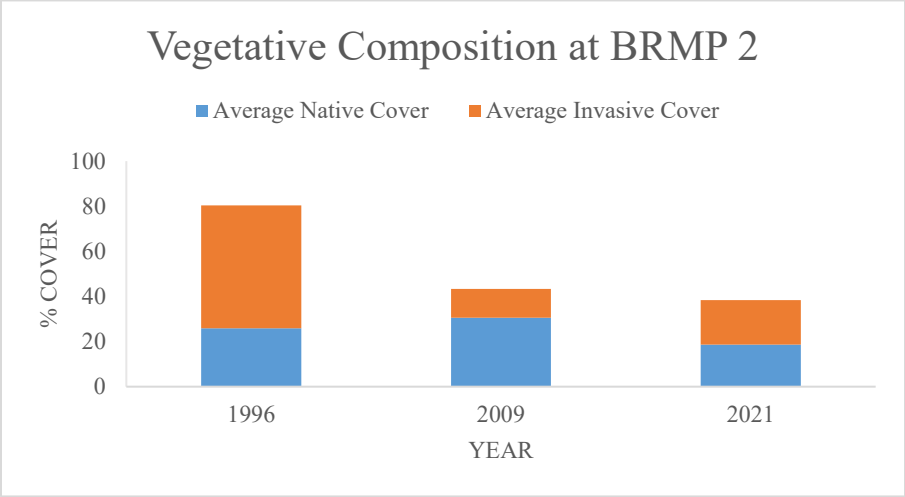

Figure 33. The Average Vegetative Composition at BRMP 2 Over Time

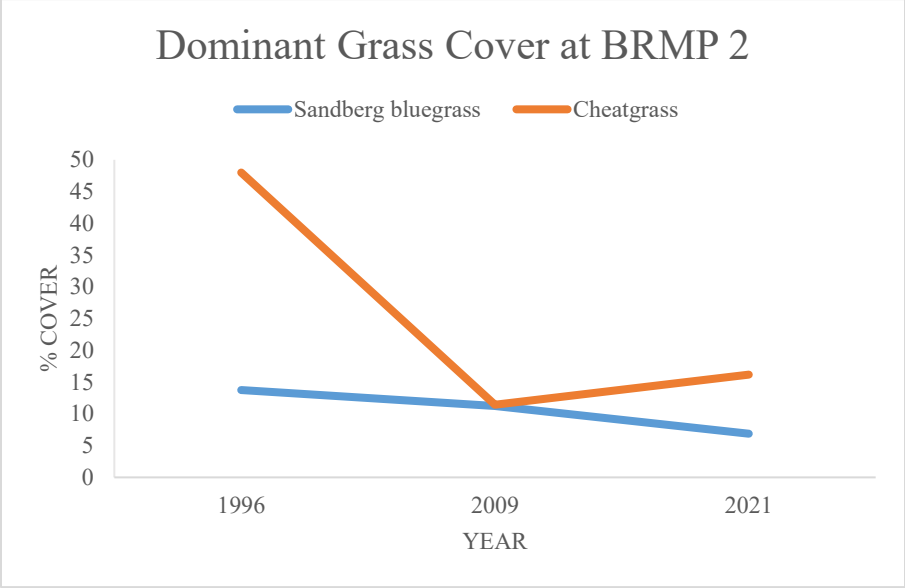

Figure 34. Changes in Dominant Grass Cover at BRMP 2 over Time

2.3.2.2 BRMP Plot 4

BRMP Plot 4 (referred to as BRMP 4) is located in an area classified by HNF-61417 as an antelope bitterbrush/Bunchgrass and antelope bitterbrush/Sandberg's bluegrass cheatgrass-dominated habitat with a low cover of antelope bitterbrush, sagebrush, and green rabbitbrush in the overstory and Sandberg's bluegrass and cheatgrass co-dominant in the understory with needle-and-thread grass ranging from a minor component to co-dominant and low coverage of ricegrass. The soil in this area varies between Quincy sand and Ephrata sandy loam. This plot was established and first monitored in 1996, four years prior to the 24 Command Fire. Two PC locations (PC-1 and PC-3) were evaluated for this study over three years (1996, 2002, and 2021). Figure 35 shows the change in vegetative composition over time and Figure 36 shows the change in the dominant grass coverage over time at BRMP 4.

Average native cover in 1996 monitoring was 10.4% at BRMP 4. Sandberg's bluegrass and dune scurfpea made up the majority of the native cover in this area. Non-native cover averaged 49.5%, with the majority of that coverage made up by cheatgrass. BRMP 4 was monitored for a second time in 2002, two years after the 24 Command Fire. Monitoring after the fire found lowered native and non-native cover at 3.8% and 30.2%, respectively. Native cover mainly consisted of Sandberg's bluegrass. Antelope bitterbrush was recorded within the transect in 2002. Non-native cover was made up of cheatgrass and early spring annuals such as jagged chickweed and spring draba.

BRMP 4 was monitored on June 7, 2021. Average native cover had increased since the fire and was measured at 13.3%. Antelope bitterbrush, needle-and-thread grass, and dune scurfpea made up the majority of the native cover. Minor native components of the understory included Sandberg's bluegrass and tarweed fiddleneck. Non-native cover had decreased below pre-fire levels with an average cover of 21% that mainly consisted of cheatgrass and rush skeletonweed (*Chondrilla juncea*). The spring annuals jagged chickweed and spring draba were minor non-native components of the understory. BRMP Plot surveys are planned every five years, therefore, the sites were not surveyed in 2022 or 2023.

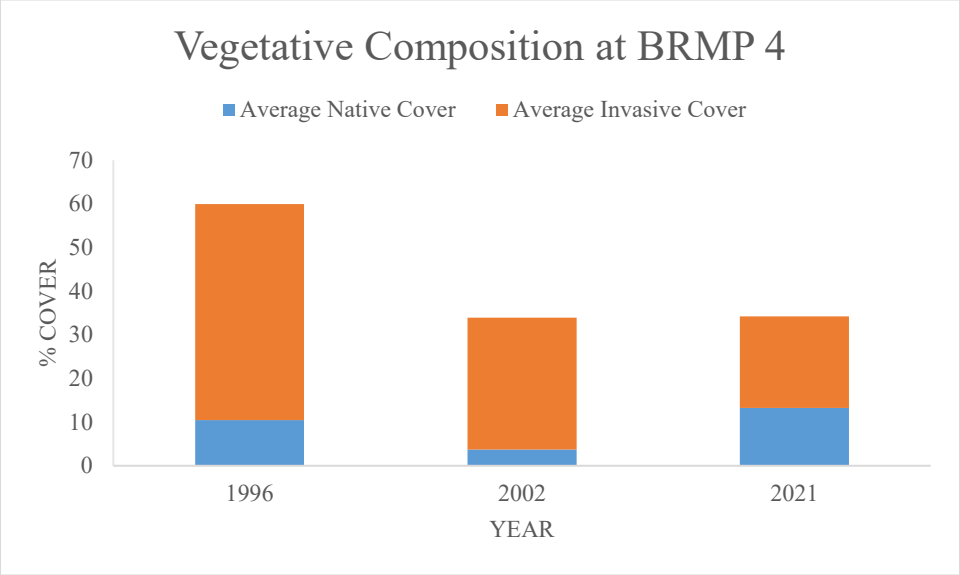

Figure 35. The Average Vegetative Composition at BRMP 4 Over Time

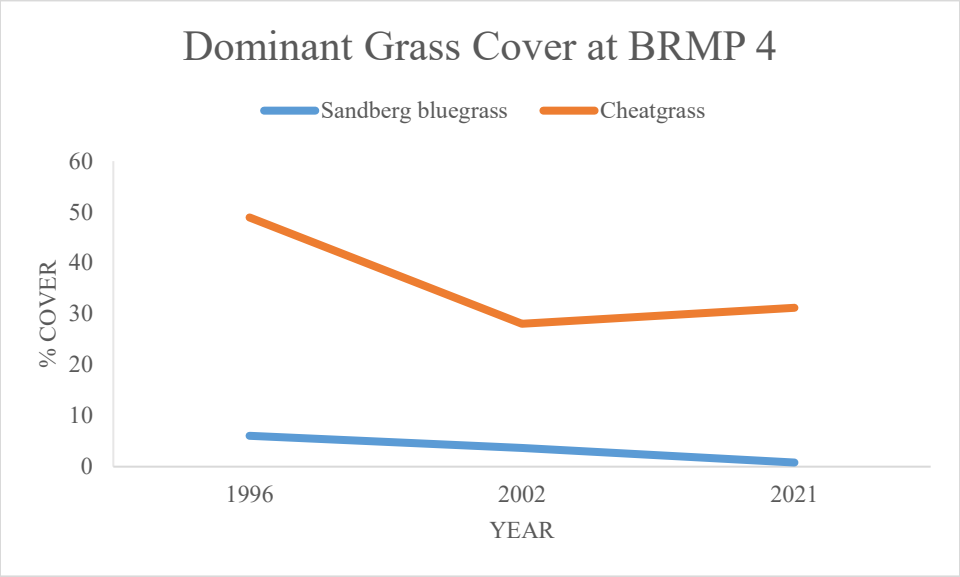

Figure 36. Changes in Dominant Grass Cover at BRMP 4 Over Time

2.3.2.3 BRMP Plot 5

BRMP Plot 5 (referred to as BRMP 5) is located in an area classified by HNF-61417 as an antelope bitterbrush/Bunchgrasses-dominated habitat. It was characterized as having 0 to 3% cover of sagebrush, antelope bitterbrush, green rabbitbrush, and rubber rabbitbrush in the overstory and co-dominant needle-and-thread grass, Sandberg's bluegrass, and cheatgrass with low cover of ricegrass in the understory. The soil in this area is characterized as Hezel sand. This plot was established and first monitored in 1996, four years prior to the 24 Command Fire. Two PC locations (PC-1 and PC-3) were evaluated for this study. Figure 37 shows the change in vegetative composition over time and Figure 38 shows the change in the dominant grass coverage over time at BRMP 5.

Average native cover measured in 1996 before the 24 Command Fire was 33.3%. This included sagebrush, which was present at over 10% cover, and spiny hopsage as a minor component of the native overstory. Other dominant native species included long-leaf phlox, Sandberg's bluegrass, desert parsley (*Cymopterus terebinthus*), and dune scurfpea. Non-native cover averaged 31% and was heavily dominated by cheatgrass. BRMP 5 was monitored again in 2005, five years after the fire. Average native cover decreased to 12.5% with Sandberg's bluegrass, rosy gilia (*Gilia sinuata*), and long-leaf phlox as the dominant components of the understory. The only shrub detected in the overstory in 2005 was green rabbitbrush. Average non-native cover was 20.7% and was dominated by both cheatgrass and tall tumblemustard, which had not been present in significant quantities before the fire.

BRMP Plot 5 was monitored on June 10, 2021. The area had a variety of forbs and grasses but was dominated by cheatgrass. Average native cover had decreased again to 8.8%. Sandberg's bluegrass, needle-and-thread grass, ricegrass, tarweed fiddleneck, and Carey's balsamroot (*Balsamorhiza careyana*) were dominant components of the understory. Sagebrush was detected on one transect but was not present at

significant levels. Average non-native cover had increased since 2005 monitoring to 25.6%, dominated by cheatgrass and with Russian thistle as a minor component. BRMP Plot surveys are planned every five years, therefore, the sites were not surveyed in 2022 or 2023.

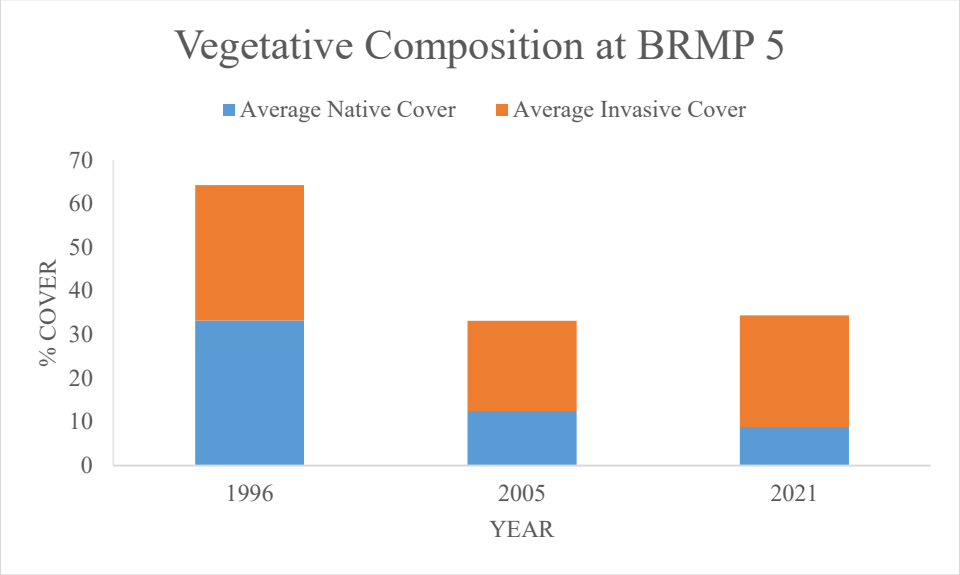

Figure 37. The Average Vegetative Composition at BRMP 5 Over Time

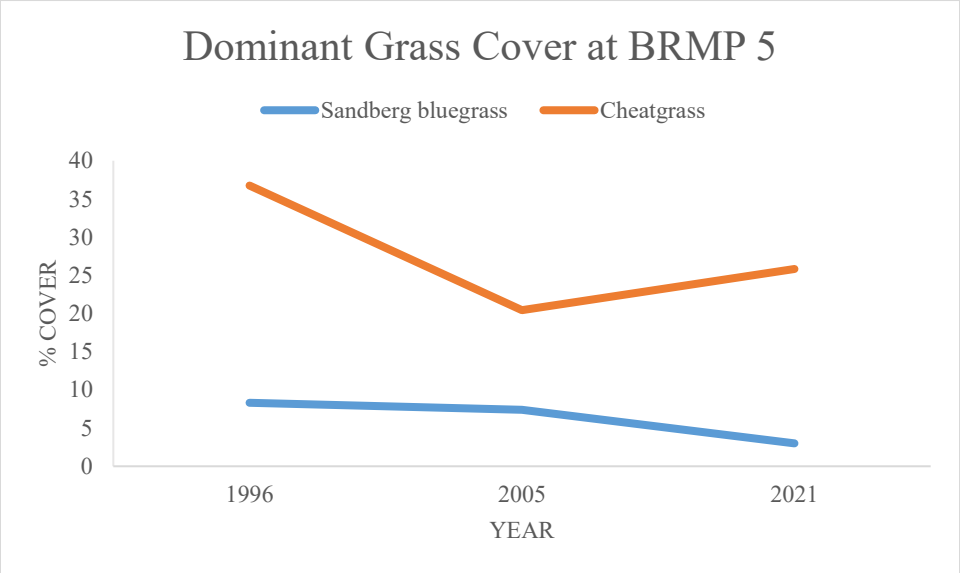

Figure 38. Changes in Dominant Grass Cover at BRMP 5 Over Time

2.3.2.4 BRMP Plot 6

BRMP Plot 6 (referred to as BRMP 6) is located in an area classified by HNF-61417 as a mix of antelope bitterbrush/bunchgrasses and Sandberg's bluegrass cheatgrass-dominated habitat. It was characterized as having 0 to 3% cover of sagebrush, antelope bitterbrush, green rabbitbrush, and rubber rabbitbrush in the

overstory and co-dominant needle-and-thread grass, Sandberg's bluegrass, and cheatgrass with low cover of ricegrass in the understory. The soil in this area is characterized as Hezel sand. This plot was established and first monitored in 1996, four years prior to the 24 Command Fire. Two PC locations (PC-1 and PC-3) were evaluated for this study. Figure 39 shows the change in vegetative composition over time and Figure 40 shows the change in the dominant grass coverage over time at BRMP 6.

Average native cover at BRMP 6 in 1996 was 28.4%, which was mainly composed of Sandberg's bluegrass. Native plants that were minor components of the environment included sagebrush and rubber rabbitbrush. Average non-native cover was 34.4%, which was composed mainly of cheatgrass with jagged chickweed, spring draba, and Russian thistle as minor components of the understory. Monitoring was performed at BRMP 6 again in 2005, five years after the 24 Command Fire. Native cover had not changed significantly and was measured at 29.6%. Sandberg's bluegrass still made up the majority of the native cover, but sagebrush and rubber rabbitbrush were no longer present and there was no overstory component. Non-native cover had decreased and measured 12%. Non-native cover was still dominated by cheatgrass and tall tumblemustard had significant cover compared to 1996 levels.

BRMP Plot 6 was monitored on June 9, 2021. Native cover averaged only 7.1%. The understory was dominated by needle-and-thread grass and Sandberg's bluegrass. A wide variety of forbs were detected on this transect but not at levels providing significant coverage. The forb with the highest cover was pale-evening primrose. Non-native coverage increased slightly in 2021 over 2005 levels to 13.8%; however, this was still below the pre-fire non-native coverage of 34.4%. Non-native coverage was dominated by cheatgrass, and Russian thistle and tall tumblemustard made up a minor component of the coverage. BRMP Plot surveys are planned every five years, therefore, the sites were not surveyed in 2022 or 2023.

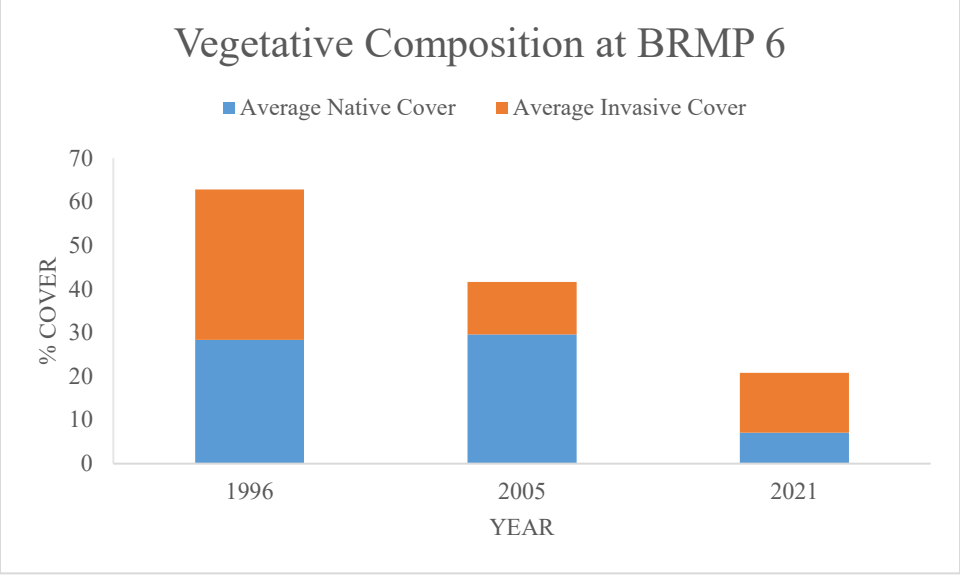

Figure 39. The Average Vegetative Composition at BRMP 6 Over Time

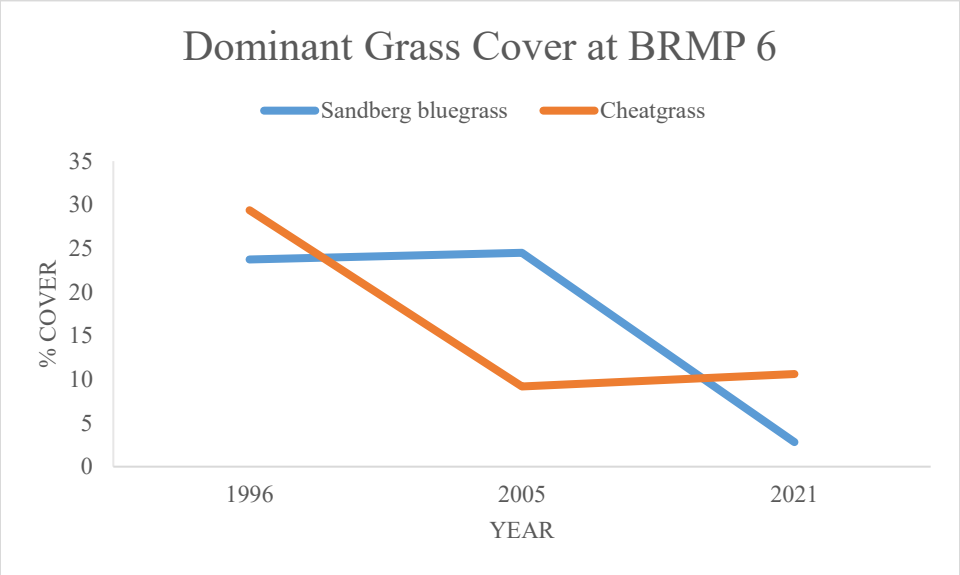

Figure 40. Changes in Dominant Grass Cover at BRMP 6 Over Time

2.3.2.5 BRMP Plot 10

BRMP Plot 10 (referred to as BRMP 10) is located in an area classified by HNF-61417 as a Bunchgrass habitat. It is characterized by having a low coverage of sagebrush, rubber rabbitbrush, and green rabbitbrush overstory along with needle-and-thread grass, Sandberg's bluegrass, and cheatgrass, all co-dominant in the understory. Ricegrass also makes up a minor component of the understory. The soil in this area is characterized as Quincy sand. This plot was established and first monitored in 1996, four years prior to the 24 Command Fire. Two PC locations (PC-1 and PC-3) were evaluated for this study. Figure 41 shows the change in vegetative composition over time and Figure 42 shows the change in the dominant grass coverage over time at BRMP 10.

Average native cover at BRMP 10 in 1996 was 32.8%. Native cover was dominated by needle-and-thread grass, which had 20.8% coverage within PC-1. Other high-coverage native species included Sandberg's bluegrass, sagebrush, and small fescue. Average non-native cover totaled 37.4%, which was almost completely dominated by cheatgrass. Vegetative cover was measured again in 2009, nine years after the 24 Command Fire. Native cover averaged 12.3% and was dominated by needle-and-thread grass, ricegrass, and Sandberg's bluegrass. Sagebrush was not recorded on either PC transect in 2009. Non-native cover averaged 21.4% and was dominated by cheatgrass.

BRMP 10 was monitored on June 9, 2021. Native cover averaged 9.4% and was dominated by needle-and-thread grass and Sandberg's bluegrass. A number of forbs were detected in the understory with hoary tansyaster and desert parsley providing some native coverage. Sagebrush was detected at 0.1% cover in PC-1. Non-native cover averaged 27.1%, more than what was detected in 2009 but still below pre-fire levels. Cheatgrass dominated the area, averaging 23.3% coverage throughout BRMP 10. Russian thistle

was also present at significant levels at this site. BRMP Plot surveys are planned every five years, therefore, the sites were not surveyed in 2022 or 2023.

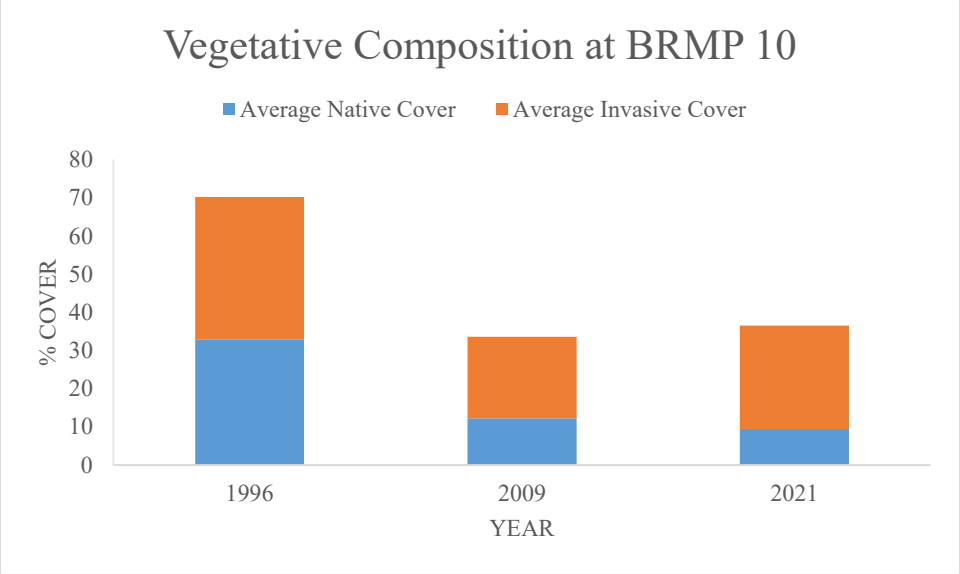

Figure 41. The Average Vegetative Composition at BRMP 10 Over Time

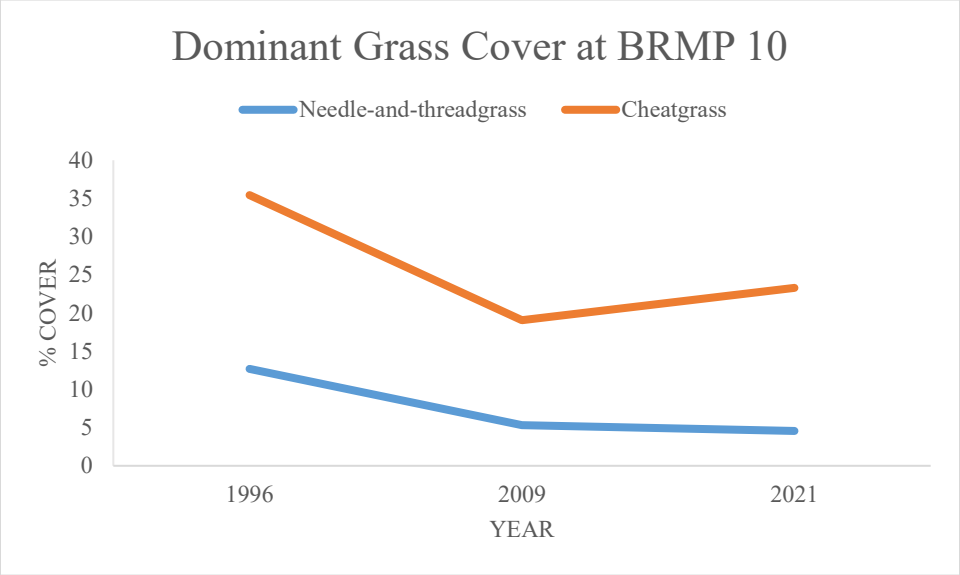

Figure 42. Changes in Dominant Grass Cover at BRMP 10 Over Time.

2.3.2.6 BRMP Plot 15

BRMP Plot 15 (referred to as BRMP 15) is located in an area classified by HNF-61417 as a bunchgrasses habitat. It is characterized by having a low coverage of rubber rabbitbrush and green rabbitbrush overstory with needle-and-thread grass dominant in the understory. Also present in the understory is Sandberg's bluegrass and cheatgrass with a patchy distribution. The soil in this area is characterized as Quincy sand.

This plot was established and first monitored in 1996, four years prior to the 24 Command Fire. Two PC locations (PC-1 and PC-2) were evaluated for this study. Figure 43 shows the change in vegetative composition over time and Figure 44 shows the change in the dominant grass coverage over time at BRMP 15.

Average native cover at BRMP 15 in 1996 was 23.7%. Sagebrush made up the majority of the native coverage with an average cover of 17.3%, followed by desert parsley, which had significant coverage in this area. Non-native cover averaged 43.6% and was heavily dominated by cheatgrass. BRMP 15 was monitored again in 2009, nine years after the 24 Command Fire. Native cover had decreased to 9.4%, mainly due to the loss of the sagebrush overstory. Forbs, including desert parsley, common yarrow (*Achillea millefolium*), and long-leaf phlox, dominated the native understory. Needle-and-thread grass was the dominant grass with some Sandberg's bluegrass interspersed. Non-native cover decreased to 28.1% with cheatgrass dominating the area. Tall tumblemustard, which had not been recorded in significant levels in 1996, was also present and averaged 2.8% cover.

BRMP 15 was monitored on June 8, 2021. Native cover averaged 6.0%, marking a steady decline in native cover since 1996 monitoring. Desert parsley and needle-and-thread grass were the dominant native species with Sandberg's bluegrass and ricegrass as minor components of the understory. Rubber rabbitbrush was the only shrub detected at either transect, no sagebrush shrubs or seedlings were found. Non-native species had 17.9% cover and had also steadily decreased since 1996 monitoring. Cheatgrass was the dominant non-native species; this was the only site where cheatgrass coverage had declined gradually since 1996 monitoring. BRMP Plot surveys are planned every five years, therefore, the sites were not surveyed in 2022 or 2023.

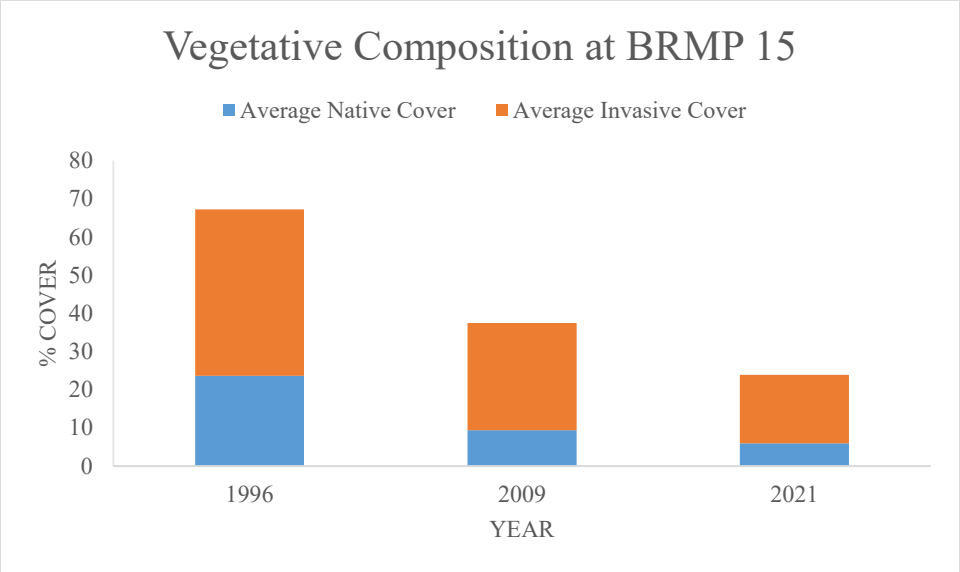

Figure 43. The Average Vegetative Composition at BRMP 15 Over Time

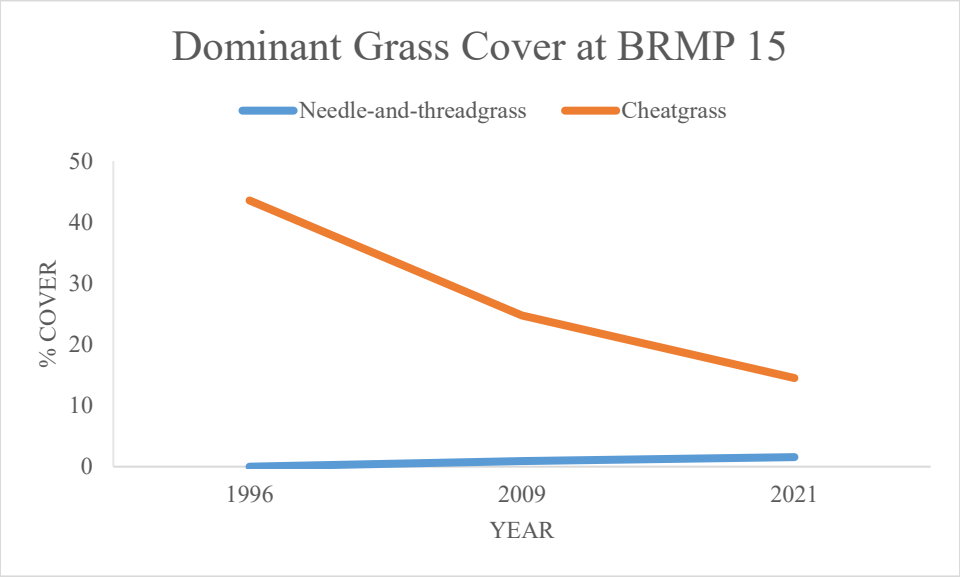

Figure 44. Changes in Dominant Grass Cover at BRMP 15 Over Time

2.3.2.7 BRMP Plot Trends

The data from BRMP Plots 2, 4, 5, 6, 10, and 15 were analyzed as a unit to identify potential trends in vegetation recovery after the 24 Command Fire. Native and non-native species coverage over time, dominant grass coverage, and shrub survival and recovery were all evaluated.

Native and non-native species coverage and dominant grass coverage over time followed similar patterns, as shown in Figures 45 and 46. Data from 1996 showed relatively high levels of non-native species before the fire, mainly consisting of cheatgrass coverage that averaged 35% across all sites. Both non-native and native cover dropped post-fire, with non-native species seeing an average decrease of 21% and native species decreasing by 9%. When looking at only the dominant native grass at each post-fire site, the dominant native grass cover dropped by 3%, significantly less than the steep decline in cheatgrass coverage of 20%. Despite this decrease in non-native species cover in the years immediately following the 24 Command Fire, by 2021, cheatgrass cover had begun to increase while native species cover continued decreasing. Native species decreased by 6% from less than 10 years after the fire to 2021 monitoring and the dominant native grass decreased by 5%. Over the same period, cheatgrass cover increased by 5%. Non-native species cover did not vary over this period, likely due to increases in cheatgrass being offset by decreases in early successional weeds like tall tumblemustard and Russian thistle.

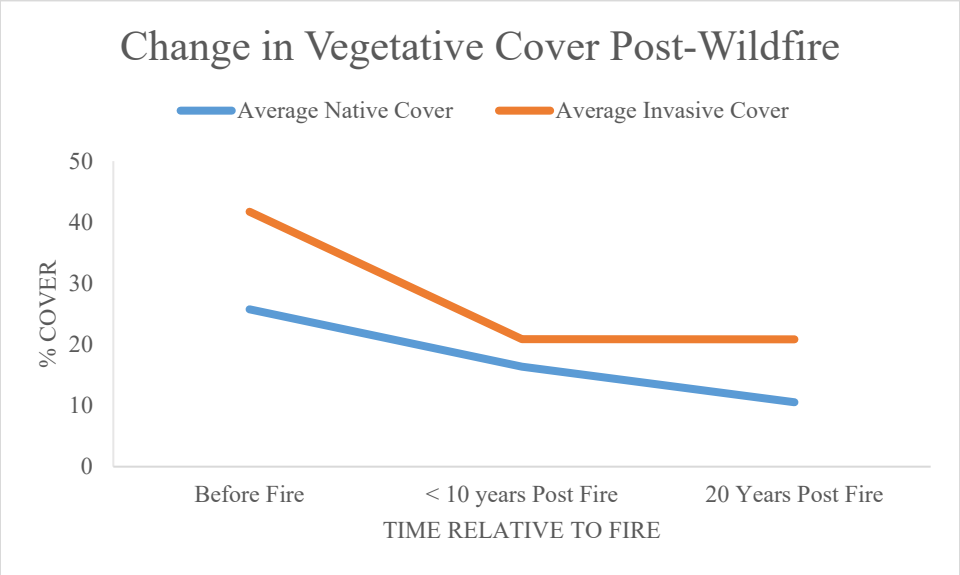

Figure 45. Change in Vegetative Cover at BRMP Plots Burned in the 24 Command Fire

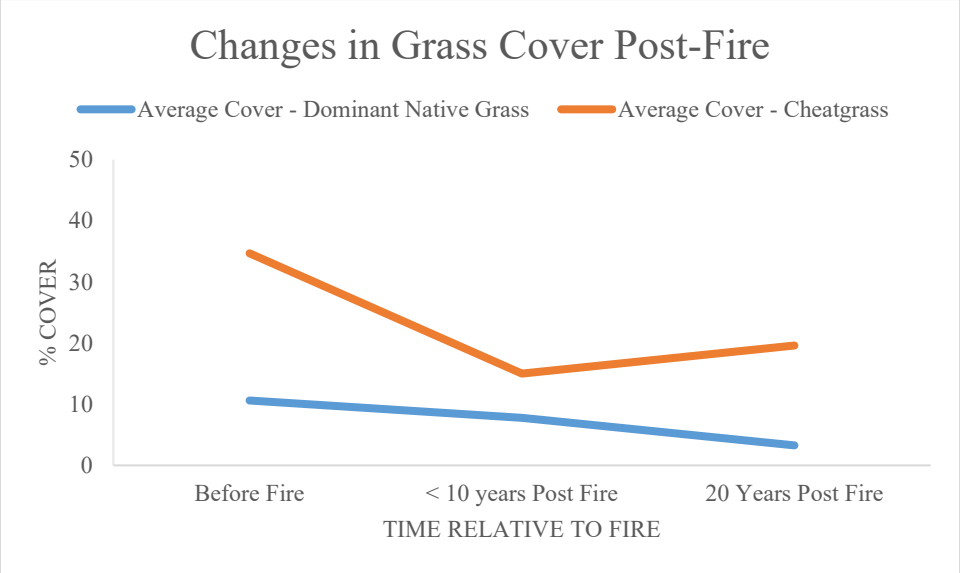

Figure 46. Change in Grass Cover in BRMP Plots Burned in the 24 Command Fire

An additional noteworthy trend is the decrease in shrub cover after fire (Figure 47) (i.e. sagebrush, spiny hopsage, and antelope bitterbrush). Four of the BRMP Plots (BRMP 5, BRMP 6, BRMP 10, and BRMP 15) had significant coverage of sagebrush or spiny hopsage before the 24 Command Fire. In the monitoring window that occurred less than 10 years after the fire, sagebrush and/or spiny hopsage cover was insignificant at all of these sites. In 2021 monitoring, sagebrush was detected at low levels within three of the four plots that previously contained high sagebrush coverage. BRMP 5 contained sagebrush seedlings and established sagebrush. BRMP 6 had sagebrush seedlings and scattered established sagebrush. BRMP 10 had low coverage of established sagebrush on the transect. BRMP 15, which had the highest average sagebrush coverage before the fire (17.3%), had no sagebrush detected on either transect.

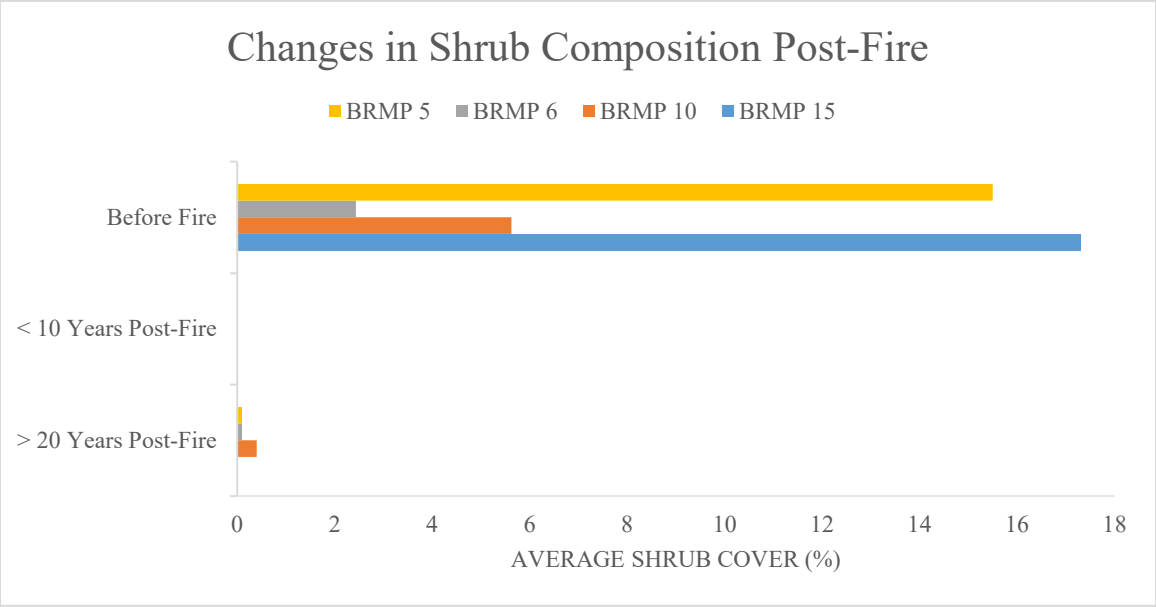

Figure 47. Changes in Shrub Composition at BRMP Plots after the 24 Command Fire

2.4 Discussion

An evaluation of how post-fire vegetation monitoring data can be used to inform management decisions in areas impacted by wildfires is provided in this section. The Gable Mountain restoration effort and BRMP plot monitoring results are assessed separately but conclusions from both of those monitoring efforts are used to inform future management.

2.4.1 Gable Mountain Fire Monitoring

The immediate post-fire monitoring that occurred after the Gable Mountain Fire in October 2020 showed little surviving vegetation throughout the majority of the burned area, with the exception of the north slope of Gable Mountain. In an area once dominated by a mature sagebrush overstory, habitat was reduced to ashes and matted cheatgrass. Though this area was considered high quality habitat prior to the Gable Mountain Fire, the unburned RA transects contained high quantities of cheatgrass in the understory with average cheatgrass cover totaling 31.4%. Monitoring in 2022 and 2023 showed very high levels of cheatgrass coverage at the RA transects, averaging 75.5% and 62.2%, respectively. This indicates that cheatgrass cover is highly variable even at sites with climax vegetation communities and likely correlated with annual precipitation, suggesting that cheatgrass was dominant in the understory of the Gable Mountain fire area prior to burning and likely fueled the fire to burn more intensely, resulting in high mortality of the native plants in the area. Pre-fire cheatgrass levels in the 24 Command Fire BRMP plots were also high, averaging 35%, resulting in a fire that eliminated the majority of the shrub overstory in that area. Monitoring at BRMP plots suggest that cheatgrass cover will be temporarily reduced in the years following fire but will gradually increase over time.

The Gable Mountain fire area was seeded with native grass species and sagebrush in January 2021 in an attempt to replenish the native seed bank and prevent cheatgrass from increasing beyond pre-fire coverage levels in the area. As there was no supplemental water added to the seeded area, this effort was heavily dependent on precipitation for success. Precipitation from January 1 to June 30, 2021, totaled 44.7 mm (1.8 in), well below the expected average level of 92.2 mm (3.6 in) for that period, as recorded by the Hanford Meteorological Station. Not only was rainfall only 48% of the average level, an early spring and above average temperatures left native and non-native plants at lower coverages than expected. This likely negatively influenced germination of both the species seeded in the restoration effort and germination of species in the seed bank that survived the fire. In 2022, precipitation from January 1 to June 30 totaled 110.0 mm (4.3 in), 119% of average, as recorded by the Hanford Meteorological Station. Cover of native and non-native species, as well as germination of some seeded and unseeded species, increased in 2022, likely due to the above average precipitation. In 2023, precipitation from January 1 to June 30 totaled 66.0 mm (2.6 in), 71% of average, as recorded by the Hanford Meteorological Station. Some decreases in both native and non-native species diversity and abundance were observed in 2023, likely as a result of the reduced precipitation relative to 2022.

Despite the abnormally low precipitation in spring 2021, bunchgrass seedlings were observed throughout the burn area. Sandberg's bluegrass was the major component of native coverage throughout the transects and had been included as a main component of the restoration seed mix in most areas. The majority of unidentified bunchgrass seedlings were believed to be needle-and-thread grass and ricegrass. Germination of bunchgrasses throughout the burned area suggests that the seeding effort had a beneficial impact or that native seed in the seed bank persisted through the fire. This germination occurred despite low precipitation, suggesting increased germination will be seen on years with average or high precipitation. In 2022, bunchgrass seedlings were found at an increased number of locations within the burned area compared to 2021, likely as a result of above average precipitation. Bunchgrasses, including bluebunch wheatgrass, sand dropseed, Sandberg's bluegrass, needle-and-thread grass, and ricegrass, were all observed growing from partially burned clumps and as seedlings throughout the burned area. This was mainly observed in areas with lower burn severity and remnants of surviving vegetation.

Sagebrush was present throughout the western and central portions of the burned area prior to the Gable Mountain Fire. Sagebrush decreases significantly in the seed bank following the fire (Allen et al. 2008). Native sagebrush was seeded over the high-density sagebrush area in an attempt to replenish the sagebrush overstory that had been decimated in the fire. With the exception of patches of sagebrush that survived the fire, in 2021 no sagebrush seedlings were observed within the high-density sagebrush area or within the Gable Mountain Area, where sagebrush had also been dominant pre-fire. Sagebrush seed remains viable in the seed bank for one to two years when buried or under litter and decreases in viability over time (Wijayratne and Pyke 2009). Typical restoration efforts increase seed to soil contact mechanically to increase seed viability; however, the Gable Mountain restoration effort prioritized execution immediately following the fire and, therefore, did not obtain authorization that would have been necessary to perform ground-disturbing activities. Sagebrush seed that remains in the seed bank and re-seeded sagebrush seed that was protected by litter has a chance to germinate the next growing season. In 2022, sagebrush seedlings were only detected at Transect 9, despite above average precipitation. Abundant sagebrush seedlings were

detected at RA 1, which is within a community of mature sagebrush shrubs, indicating that precipitation conditions were adequate for seedling germination in 2022. In 2023, additional juvenile sagebrush shrubs were detected near Transects 2, 7, 8, 9 11, and 14. These appeared to be greater than one year old and it is likely that they germinated in a previous year but were not detected until 2023.

Monitoring in spring 2021 showed little vegetative coverage, likely due to both the recency of the fire and the low precipitation for the year. Monitoring in 2022 recorded a trend of increasing native and non-native cover at most sites, with the level of increases varying substantially between sites. Large increases in non-native cover were observed across all five RAs in 2022, especially for cheatgrass. This indicates that the increase in non-native cover measured in 2022 may be a sitewide trend for the year because it was measured within the burned area and in the RAs. The above average precipitation received at the Hanford Site in 2022 was a likely factor driving large cover increases for cheatgrass and other non-native species. Additionally, the number of native species increased at most sites, particularly for non-seeded species, indicating that natural recovery is occurring. In 2023, native cover decreased slightly at a majority of transects, which is likely due to lower-than-average precipitation levels reducing germination of precipitation-dependent annuals. This trend was observed at two out of five RA transects, which does not clearly indicate whether this was part of a sitewide trend for that year, or due to other factors. Non-native cover increased at a majority of sites in 2023 despite the lower-than-average precipitation, indicating that non-native species may be displacing native species. This trend was observed at two out of five RA transects, which does not clearly indicate whether this was part of a sitewide trend for that year or due to other factors. With few exceptions, non-native cover at the RA transects greatly exceeds non-native cover at the burned transects. In 2023, one transect in the Gable Mountain Area and one transect in the High-Density Sagebrush Area were shown to have higher native cover than the average native cover of the RA transects. This indicates that native and non-native plant species will likely continue to increase in cover over time before reaching equilibrium. Continued monitoring will help to determine the effectiveness of selected restoration techniques under the conditions that occurred following the Gable Mountain Fire.

In 2022, increasing cover of tall tumblemustard was observed in the Gable Mountain Area, High-Density Sagebrush Area, and the Low-Density Sagebrush Area, with substantial increases at some transects. Tall tumblemustard is considered an early seral stage dominant in many habitats; however, in the dry Pasco Basin region, where the Hanford Site is located, it has been observed to reach equilibrium with cheatgrass for up to 30 years (Cline and Rickard 1973). Tall tumblemustard has important ecological considerations, as it has the potential to uptake and spread radioactive contamination. Additionally, dried tumblemustard plants accumulate and increase fire risk in some areas. Tall tumblemustard coverage declined substantially at all sites in 2023, indicating that its dominance was part of an early seral stage, or due to annual variation in precipitation.

2.4.2 BRMP Plot Monitoring

Results from long-term BRMP plot monitoring help increase understanding of vegetation recovery post-fire. Spring 2021 monitoring of BRMP plots revealed a number of significant trends among the plots that will be critical in understanding how areas of the Hanford Site recover post-fire.

Cheatgrass coverage was evaluated for BRMP plots that burned in the 24 Command Fire. Pre-fire coverage was relatively high at 35%. That coverage decreased in the first monitoring effort after the fire, then increased when monitored in 2021. It is expected that cheatgrass coverage will continue to increase at these sites. Cheatgrass coverage percentages in 2021 are likely lower than normal due to the low precipitation and corresponding lack of significant vegetative growth in 2021. Native species followed a different trend and decreased across the BRMP plots after the 24 Command Fire. Pre-fire native cover averaged 26.0%, decreasing to 16.0% less than 10 years after the fire and to 11.0% in 2021. This gradual decrease is concerning and reflects a gradual conversion of habitats dominated by native species to non-native species after fire. This conversion can be combatted by reseeding areas with native species after fire in an attempt to replenish the native seed bank and outcompete non-native species.

Four of the six BRMP plots burned in the 24 Command Fire contained sagebrush as a dominant overstory plant prior to the fire. Within these four sites, sagebrush coverage did not begin to increase significantly until 2021 monitoring where sagebrush cover still averaged less than 1.0%. The slow to non-existent recovery of the sagebrush overstory in burned areas has been observed after multiple fires on the Hanford Site, where a lack of sagebrush, decrease in native species, and increase in non-native species results in fire-converting sagebrush habitat to cheatgrass monocultures. This increases future fire danger as cheatgrass provides increased fuel loads for fire and perpetuates a destructive fire cycle (Knapp 1996).

Recovery of the BRMP Plots after the 24 Command Fire provide trends that can be used to interpret the recovery of the Gable Mountain fire area. Without restoration actions, the recovery of the Gable Mountain fire area would be expected to look similar to the 24 Command Fire area, especially in the BRMP plots with high sagebrush and cheatgrass cover prior to the fire (BRMP 5, 10, 15). If restoration actions are successful, the decreases in native cover would not be as pronounced at the Gable Mountain fire area compared to the 24 Command Fire BRMP plots. The initial results of BRMP plot monitoring support re-seeding after fire, especially for species like sagebrush that do not naturally recover well after fire.

2.4.3 Future Actions

The results of the Gable Mountain Fire and 24 Command Fire monitoring provide an initial dataset that can be used to track the recovery of a restored burned area versus an unrestored burned area. Future monitoring will help develop the Gable Mountain Fire dataset and will provide needed information about continued recovery after fire. Monitoring frequency in the Gable Mountain fire area should be maintained on an annual basis, with effort made to repeat the monitoring activity around the same time each year, adjusted for phenology. BRMP plot vegetative composition is not expected to change significantly on an annual basis, it is recommended the BRMP plots burned in the 24 Command Fire be revisited every five years to collect additional trend data. These plots are scheduled to be monitored next in 2026.

Based on the results of BRMP plot monitoring, it is recommended that restoration action be taken within burned areas on the Hanford Site. Both supplementing native grasses and returning the shrub overstory is crucial to restoring pre-fire habitat quality. Where sagebrush is a critical component of the ecosystem, sagebrush seed should be included within the restoration mix and efforts should be made to increase seed

to soil contact, when feasible. Continued monitoring of the Gable Mountain fire area will help restoration practitioners refine the Hanford Site post-fire seed mix and determine the best restoration for an area.

3.0 Route 11A Fire

3.1 Background

A 1,295 ac (524 ha) fire occurred near route 11A on the Hanford Site in May 2023. The burned area consisted of 92% Inter-Mountain-Basins Big Sagebrush Steppe, 7% Columbia Plateau Steppe and Grassland, and 1% unvegetated consisting of roads. Inter-Mountain-Basins Big Sagebrush Steppe and Columbia Plateau Steppe and Grassland are both considered Imperiled (S2) in Washington State. An example photo point of intact Inter-Mountain Basins Big Sagebrush Steppe is shown in Figure 48.

Approximately 6,200 m (6,780 yd) of fire break were constructed along the western, southern, and eastern boundaries of the fire, while the northern boundary was made by existing roads Route 11A and Route 2 South

The resource categories identified by the BRMP prior to the burn include level 4 high quality mature shrub steppe, level 3 vegetation cover types, level 3 conservation corridors, level 2 mid-successional habitats, and level 1 marginal habitats.

An Ecological Integrity Assessment and species inventory was not completed in this area prior to the burn. No element occurrences for habitat, or rare plants were identified in this area.

Figure 48. Photo point CH-112 taken in 2013, showing Inter-Mountain Basins Big Sagebrush Steppe

3.2 Monitoring Results

A site walkthrough completed on May 25, 2023, noted that the burn appeared to be of relatively low intensity and some big sagebrush individuals had maintained their leaves.

Six transects were installed and monitored for shrub survival transects and vegetation cover in mid-July 2023. Only one of six shrub survival transects detected living shrubs. Five living big sagebrush shrubs and one green rabbitbrush shrub were detected. Vegetation cover transects showed an average vegetation cover of 2.0% cover across all transects. Native cover averaged 1.6% and consisted mostly of needle-and-thread grass. Non-native cover averaged 0.4% and consisted mostly of cheatgrass.

Nine existing photo points were identified within the burned area, all of which were reimaged. No new photo points were established. A photo point in the burned area in 2023 is shown in Figure 49.

By July, big sagebrush individuals that had maintained leaves immediately after the fire were dead. Small patches of surviving big sagebrush were recorded. Twenty-two surviving big sagebrush individuals were observed throughout the burned area.

Figure 49. Photo point CH_112 taken in 2023, showing the burned area

A species inventory found five non-native species, four of which are considered invasive, and 11 native species (Table 2). The native, invasive, noxious, or exotic status is provided by the Washington Natural Heritage Program (Rocchio et al. 2020) and the Washington State Noxious Weed Control Board (NWCB 2021). Invasive species are distinguished from exotic species. Exotic species are not native to an area but do not have the potential to spread aggressively or cause ecological harm like invasive species. Designation

as a noxious weed is a legal distinction based on proven harm to human interests (NWCB 2021). Infestations of rush skeletonweed, a class B noxious weed, baby's breath (*Gypsophila paniculata*), a class C noxious weed, and yellow star-thistle *(Centaurea solstitialis*), a class B noxious weed, were recorded while traveling between transects. Noxious weed data was submitted to the Noxious Weed Program Manager.

Table 2. Route 11A Fire Surviving Species List.

Species	Status
Achillea millefolium (yarrow)	native
Amsinckia lycopsoides (tarweed fiddleneck)	native
Astragalus caricinus (buckwheat milk-vetch)	native
Balsamorhiza careyana (Carey's balsamroot)	native
Centaurea solstitialis (yellow star-thistle)	Class B noxious weed
Chondrilla juncea (rush skeletonweed)	Class B noxious weed
Chrysothamnus viscidiflorus (green rabbitbrush)	native
Cymopteris terebinthinus (turpentine spring parsley)	native
Gypsophila paniculata (baby's breath)	Class C noxious weed
Hesperostipa comata (needle-and-thread grass)	native
Opuntia columbiana (Columbia prickly-pear)	native
Phlox longifolia (long-leaf phlox)	native
Rumex venenosus (winged dock)	native
Sisymbrium altissimum (tall tumblemustard)	invasive
Sporobolus cryptandrus (sand dropseed)	native
Tragopogon dubius (yellow salsify)	exotic

3.3 Management Recommendations

Management actions are recommended to restore lost level 4 and level 3 BRMP resources. Without intervention and active management, cheatgrass fires result in a loss of total plant diversity and can result in the complete loss of the sagebrush overstory (Colorado State University and University of Wyoming 2013, Bakker et al. 2011). To decrease future fire risk and to disrupt the positive feedback cycle between cheatgrass and fire, land managers can make efforts to restore native vegetation following a fire. Restoration post-fire is thought to be advantageous; immediately following a fire cheatgrass seeds are temporarily reduced in the seed bank (Humphrey and Schupp 2001). This temporary reduction in cheatgrass dominance would give native plants a chance to establish; however, studies have shown that in cheatgrass-dominated areas few native seeds (less than 4%) are present in the seed bank following a fire (Humphrey and Schupp 2001). This is not sufficient to establish a strong native population, suggesting human intervention may be required.

3.3.1 Noxious Weed Treatment

Noxious weed treatment is recommended before revegetation. Eradication of baby's breath and yellow star-thistle is top priority, as these species are aggressive invaders and are not widespread on the Hanford Site.

Eradication of rush skeletonweed is of secondary concern but recommended to prevent the infestation from expanding. Eradicating noxious weeds throughout the burned area reduces competition with native species.

Hand-pulling is recommended for noxious weed eradication. Herbicide use is not recommended due to the potential for non-target effects, as the invasion areas are currently small. All-terrain vehicle (ATV) use is not recommended for locating or treating noxious weeds. The use of ATVs is likely to damage sensitive native plants during re-establishment and destroy small pockets of surviving cryptobiotic crust. ATV use may also exacerbate erosion and dust problems. The use of herbicides and/or ATVs are likely to be counterproductive to the restoration effort.

3.3.2 Revegetation

Revegetation is recommended to maintain habitat quality in the burned area. Re-establishment of shrubs after fire is highly dependent on nearby seed sources. Big sagebrush seed dispersal range has been shown to be between 1 and 15 m (1 and 49 ft; Clements and Harmon 2019, Jacobs et al. 2011). Surviving big sagebrush cover is very low within the burned area and was observed to be fairly low surrounding the burned area. This is likely insufficient for big sagebrush to re-establish in the burned area before it is overtaken by invasive species. This indicates that level 3 and level 4 resources are unlikely to recover without intervention, and the burned area would likely stabilize at level 1 and level 2 vegetation cover types.

Vegetation cover transects showed an average cover of 1.0% for surviving needle-and-thread grass and some burned clumps that may or may not be alive. This may be sufficient to re-establish in the burned area, particularly in the area identified as Columbia Plateau Steppe and Grassland prior to the burn. This ecological system is more fire tolerant than Inter-Mountain Basins Big Sage Steppe and, therefore, more likely to recover without intervention. However, this ecological system only covered a small portion of the burned area and it represents a BRMP level 3 resource.

Species used for restoration should be selected based on vegetation present prior to the burn, using regionally sourced seeds. It should include big sagebrush, Sandberg's bluegrass, mixed bunchgrasses and mixed forbs. The seed mix may be modified based on availability. Detailed revegetation methods, including seeding mix rate and seeding timing recommendations, can be found in DOE/RL-2011-116, *Hanford Site Revegetation Manual*.

3.3.3 Fire Break Revegetation

The BRMP states that 6,200 m (3.9 mi) of temporary firebreaks constructed during firefighting should be re-contoured and reseeded with an appropriate mix of locally derived native plant species as described in the DOE/RL-2011-116*, Hanford Site Revegetation Manual.*

3.3.3.1 Annual Monitoring

Annual monitoring is recommended to track revegetation progress, if initiated, and secondary invasion after noxious weed treatment. Monitoring should follow the methods for short-term and long-term monitoring described in the HNF-67070, *Hanford Site Post-Fire Vegetation Monitoring Report for Calendar Year 2021.* This will consist of revisiting photo points, monitoring transects, and re-mapping noxious weed infestations. Annual monitoring (short-term monitoring) is recommended for the first five years, then the monitoring schedule may be reduced to once every five years (long-term monitoring).

4.0 Gable Butte Fire

4.1 Background

A 17.2 ha (42.4 ac) fire occurred at Gable Butte on September 2, 2023 (Figure 50). The area that burned consisted of 3.7 ha (9.2 ac) of Columbia Plateau Steppe and Grassland, 5.2 ha (13.0 ac) of Columbia Plateau Scabland Shrubland, 6.5 ha (16.0 ac) of Inter-Mountain-Basins Big Sagebrush Steppe, 1.6 ha (4.0 ac) of Invasive Annual Grassland, and 0.1 ha (0.3 ac) of non-vegetated area. Inter-Mountain-Basins Big Sagebrush Steppe and Columbia Plateau Steppe and Grassland are both considered Imperiled (S2), Columbia Plateau Scabland Shrubland is considered Secure (S5), and Invasive Annual Grassland is not ranked in Washington State. An example of intact Columbia Plateau Scabland Shrubland is shown in Figure 51. Table 3 shows a breakdown of the vegetation communities that burned based on vegetation mapping units from HNF-61417, *Upland Vegetation of the Central Hanford Site*.

Table 3. Vegetation Communities impacted by Gable Butte 2023 Burn.

Vegetation Type	Acres	Hectares
Big sagebrush (Half-shrubs)/Bunchgrasses	1.9	0.8
Big sagebrush (Half-shrubs)/Sandberg bluegrass-Cheatgrass	11.1	4.5
Big sagebrush/Bunchgrasses	0.1	<0.1
Big sagebrush/Sandberg bluegrass-Cheatgrass	0.2	0.1
Bunchgrasses	9.2	3.7
Sandberg bluegrass-Cheatgrass	19.7	8.0
Non-vegetated	0.3	0.1
Total	42.4	17.2

Figure 50. Aerial view of Gable Butte Fire photographed in October 2023

Figure 51. Photo point M_631 taken in 2015 prior to the recent fire, showing Columbia Plateau Scabland Shrubland

Fire breaks were not constructed in support of the firefighting effort for the Gable Butte Fire. Extensive off road vehicle travel was utilized to extinguish the fire. The long-term effects of this off-road travel are not fully known but could include increased invasive species cover and erosion due to the disturbance of the existing vegetation and microbiotic crusts.

The entire burned area was ranked as a level 5 resource by the BRMP. The area is not recorded to have burned since record keeping began in 1978.

An Ecological Integrity Assessment and species inventory was not completed in this area prior to the burn. No Element Occurrences were identified in this area prior to the burn.

4.2 Monitoring Results

A site walkthrough was conducted in September 2023. Near total plant mortality was observed with sparse patches of surviving vegetation and biological soil crust. Some big sagebrush, slender buckwheat, and bluebunch wheatgrass (Figure 52) survived the fire, sheltered in a few high, rocky places. Approximately 30 individuals of big sagebrush were observed to have survived the burn. The near total plant mortality challenges the assumption that the Columbia Plateau Scabland Shrubland ecological system is more resilient to fire than other ecological systems (Rocchio and Crawford 2015). The burned area is surrounded by a perimeter of mature shrubs and bunchgrasses with a thick cheatgrass understory.

One existing photo point was identified in the burned area, and one existing photo point was identified just outside of the burned area. Both points were revisited, and five new photo points were established.

A plant species inventory found 11 surviving native species and 5 surviving non-native species (Table 4). The native, invasive, noxious, or exotic status is provided by the Washington Natural Heritage Program (Rocchio et al. 2020) and the Washington State Noxious Weed Control Board (NWCB 2021). Invasive species are distinguished from exotic species. Exotic species are not native to an area but do not have the potential to spread aggressively or cause ecological harm like invasive species. Designation as a noxious weed is a legal distinction based on proven harm to human interests (NWCB 2021). Two individuals of rush skeletonweed were observed just outside the Northern Boundary of the burned area. No noxious weeds were observed within the burned area. Noxious weed data was submitted to the Noxious Weed Program Manager.

Table 4. Gable Butte Fire Surviving Vegetation Species List.

Species	Status
Achillea millefolium (yarrow)	native
Artemisia tridentata (big sagebrush)	native
Bromus tectorum (cheatgrass)	invasive
Dieteria canescens (hoary-aster)	native
Draba verna (spring draba)	exotic
Ericameria nauseosa (rubber rabbitbrush)	native
Eriogonum microtheca (slender buckwheat)	native
Eriogonum sphaerocephalum (rock buckwheat)	native
Lomatium sp. (unidentifiable)	native
Microsteris gracilis (slender phlox)	native
Poa bulbosa (bulbous bluegrass)	invasive
Poa secunda (Sandberg's bluegrass)	native
Pseudoroegneria spicata (bluebunch wheatgrass)	native
Salsola tragus (Russian thistle)	invasive
Tragopogon dubius (yellow salsify)	exotic
Vulpia microstachys (small fescue)	native

Figure 52. Photo point M_631 taken in 2023, showing Columbia Plateau Scabland Shrubland with surviving clumps of bluebunch wheatgrass

4.3 Management Recommendations

Management actions are recommended to restore lost level 5 BRMP resources. Without intervention and active management, cheatgrass fires result in a loss of total plant diversity and can result in the complete loss of the sagebrush overstory (Colorado State University and University of Wyoming 2013, Bakker et al. 2011). To decrease future fire risk and to disrupt the positive feedback cycle between cheatgrass and fire, land managers can make efforts to restore native vegetation following a fire. Restoration post-fire is thought to be advantageous; immediately following a fire cheatgrass seeds are temporarily reduced in the seed bank (Humphrey and Schupp 2001). This temporary reduction in cheatgrass dominance would give native plants a chance to establish, but studies have shown that in cheatgrass-dominated areas few native seeds (less than 4%) are present in the seed bank following a fire (Humphrey and Schupp 2001). This is not sufficient to establish a strong native population, suggesting human intervention may be required.

4.3.1 Noxious Weed Treatment

Although no noxious weeds were identified within the burned area, noxious weed treatment for rush-skeletonweed is recommended in a buffer around the burned area. Burned areas present a disturbance opportunity for noxious weeds to rapidly spread and increase in abundance.

Hand-pulling is recommended for noxious weed eradication. Herbicide use is not recommended due to the potential for non-target effects, as the invasion areas are currently small. ATV use is not recommended for locating or treating noxious weeds. The use of ATVs is likely to damage sensitive native plants during re-establishment and destroy small pockets of surviving cryptobiotic crust. ATV use may also exacerbate erosion and dust problems. The use of herbicides and/or ATVs are likely to be counterproductive to the restoration effort. The proximity to rare plant occurrences and vernal pools makes it essential that great care is taken to avoid disturbing these sensitive resources during noxious weed treatment.

4.3.2 Restoration

Supplemental seeding of native species is recommended to mitigate the damage caused by the fire. Re-establishment of shrubs after fire is highly dependent on nearby seed sources. Big sagebrush seed dispersal range has been shown to be between 1 to 15 m (3 to 49 ft; Clements and Harmon 2019, Jacobs et al. 2011). Surviving big sagebrush cover is very low. The perimeter of mature sagebrush will likely improve the rate of natural recovery; however, it is likely insufficient for big sagebrush to re-establish in the burned area before it is overtaken by invasive species. This indicates that level 5 resources are unlikely to recover without intervention, and the burned area would likely stabilize at lower ranked resource level vegetation cover types.

Species used for restoration should be selected based on vegetation present prior to the burn, using regionally-sourced seeds. It should include big sagebrush, Sandberg's bluegrass, slender buckwheat, rock buckwheat, spiny hopsage, purple sage (*Salvia dorrii*), mixed bunchgrasses, and mixed forbs. The seed mix may be modified based on availability. Detailed revegetation methods, including seeding mix rate and

seeding timing recommendations, can be found in the *Hanford Site Revegetation Manual* (DOE/RL-2011-116)

4.3.3 Fire Break Revegetation

The BRMP requires that temporary firebreaks constructed during firefighting should be re-contoured and reseeded with an appropriate mix of locally-derived native plant species as described in the *Hanford Site Revegetation Manual (*DOE/RL-2011-116*).* Although firebreaks were not constructed, restoration of the off-road vehicle tracks would help to stabilize those areas and prevent invasion of non-native species.

4.3.3.1 Annual Monitoring

Annual monitoring is recommended to begin in spring/summer 2024 to track vegetation cover and noxious weed invasion. Additionally, monitoring this site is beneficial to test the assumption that the Columbia Plateau Scabland Shrubland system is more resilient to fire than other ecological systems. Monitoring recovery in an area categorized as a BRMP level 5 resource is essential to track if biological resources are expected to recover or if there will be a long-term loss in resources. Monitoring should follow the methods for short-term and long-term monitoring described in the *Hanford Site Post-Fire Vegetation Monitoring Report for Calendar Year 2021* (HNF-67070). This will consist of revisiting photo points, monitoring transects, and re-mapping noxious weed infestations. Annual monitoring (short-term monitoring) is recommended for the first five years, then the monitoring schedule may be reduced to once every five years (long-term monitoring).

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APPENDIX A

TRANSECT RESULTS

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Table A-1. Gable Mountain Transect Results.

GABLE MOUNTAIN TRANSECTS				
Transect #	**Year**	**% Native Cover**	**% Non-Native Cover**	**# of native species**
11	2021	1.8	8.5	13
	2022	7.5	38.9	18
	2023	4.6	45.5	15
12	2021	16.1	17.4	22
	2022	21.1	41.5	28
	2023	15.8	47.6	23
13	2021	16.6	5.7	15
	2022	27	13.9	24
	2023	39.9	15.5	22
14	2021	0.9	7.8	7
	2022	1.8	19.9	6
	2023	6.9	54.2	5
Average	2021	8.85	9.85	14
	2022	14.4	28.5	19
	2023	16.8	40.7	16

Table A-2. High-Density Sagebrush Transect Results.

HIGH-DENSITY SAGEBRUSH TRANSECTS				
Transect #	**Year**	**% Native Cover**	**% Non-Native Cover**	**# of native species**
1	2021	1.1	3	5
	2022	10.6	20.1	17
	2023	14.9	46.4	10
2	2021	8.1	11.6	21
	2022	19.1	34.6	29
	2023	13.9	39	18
3	2021	9.3	6.8	17
	2022	15	27	21
	2023	21	32.1	20
4	2021	6.8	1.9	19
	2022	16.5	22.8	28
	2023	30.9	17.4	22
7	2021	12.6	10	21
	2022	29.9	17.6	26
	2023	22.1	36.6	25
8	2021	3.1	0.9	12
	2022	2.4	12.5	16
	2023	10.8	40.1	18

HIGH-DENSITY SAGEBRUSH TRANSECTS				
9	2021	0.4	9.6	2
	2022	1	73.9	8
	2023	1.5	87.8	7
15	2021	5.3	0	2
	2022	9.6	26.4	28
	2023	16.5	40.3	19
Average	2021	5.8	5.5	12
	2022	13.0	29.4	22
	2023	16.5	42.5	17

Table A-3. Low-Density Sagebrush Transect Results.

LOW-DENSITY SAGEBRUSH TRANSECTS				
Transect #	**Year**	**% Native Cover**	**% Non-Native Cover**	**# of native species**
5	2021	4.5	28.4	3
	2022	0	69.9	3
	2023	0	90.1	1
6	2021	10.1	8	8
	2022	2.9	49.4	15
	2023	7.3	34.5	11
10	2021	0	21.5	2
	2022	1.5	51.6	3
	2023	0	90	2
Average	2021	4.9	19.3	4
	2022	1.5	57.0	7
	2023	2.4	71.5	5

Table A-4. RA Transect Results.

RA TRANSECTS				
Transect #	**Year**	**% Native Cover**	**% Non-Native Cover**	**# of native species**
RA1	2021	4.5	44	3
	2022	3.6	82.9	10
	2023	9.6	72.5	6
RA2	2021	1.6	34.2	5
	2022	5.6	70.8	6
	2023	12.3	58	5
RA3	2021	17.9	23.3	17
	2022	23.9	63.1	30
	2023	8	82.5	22
RA4	2021	15.6	31.8	11

	2022	7.8	63.5	14
	2023	5.8	81.9	17
RA5	2021	0	42.4	2
	2022	0.5	86	3
	2023	1	80.6	2
Average	2021	7.9	35.1	8
	2022	8.3	73.3	13
	2023	7.3	75.1	10