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HNF-69774
Revision 0

Hanford Site Post-Fire Vegetation Monitoring Report for Calendar Year 2022

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 2022

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Date Published
January 2024

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

HANFORD MISSION INTEGRATION SOLUTIONS
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APPROVED
By Lynn M Ayers at 3:04 pm, Feb 01, 2024

Release Approval Date

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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 Site and in the surrounding greater Columbia Basin. The greatest threat to this habitat is fire-related conversion to a cheatgrass-dominated monoculture. In order 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 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 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 act 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 west 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 2). 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 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). 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 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 (Figure 1, HNF-61417).

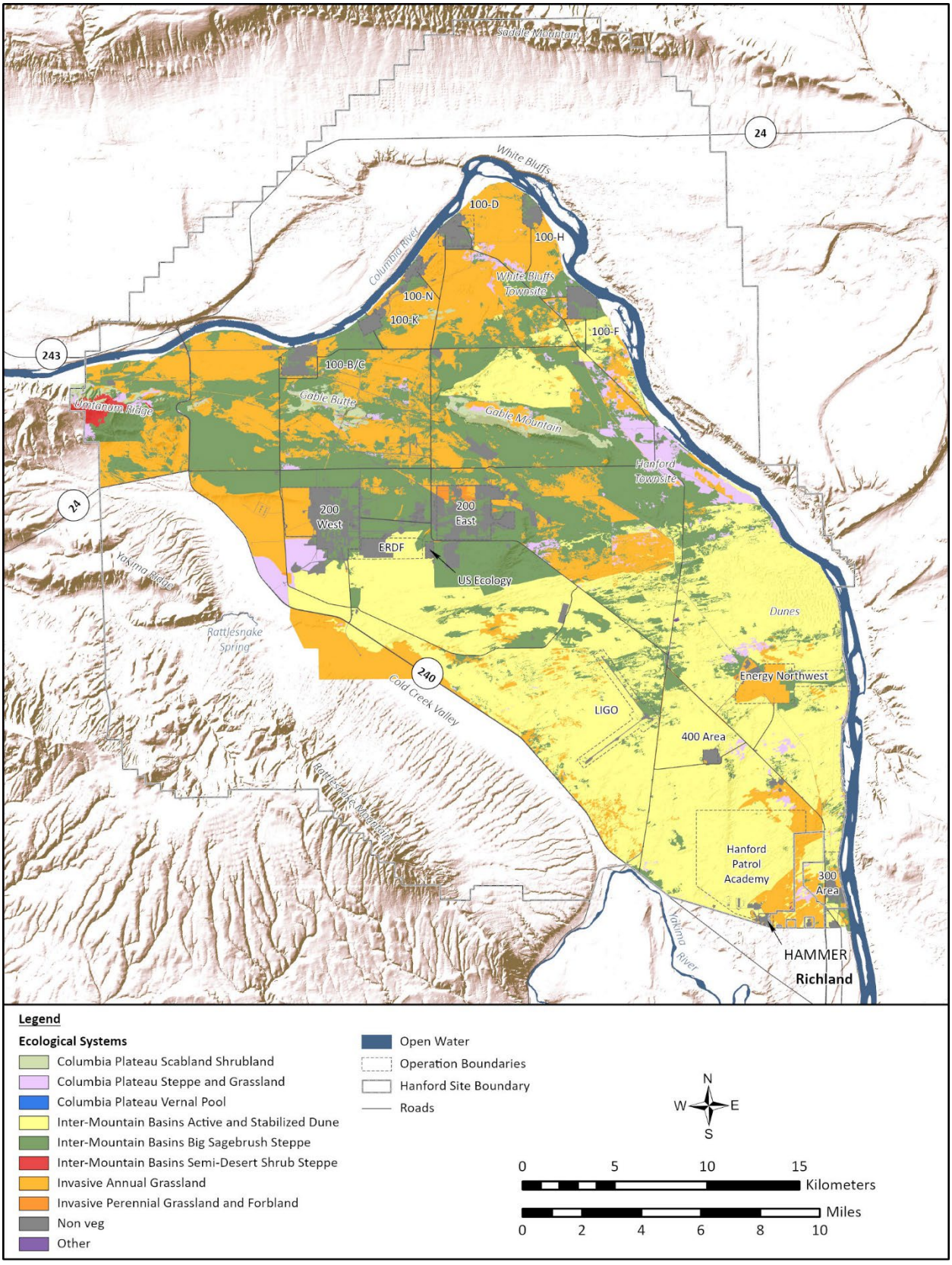

Figure 1. Ecological Systems of the Hanford Site.

In order 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 this monitoring effort 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 2022 built on previous data and focused on the short-term recovery of an area burned in June 2020 that was reseeded with native grasses and sagebrush.

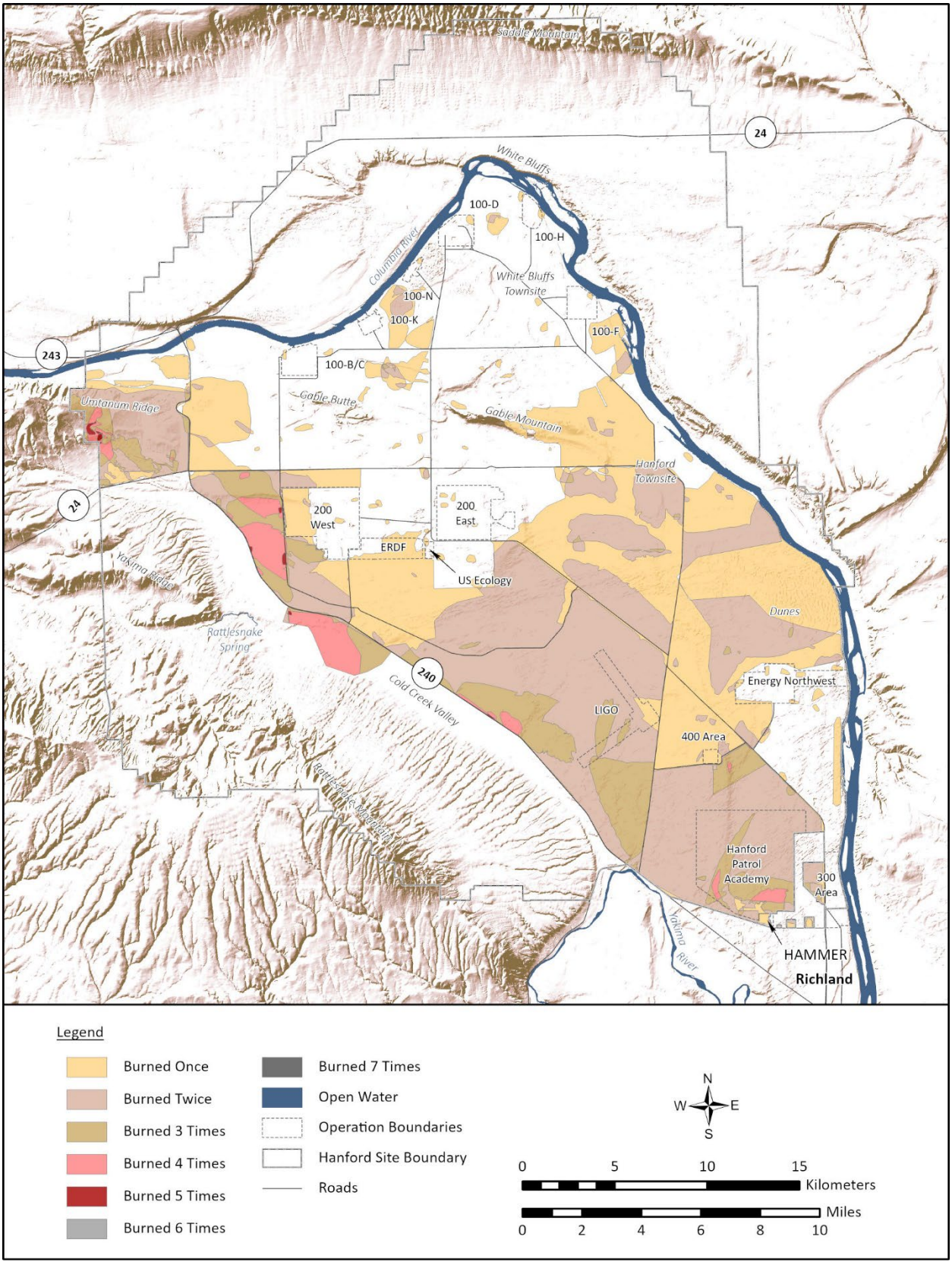

Figure 2. Hanford Site Fire Frequency from 1974 to 2022.

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. Additionally, this policy emphasizes prevention, which includes mitigating risks and losses to ecosystems (USDOI 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-96-62, *Hanford Site Biological Resources Management Plan,* (BRMP) is identified by DOE/EIS-0222-SA-01, *Hanford Comprehensive Land-Use Plan,* (CLUP) is the primary implementation control for managing and protecting natural resources on the Hanford Site. According to Section 1.4.1 of the *Hanford Comprehensive Land-Use Plan* (DOE/EIS-0222-SA-01), 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 an effective steward of the Hanford biological resources; and implements an ecosystem management approach for biological resources on the Site. The BRMP provides a comprehensive direction that specifies DOE biological resource policies, goals, and objectives.

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

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:

- Provide second-year data on post-fire restoration
- Evaluate the impacts of post-fire restoration actions
- Recommend actions to improve post-fire vegetation management.

This monitoring report is the second 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 and ongoing monitoring and restoration efforts that occurred.

- **Section 3** summarizes the methods used in short-term and long-term post-fire monitoring.

- **Section 4** presents the results of the monitoring effort for calendar year 2022.

- **Section 5** discusses the results and their overall implications for post-fire vegetation recovery on the Hanford Site.

- **Section 6** lists the literature cited throughout this report.

2.0 FIRE SUMMARY

No large (more than 100 acre) fires occurred on the Hanford Site in 2021, and no post-fire restoration actions occurred. This section provides background describing the Gable Mountain Fire that occurred in 2020 and is the subject of short-term post-fire restoration monitoring in this report. Additionally, this section records the rationale behind post-fire restoration decisions and provides details regarding the post-fire restoration process.

2.1 GABLE MOUNTAIN FIRE

On May 30, 2020, a 22.3 km^2 (5,510-acre) 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 and resulted 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. In order to confirm these 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 which established transects for long-term vegetation monitoring. The details of this survey are described in Section 3.1. 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 in an attempt 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 targeted seeding rate 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, 7 months after the fire had occurred.

The area restored in this effort will be monitored annually for 5 years to track the recovery of the burned area. The second year of this monitoring 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).

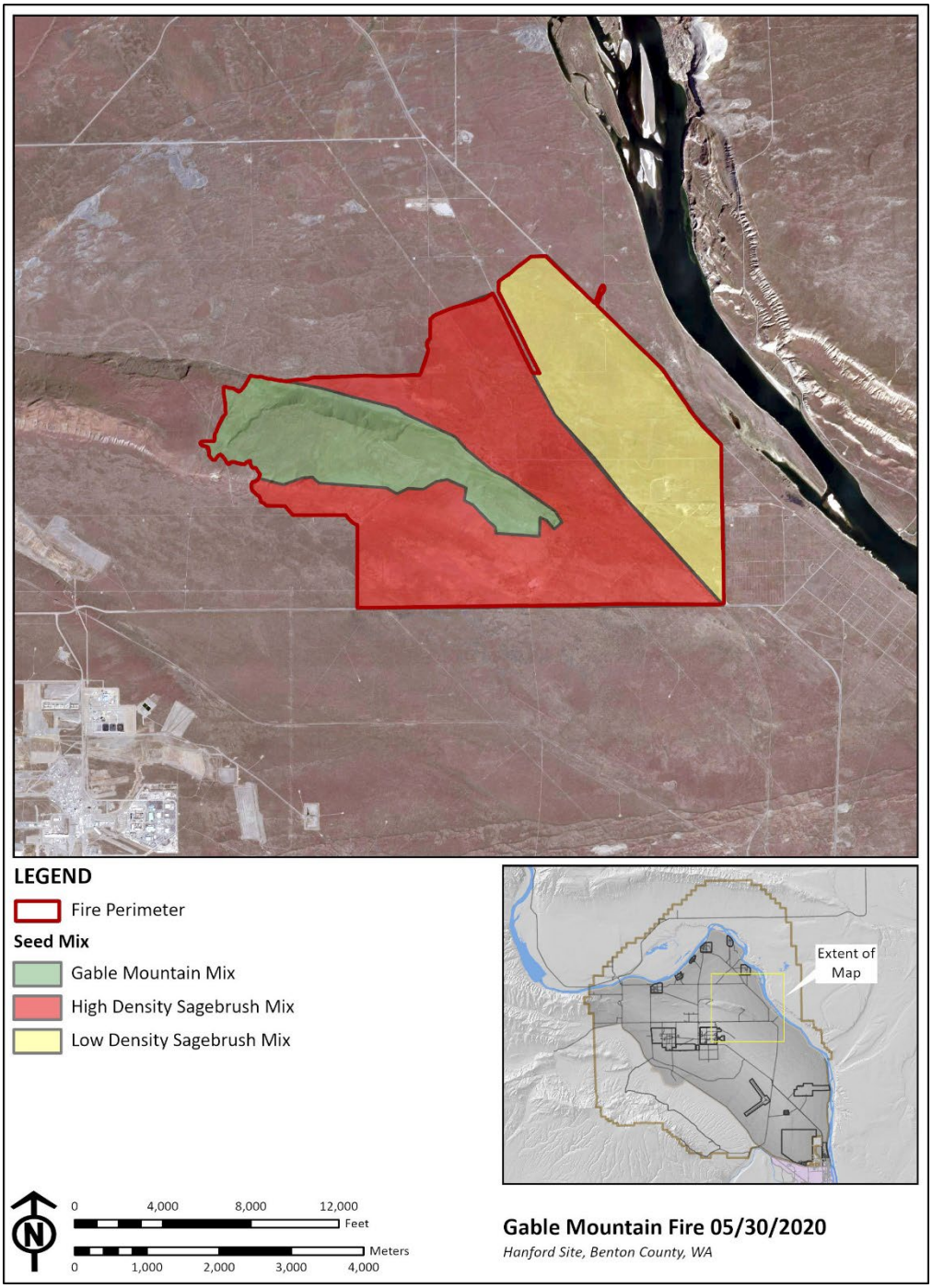

Figure 5. Locations of the Seed Mixes Used in the Gable Mountain Restoration.

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

3.0 METHODS

Monitoring in 2022 was the second-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.

3.1 SHORT-TERM MONITORING

Short-term monitoring occurs in areas burned within the last 5 years and can occur in areas where restoration was performed. The goal of short-term monitoring is to collect data on the short-term 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, and early May 2022.

In order 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 5 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, 5 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 transects are displayed in Figure 6 with "RA."

Coordinates were recorded at the start and end points of each 100-m 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.

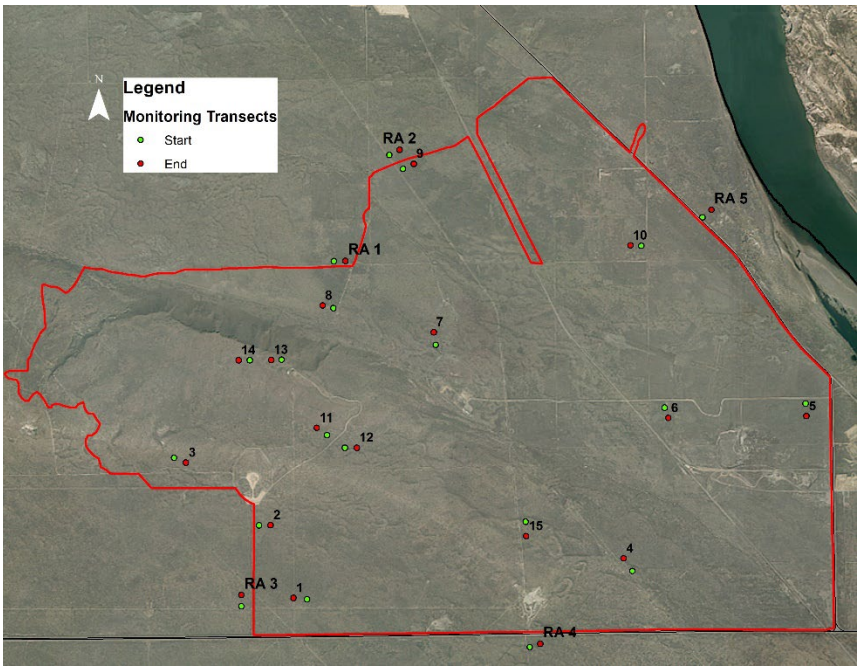

Figure 6. Monitoring Transects for the Gable Mountain Fire Area Established in 2020.

Plot frame data were taken along each of the transects in May 2022. 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 long measuring tape, stretched from the start point to the end point so that it is straight and taut. One 20- by 50-cm plot was placed every 5 m 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 of either side of the transect were recorded. In addition to plant species observed within 5 m 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 at Hanford Mission Integration Solutions (HMIS) for management planning.

4.0 RESULTS

Second-year monitoring results for the Gable Mountain Fire area are provided in this section. No long-term BRMP plot monitoring occurred in 2022 and the next scheduled monitoring will occur in 2026. The implications of these results are discussed in Section 5.0.

4.1 GABLE MOUNTAIN FIRE AREA

Second-year post-fire monitoring occurred in the Gable Mountain Fire area in 2022. This effort measured vegetation on the same 15 transects and with the same methods used in 2021. Above-average April rainfall and cold temperatures in 2022 led to a delayed spring, and monitors checked the phenology of plants within the Gable Mountain Fire area to align the maturity of monitored plants in 2022 with their condition in 2021. Monitoring occurred in early May 2022, when it was determined the plants were at a similar maturity to when they were monitored in 2021.

The 15 monitored transects are categorized into 4 areas: Gable Mountain, high-density sagebrush, low-density sagebrush, and reference areas. 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.

4.1.1 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. The north slope of Gable Mountain was not surveyed 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. Table 2 summarizes monitoring results for the 4 Gable Mountain Area Transects for 2021 and 2022.

Table 2. 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
12	2021	16.1	17.4	22
	2022	21.1	41.5	28
13	2021	16.6	5.7	15
	2022	27	13.9	24
14	2021	0.9	7.8	7
	2022	1.8	19.9	6
Average	2021	8.85	9.85	14
	2022	14.4	28.5	19

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*); rock buckwheat (*Eriogonum sphaerocephalum*) and slender buckwheat (*Eriogonum microthecum*); rubber rabbitbrush (*Ericameria nauseosa*) and 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 2022 measured continued recovery of both native and non-native vegetation. Across the four transects in the Gable Mountain area, native cover averaged 14.4% and non-native cover averaged 28.5%. Transect 12 and 13 had the highest native cover with

21.1% and 27.0% 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 than Transects 11 and 14 immediately after the fire. In May 2022 native cover at Transects 11 (Figure 7) and 14 (Figure 10) was quite low at 7.5% and 1.8%, respectively. Non-native species appeared to be recovering in those areas at a much faster rate than native species. Transects 12 and 13 are shown in Figure 8 and Figure 9, respectively.

Sandberg's bluegrass had the highest cover of any native species across all four transects at 28.8% coverage. This species had been included in the restoration seed mix for this area. Bluebunch wheatgrass, a defining species for this area pre-burn, was recorded only at Transect 13 with 0.9% cover. Cheatgrass was the dominant non-native species at all transects within this area and had greater coverage on the transects on the south slope of the mountain, similar to pre-fire distribution. Cheatgrass cover increased dramatically at Transect 14 in 2022, increasing 18.7% for a total of 25.3% cover. Tall tumblemustard (*Sisymbrium altissimum*) cover also increased dramatically in 2022. In 2021, tall tumblemustard had an average cover of 1.8% in this area, which increased to 9.8% average cover in 2022. The largest increases were observed at Transects 11 and 14.

The number of native species found in the Gable Mountain area in 2021 was 29. In 2022, 42 native species were found. The increase in native species from 2021 to 2022 could be from the increase in precipitation in 2022, triggering germination of native annual species; this indicated the overall native species diversity is increasing. The number of non-native species found in the Gable Mountain area in 2021 was seven. In 2022, 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.

Figure 7. Transect 11 in October 2020 (top left), May 2021 (top right), and May 2022 (below).

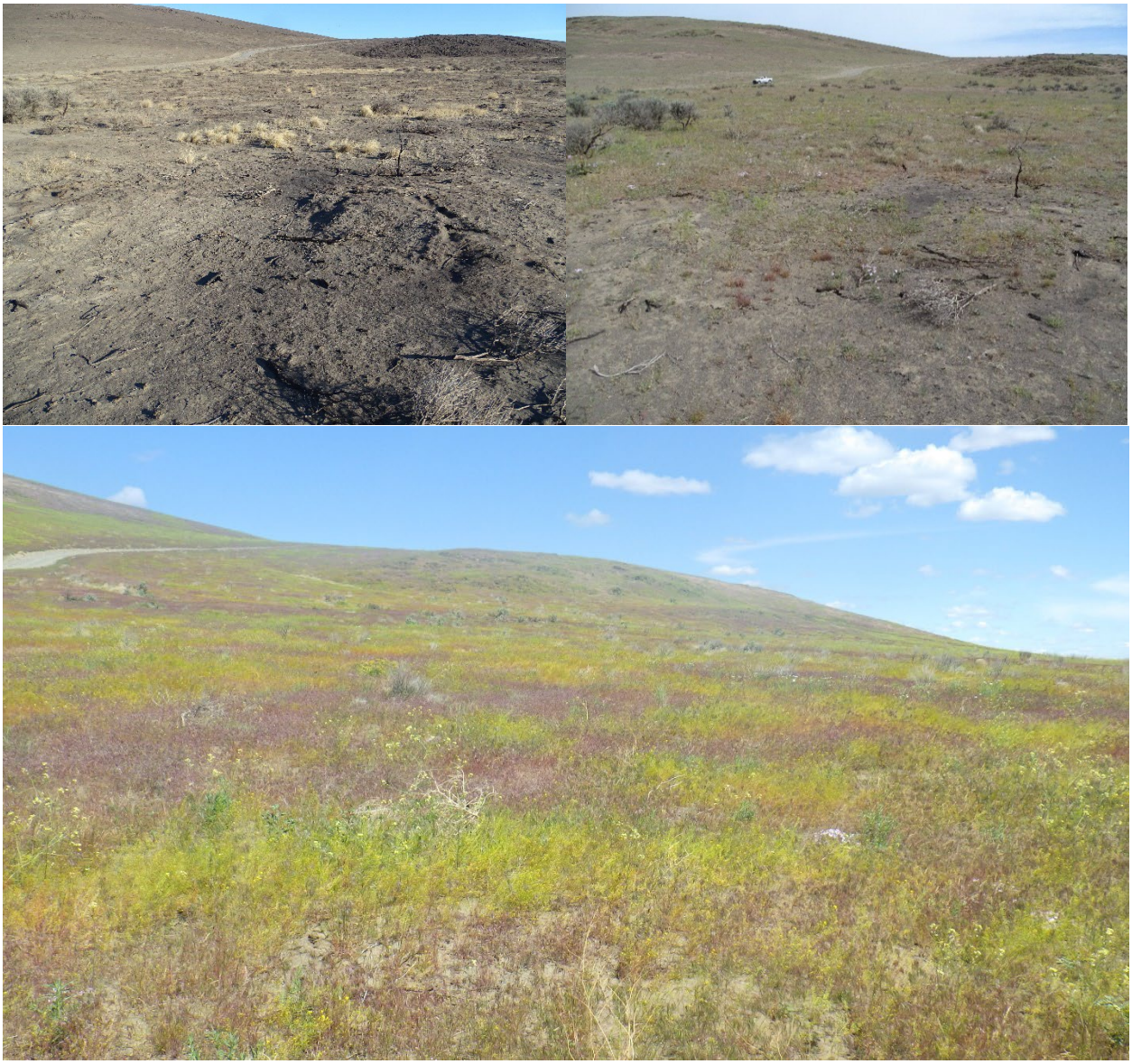

Figure 8. Transect 12 in October 2020 (top left), May 2021 (top right), and May 2022 (below).

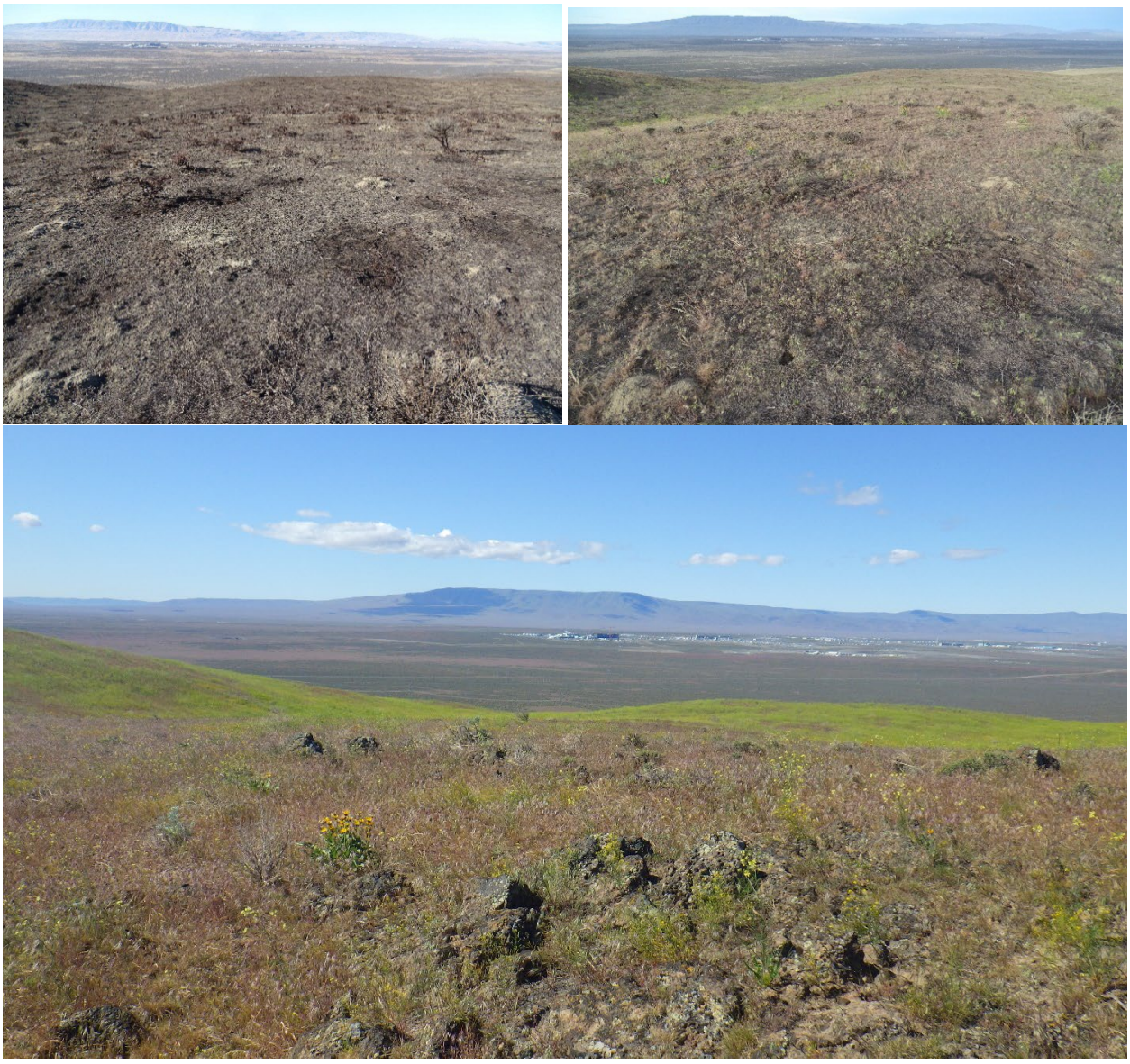

Figure 9. Transect 13 in October 2020 (top left), May 2021 (top right), and May 2022 (below).

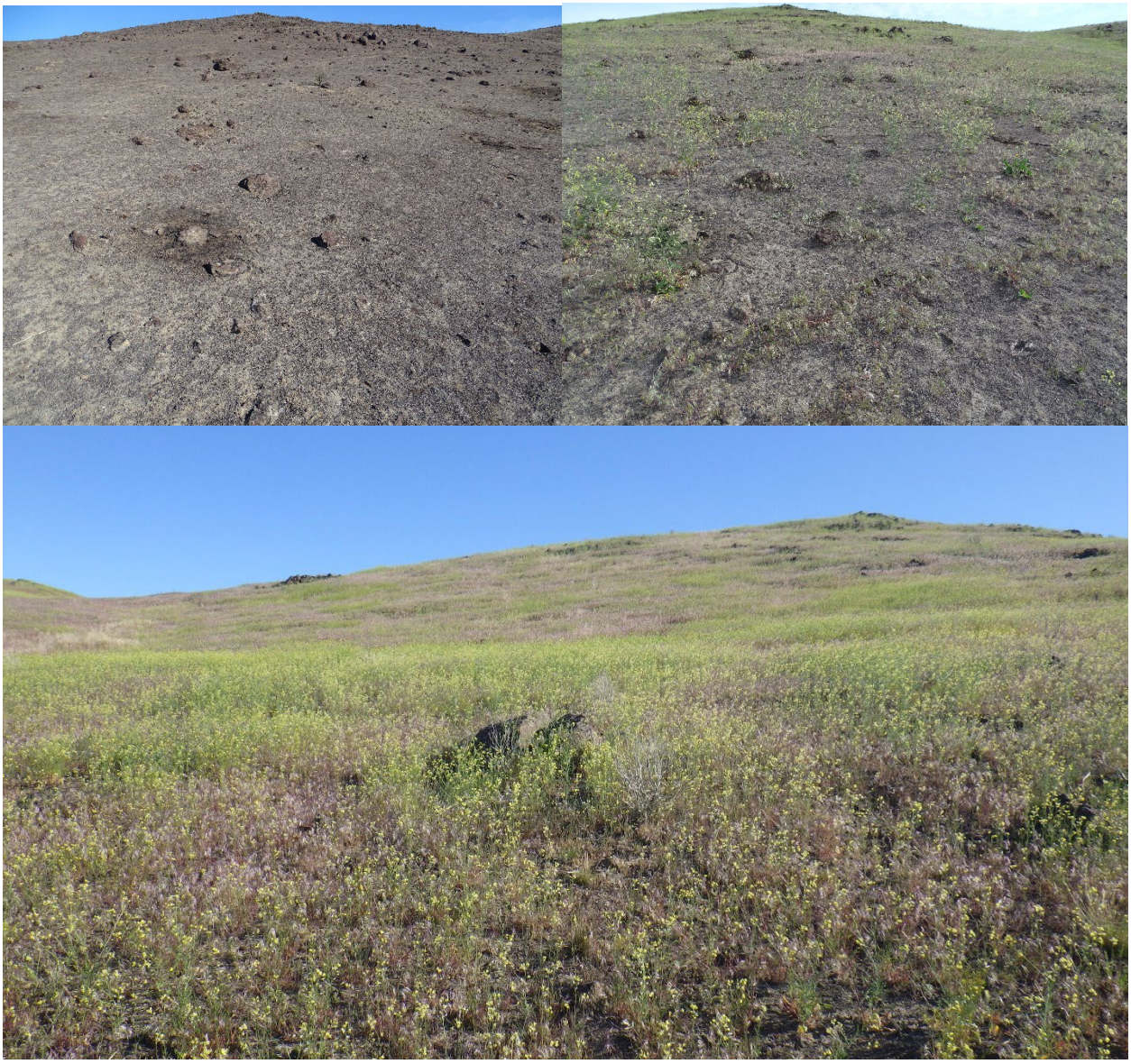

Figure 10. Transect 14 in October 2020 (top left), May 2021 (top right) and May 2022 (below).

4.1.2 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. Figure 11 through Figure 18 show each of the transects in 2020, 2021, and

2022. These transects span a variety of habitats with changing soil types. Table 3 summarizes monitoring results for the 8 High-Density Sagebrush Transects for 2021 and 2022.

Table 3. 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
2	2021	8.1	11.6	21
	2022	19.1	34.6	29
3	2021	9.3	6.8	17
	2022	15	27	21
4	2021	6.8	1.9	19
	2022	16.5	22.8	28
7	2021	12.6	10	21
	2022	29.9	17.6	26
8	2021	3.1	0.9	12
	2022	2.4	12.5	16
9	2021	0.4	9.6	2
	2022	1	73.9	8
15	2021	5.3	0	2
	2022	9.6	26.4	28
Average	2021	5.8	5.5	12
	2022	13.0	29.4	22

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. The only transect with significant vegetation cover was Transect 4, where needle-and-thread grass covered approximately 1.0% of the area. Transect 4 was distinguished from the other transects with fairly 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. Monitoring in May 2022 across the eight transects in the high-density sagebrush area showed native cover averaged 13.0% and non-native cover averaged 29.4%. Transect 7 had the highest native cover at 29.9% with Western tansy mustard (*Descurainia pinnata*) accounting for 6.8%, slender phlox (*Microsteris gracilis*) for 6.3%, and Sandberg's bluegrass for 6.2%. Transect 7 was one of the few transects with surviving sagebrush in the immediate area and was notably more diverse, hosting many forbs both on the transect and in the immediate area. Needle-and-thread grass coverage continued to grow at Transect 4, increasing to 6.4% in 2022 monitoring. Transects 8 and 9 had the lowest native coverage with 2.4% and 1.0% coverage, respectively. These areas saw high burn intensity and had no surviving sagebrush overstory. cheatgrass was the dominant non-native species in these transects with Transects 9, 2, and 5 having the highest non-native species coverage at 73.9%, 34.0%, at 29.9% coverage, respectively.

The species with the greatest native coverage in this area was Sandberg's bluegrass, with an average cover of 3.0%, followed by slender phlox, with an average cover of 2.9%. Sandberg's bluegrass was a major 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 2, 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 transect 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 2022 detected a small number of sagebrush recruits at Transect 9.

The number of native species found in the high-density sagebrush transect area in 2021 was 37. In 2022, 45 native species were found. The increase in native species from 2021 to 2022 could be from the increase in precipitation in 2022, but this indicates that overall native species diversity is increasing. The number of non-native species found in the Gable Mountain area in 2021 was five. In 2022, nine 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.

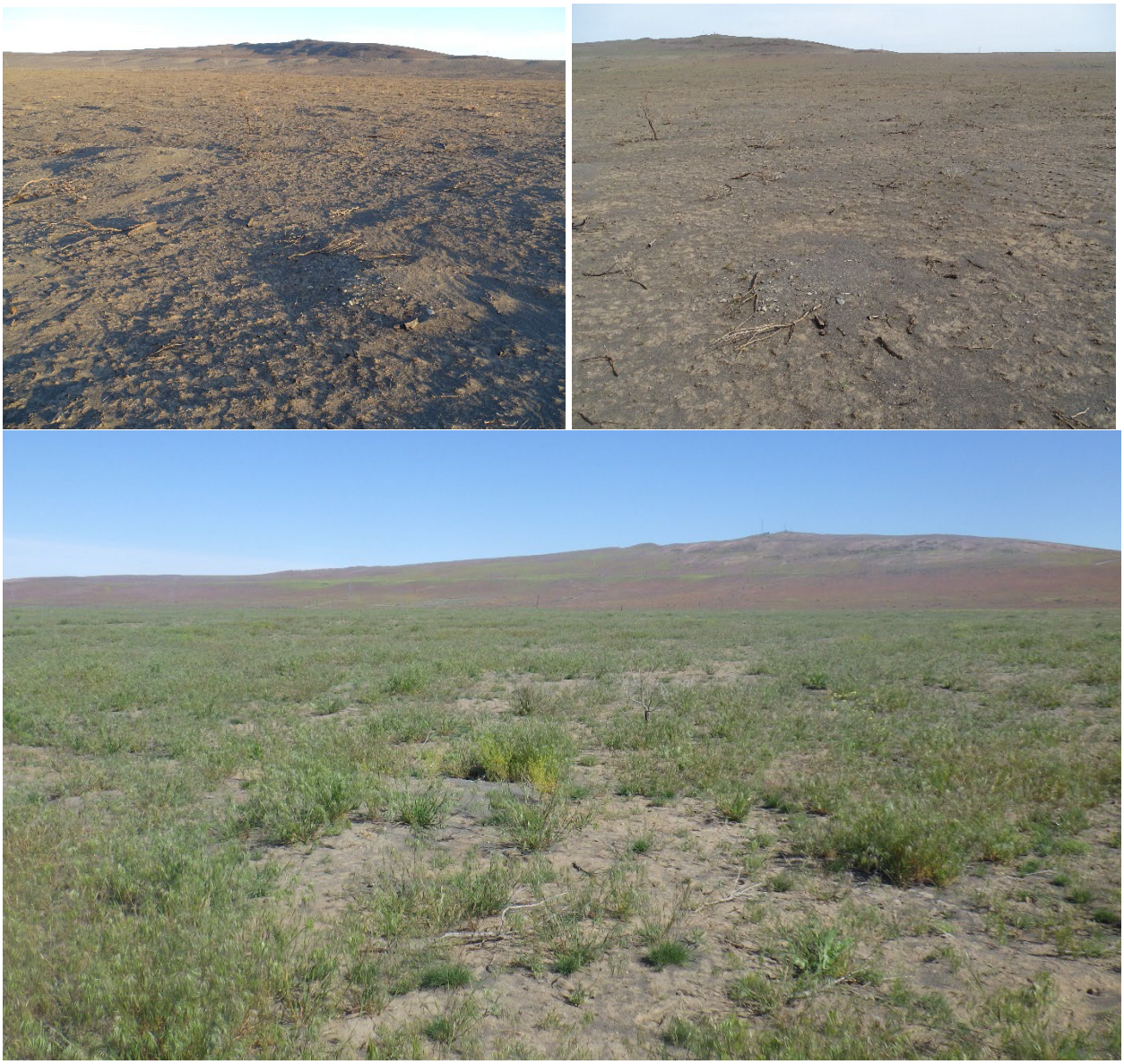

Figure 11. Transect 1 in October 2020 (top left), May 2021 (top right), and May 2022 (below).

Figure 12. Transect 2 in October 2020 (top left), May 2021 (top right) and May 2022 (below).

Figure 13. Transect 3 in October 2020 (top left), May 2021 (top right), and May 2022 (below).

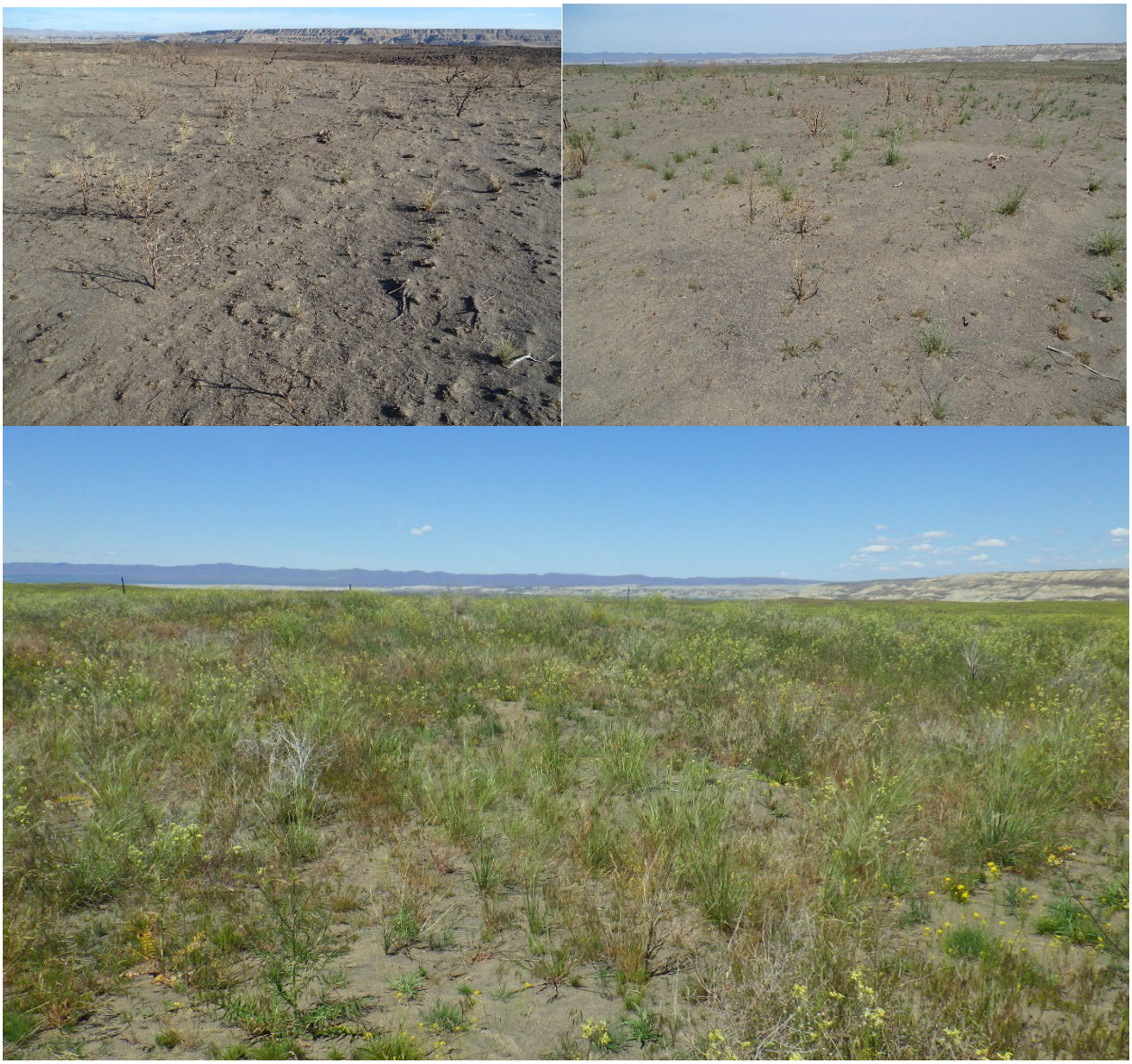

Figure 14. Transect 4 in October 2020 (top left), May 2021 (top right), and May 2022 (below).

Figure 15. Transect 7 in October 2020 (top left), May 2021 (top right), and May 2022 (below).

Figure 16. Transect 8 in October 2020 (top left), May 2021 (top right), and May 2022 (below).

Figure 17. Transect 9 in October 2020 (top left), May 2021 (top right), May 2022 (below).

Figure 18. Transect 15 in October 2020 (top left), May 2021 (top right), and May 2022 (below).

4.1.3 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, 6, and 10 are within the low-density sagebrush area. Table 4 summarizes monitoring results for the 3 Low-Density Sagebrush Transects for 2021 and 2022. Figure 19 through Figure 21 depict Transects 5, 6, and 10.

Table 4. 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
6	2021	10.1	8	8
	2022	2.9	49.4	15
10	2021	0	21.5	2
	2022	1.5	51.6	3
Average	2021	4.9	19.3	4
	2022	1.5	57.0	7

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 regrow in April and May 2021, and cover continued to increase in 2022. Native cover in this area was the lowest of the three areas, averaging 1.5% across the three transects, representing a decrease of 3.5% from 2021. Non-native cover was by far the highest of the three areas, averaging 57.0%, representing an increase of 37.7% from 2021. Each of these transects were distinct in their native and non-native cover patterns. Transect 5 had no native cover detected on the transect and 69.9% non-native cover. Only three native species were present at this site, none of which were detected on the transect. The dominant non-native species consisted of tall tumblemustard, cheatgrass, and jagged chickweed (*Holosteum umbellatum*). Transect 6 had the highest native cover at 2.9%, which mainly consisted of hoary tansyaster (*Dieteria canescens*) and needle-and-thread grass. Non-native cover at Transect 6 totaled 49.4% and was made up of mainly cheatgrass and tall tumblemustard. Transect 10 had 1.5% native cover and 21.5% non-native cover. The dominant native species was Western tansymustard, a non-seeded species. Non-native cover mainly consisted of bulbous bluegrass (*Poa bulbosa*) and cheatgrass.

Sandberg's bluegrass was common at Transect 5 and 6 and was the major component of the restoration seed mix for this area. Also included in the seed mix were prairie junegrass and sand dropseed, which were detected in the low-density sagebrush area in 2021; however, prairie junegrass was not detected in the low-density area in 2022. Species included in the seed mix

that were not detected in the low-density transects were ricegrass and bottlebrush squirreltail (*Elymus elymoides*).

The number of native species found in the low-density sagebrush transect area in 2021 was nine. In 2022, 16 native species were found. The increase in native species from 2021 to 2022 could be from the increase in precipitation in 2022, but this indicates that native species diversity is increasing. The number of non-native species found in the Gable Mountain area in 2021 was eight. In 2022, nine 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.

Figure 19. Transect 5 in October 2020 (top left) and April 2021 (top right), and May 2022 (below).

Figure 20. Transect 6 in October 2020 (top left), May 2021 (top right), and May 2022 (below).

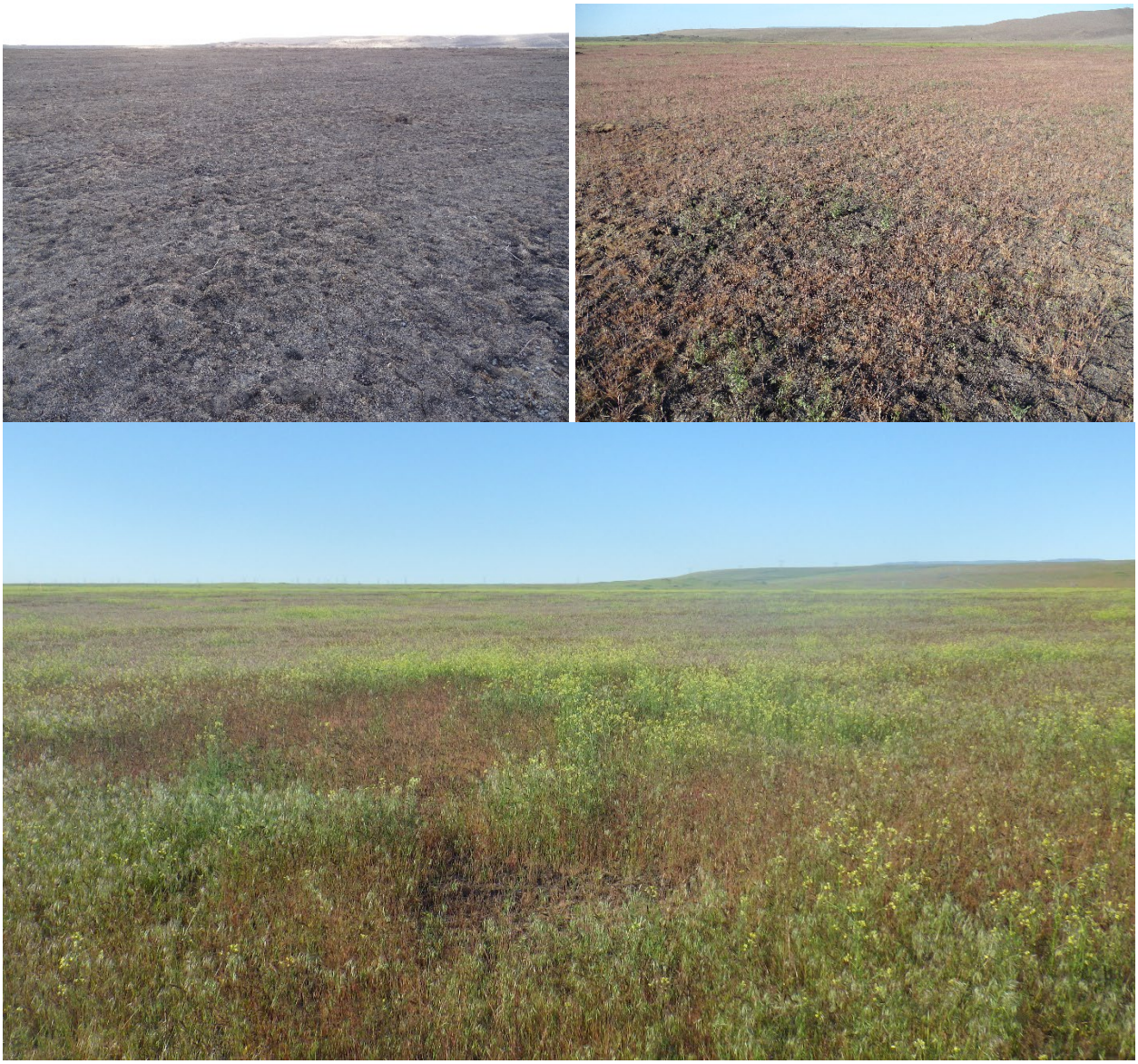

Figure 21. Transect 10 in October 2020 (top left), May 2021 (top right), and May 2022 (below).

4.1.4 Reference Area Transects

The Reference Area (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 Reference Area. 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). Table 5 summarizes monitoring results for the 5 Gable Mountain Area Transects for 2021 and 2022. Figure 22 through Figure 26 show each of the Reference Area transects in 2022.

Table 5. Reference Area Transect Results.

REFERENCE AREA TRANSECTS				
Transect #	Year	% Native Cover	% Non-Native Cover	# of Native Species
RA1	2021	4.5	44	3
	2022	3.6	82.9	10
RA2	2021	1.6	34.2	5
	2022	5.6	70.8	6
RA3	2021	17.9	23.3	17
	2022	23.9	63.1	30
RA4	2021	15.6	31.8	11
	2022	7.8	63.5	14
RA5	2021	0	42.4	2
	2022	0.5	86	3
Average	2021	7.9	35.1	8
	2022	8.3	73.3	13

Reference Area 1 is representative of the low-elevation area north of Gable Mountain, where Transect 7 and Transect 8 are located. In 2021 Reference Area 1 had 4.5% native cover, mainly made up of sagebrush and Sandberg's bluegrass. In 2022, native cover decreased to 3.6%, mainly consisting of sagebrush and slender phlox. In 2021, Reference Area 1 had 44.0% non-native cover, nearly completely made up of cheatgrass. In 2022, non-native cover increased to 82.9%, almost entirely consisting of cheatgrass. It is characterized as a mature sagebrush habitat with a highly disturbed understory.

Reference Area 2 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 2021, Reference Area 2 had 1.6% native cover, mainly made up of Sandberg's bluegrass and slender phlox. In 2022, native cover increased to 5.6%, mainly consisting of Sandberg's bluegrass and slender phlox. In 2021, Non-native cover totaled 34.2%, with the majority of that cover being cheatgrass. In 2022, non-native cover increased to 70.8%, consisting of cheatgrass, spring draba (*Draba verna*), and Russian thistle (*Salsola tragus*).

Reference Area 3 is located on the west side of the fire boundary and is representative of pre-fire conditions for Transects 1 and 2. Reference Area 3 is within the element occurrence that spanned over Transect 1 prior to the fire. In 2021, Reference Area 3 had 17.9% native cover, with 14.4% of that native cover made up by mature sagebrush. Hoary tansyaster, slender phlox, and Sandberg's bluegrass also made-up significant coverage native understory. In 2022, native cover increased to 23.9%, mainly consisting of sagebrush. In 2021, Reference Area 3 had 23.3%

non-native cover, with 21.9% of that made up by cheatgrass. In 2022, non-native cover increased to 63.1%, mainly consisting of cheatgrass.

Reference Area 4 is located south of the fire boundary in an area similar to pre-fire conditions for Transects 15 and 4. In 2021, Reference Area 4 had 15.6% native cover, with 10.8% of the cover made up of sagebrush. This area had a higher cover of Sandberg's bluegrass compared to other Reference Area sites at 4.4% cover. In 2022, native cover decreased to 7.8%, mainly consisting of sagebrush. Sandberg's bluegrass cover decreased to 1.6%. In 2021, Reference Area 4 had 31.8% non-native cover, with 28.1% of that made up by cheatgrass. In 2022, non-native cover increased to 63.5%, consisting mostly of cheatgrass and jagged chickweed.

Reference Area 5 is located on the east side of the fire boundary and is representative of pre-fire conditions for Transects 5, 6, and 10. In 2021, Reference Area 5 had no native species cover on the transect, though sand dropseed and tarweed fiddleneck (*Amsinckia lycopsoides*) were observed in the area. In 2022, native cover was found to be 0.5%, consisting of mountain tansymustard (*Descurainia longepedicellata*) and Western tansymustard. In 2021, non-native cover totaled 42.4%, which was made up by cheatgrass at 34.3%, tall tumblemustard at 4.4%, and jagged chickweed at 3.8%. In 2022, non-native cover increased to 86%, consisting of cheatgrass at 73.5%, tall tumblemustard at 8.9%, and jagged chickweed at 1.9%.

The number of native species found in the Reference Area in 2021 was 23. In 2022, 34 native species were found. The increase in native species from 2021 to 2022 could be from the increase in precipitation in 2022 or could represent an overall increase in native diversity. The number of non-native species found in the Gable Mountain reference area in 2021 was seven. In 2022, 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.

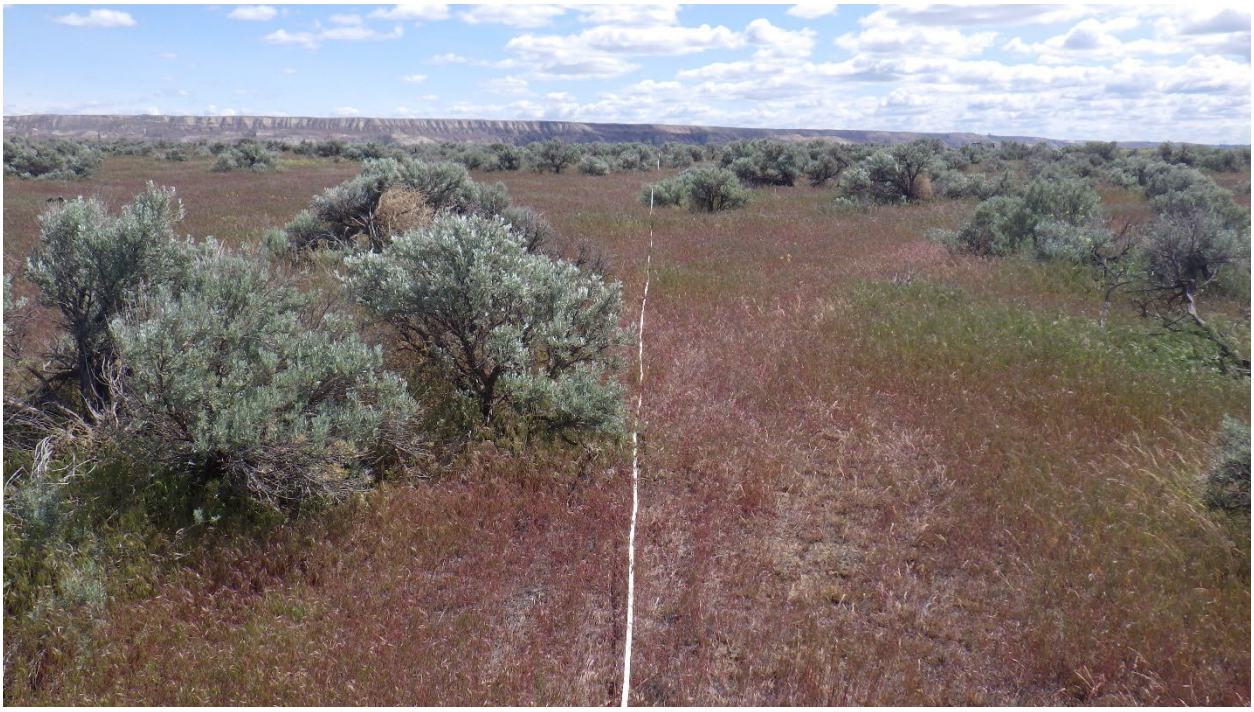

Figure 22. Transect for Reference Area 1 in 2022. Note the high cheatgrass density in the understory, typical of the Reference Area Transects.

Figure 23. Transect for Reference Area 2 in 2022.

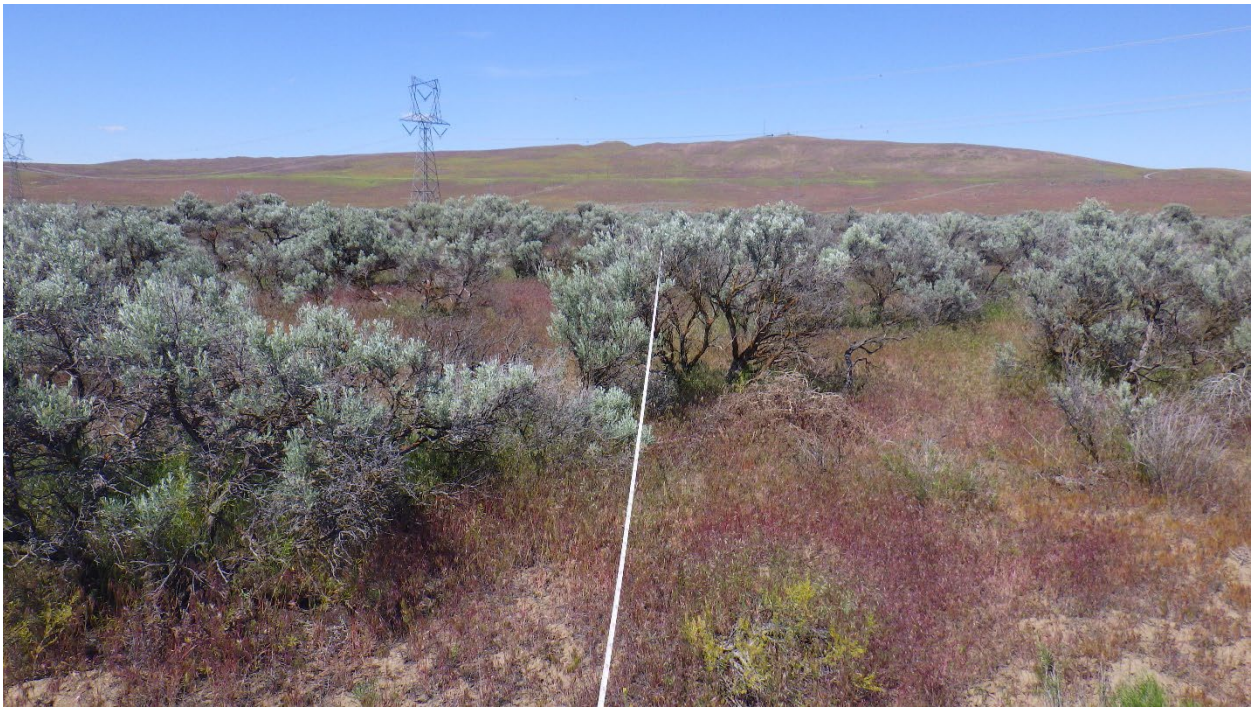

Figure 24. Transect for Reference Area 3 in 2022.

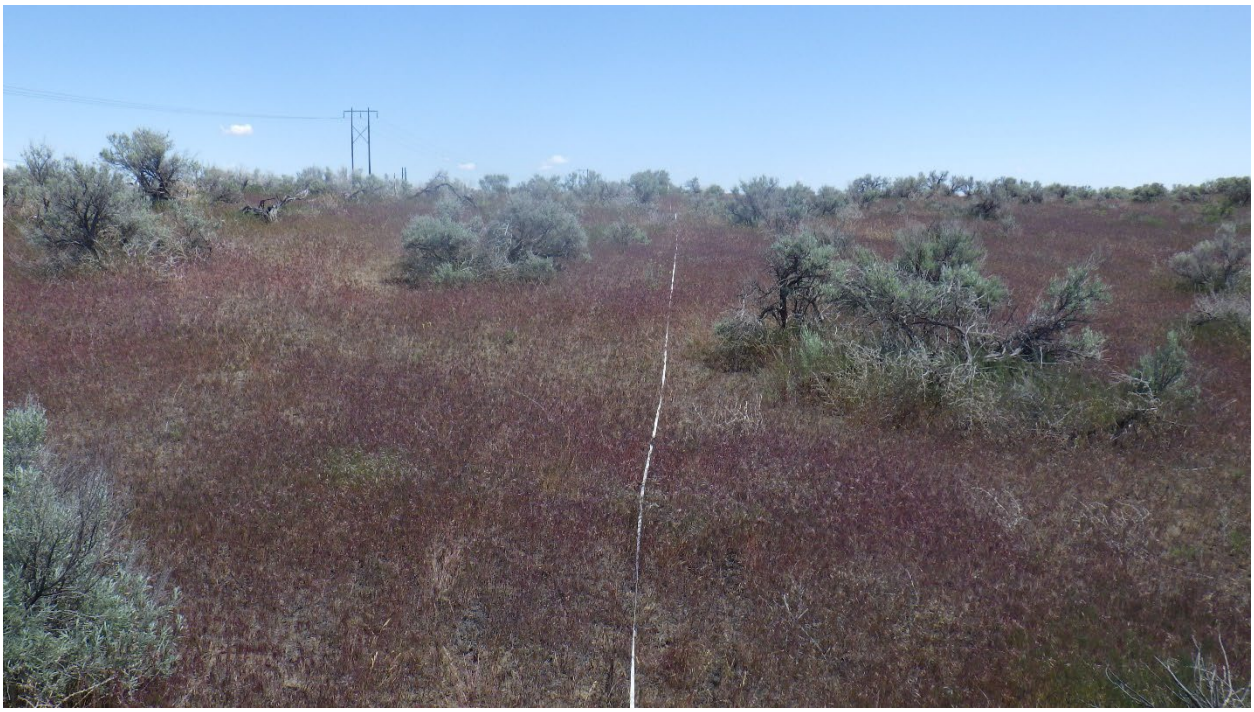

Figure 25. Transect for Reference Area 4 in 2022.

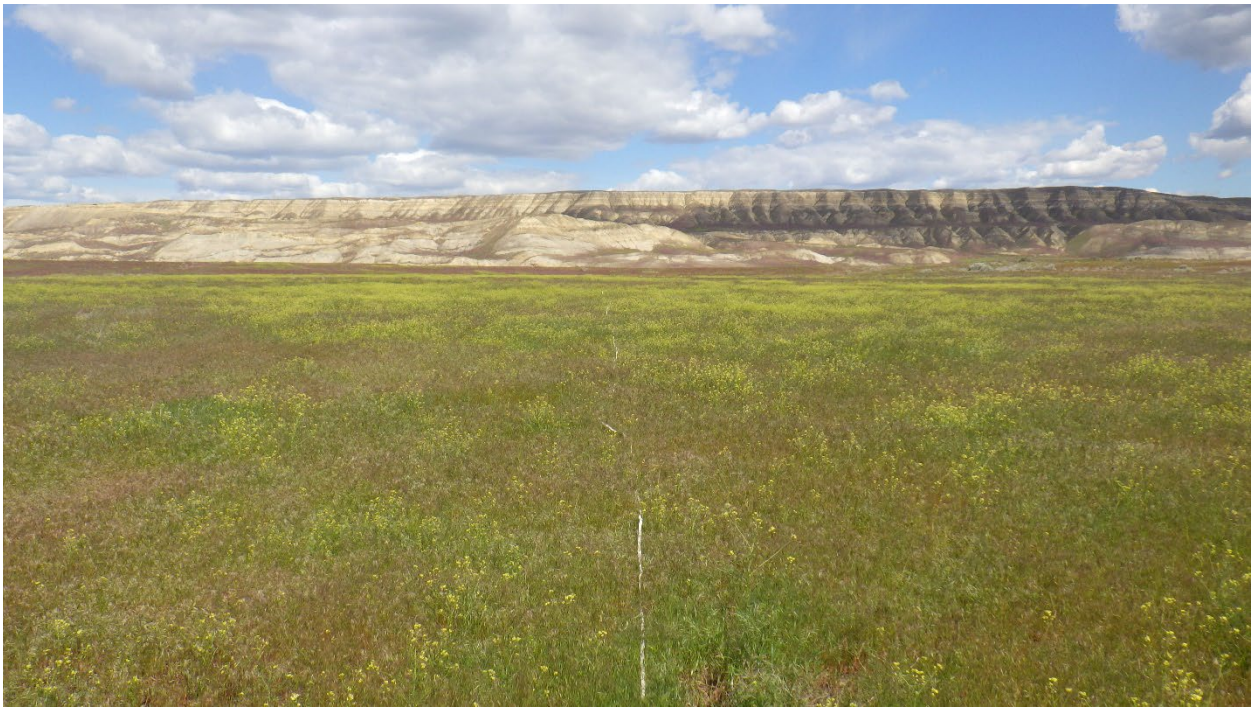

Figure 26. Transect for Reference Area 5 in 2022.

4.1.5 BRMP Plot 25

BRMP Plot 25 (referred to as BRMP 25) is located in an area classified by HNF-61417 as a 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 2022 because these plots are on a five year monitoring schedule, but the results from previous monitoring are included for reference.

It is characterized by having an overstory dominated by sagebrush, with lower coverage of 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 27 shows the change in vegetative composition over time and Figure 28 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 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.

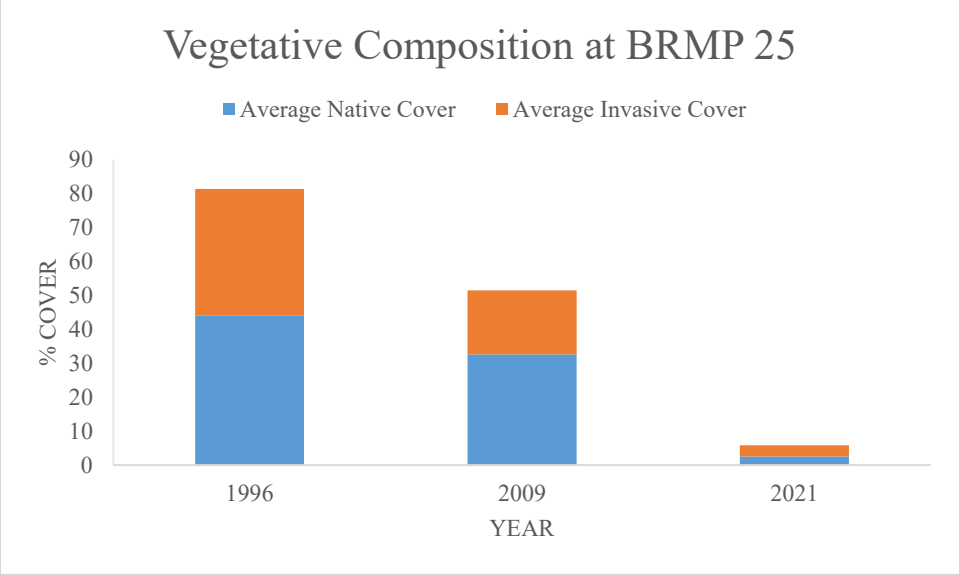

Figure 27. The Average Vegetative Composition at BRMP 25 over Time.

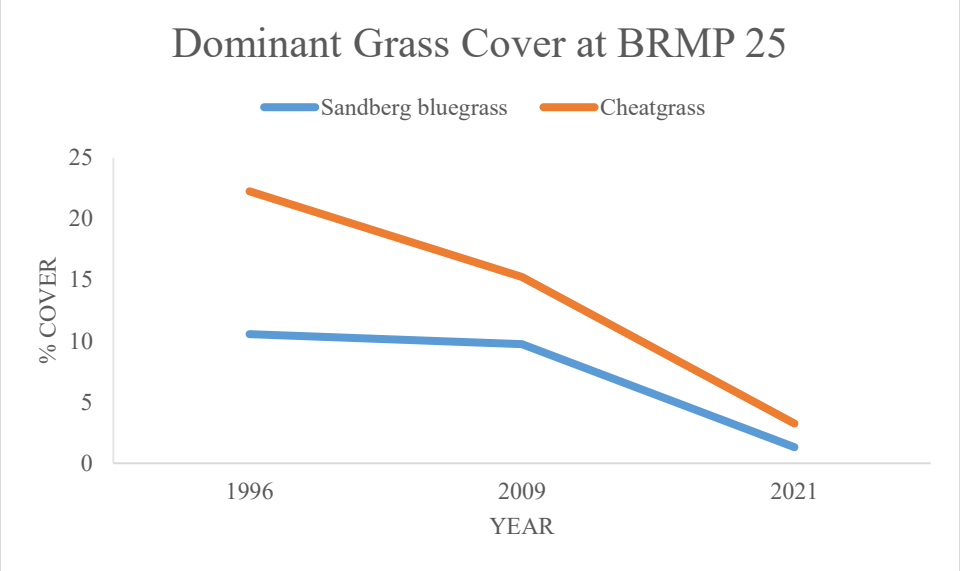

Figure 28. Changes in Dominant Grass Cover at BRMP 25 over Time.

4.2 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, but the results from previous monitoring are included as reference. 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.

4.2.1 BRMP Plot 2

BRMP Plot 2 (referred to as BRMP 2) is located in an area classified by HNF-61417 as a bitterbrush / Sandberg's bluegrass – cheatgrass-dominated habitat with a low cover of bitterbrush, rubber rabbitbrush, and green rabbitbrush in the overstory and 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 29 shows the change in vegetative composition over time and Figure 30 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 (*Ladeania lanceolata*) 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.

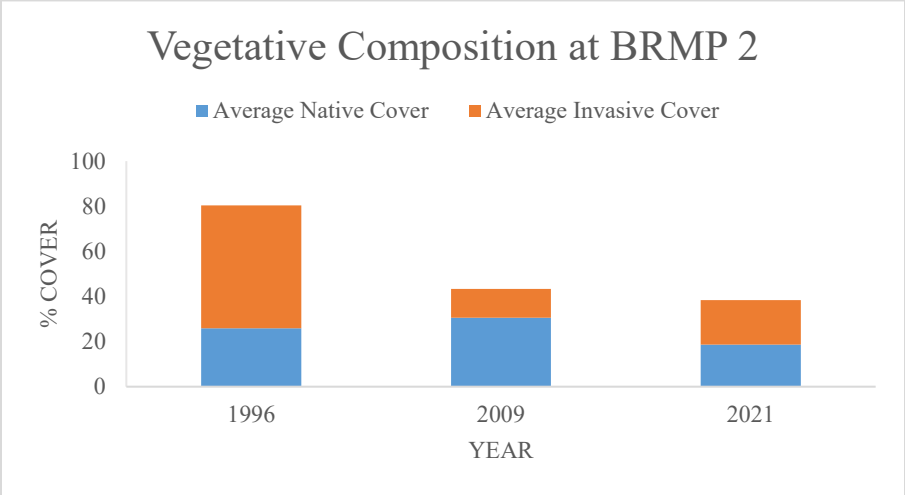

Figure 29. The Average Vegetative Composition at BRMP 2 over Time.

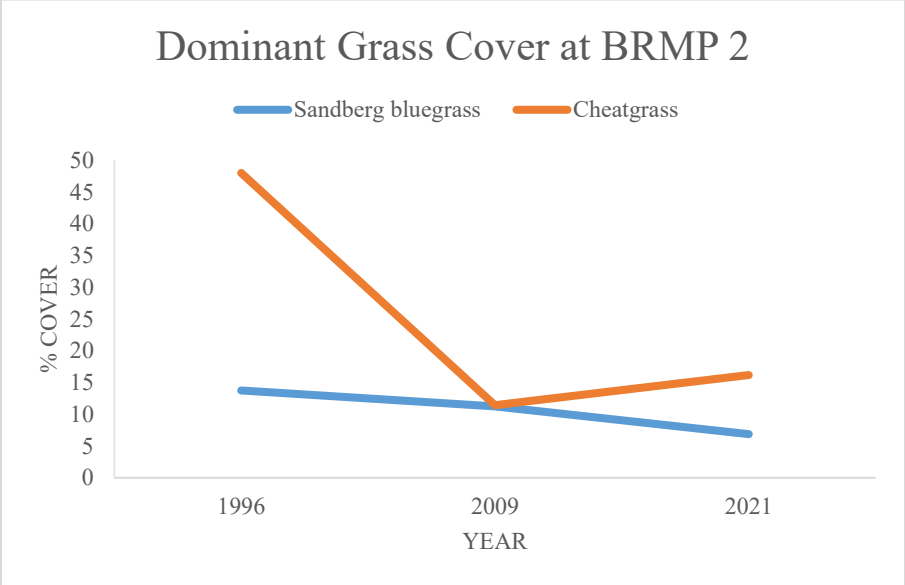

Figure 30. Changes in Dominant Grass Cover at BRMP 2 over Time.

4.2.2 BRMP Plot 4

BRMP Plot 4 (referred to as BRMP 4) is located in an area classified by HNF-61417 as a bitterbrush/Bunchgrass and bitterbrush/Sandberg's bluegrass – cheatgrass-dominated habitat with a low cover of 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 31 shows the change in vegetative composition over time and Figure 32 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% cover, respectively. Native cover mainly consisted of Sandberg's bluegrass. 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%. 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*). Spring annuals, jagged chickweed, and spring draba were minor non-native components of the understory.

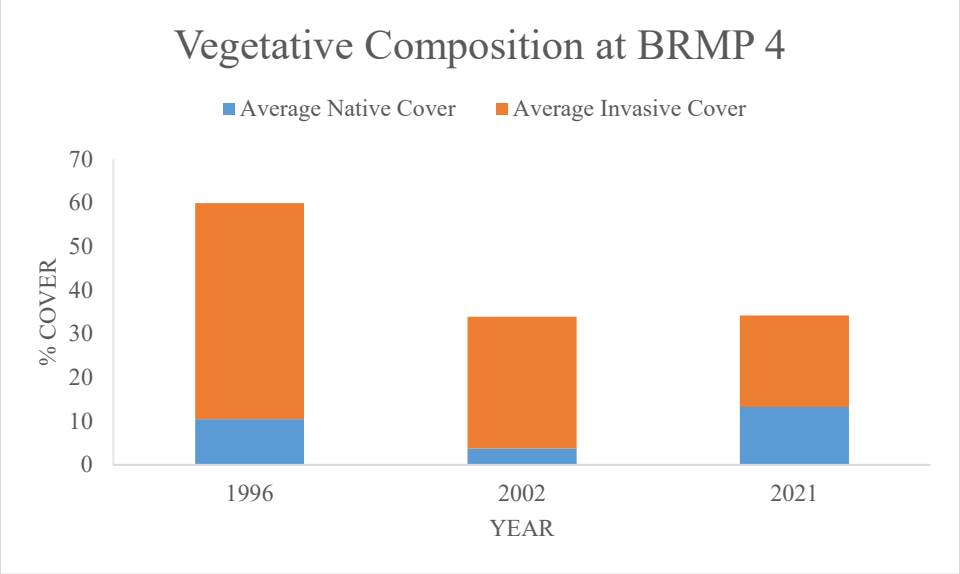

Figure 31. The Average Vegetative Composition at BRMP 4 over Time.

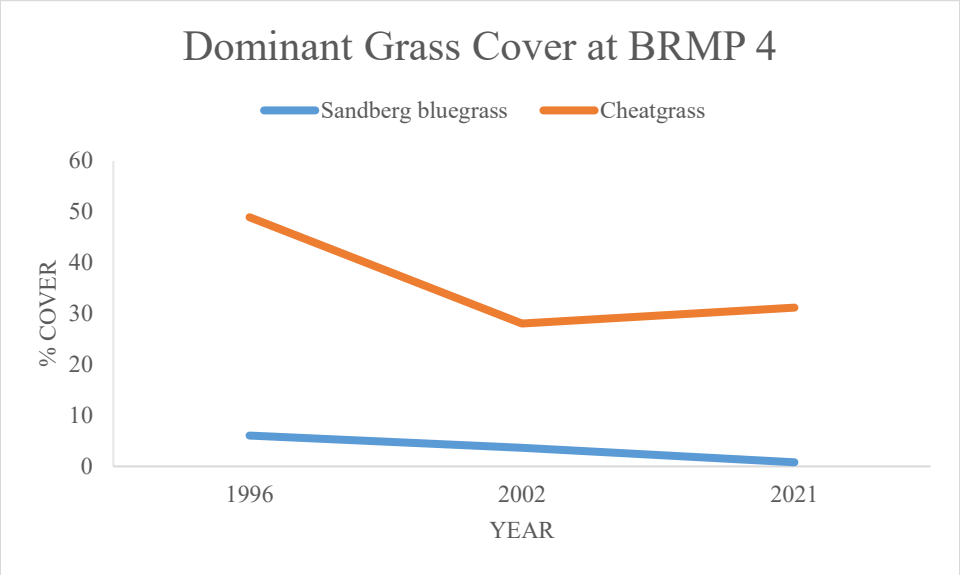

Figure 32. Changes in Dominant Grass Cover at BRMP 4 over Time.

4.2.3 BRMP Plot 5

BRMP Plot 5 (referred to as BRMP 5) is located in an area classified by HNF-61417 as a bitterbrush/Bunchgrasses-dominated habitat. It was characterized as having 0 to 3% cover of sagebrush, 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 33 shows the change in vegetative composition over time and Figure 34 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.

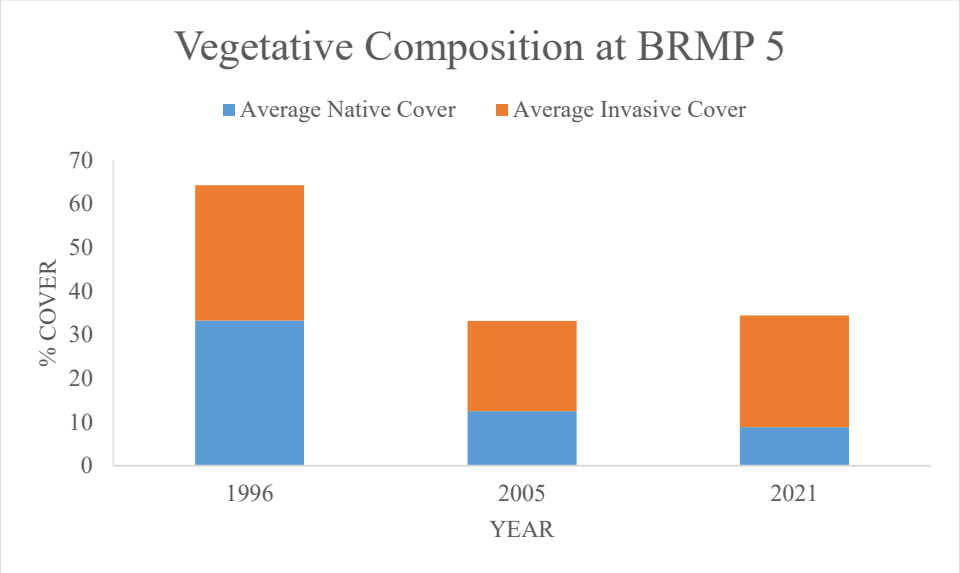

Figure 33. The Average Vegetative Composition at BRMP 5 over Time.

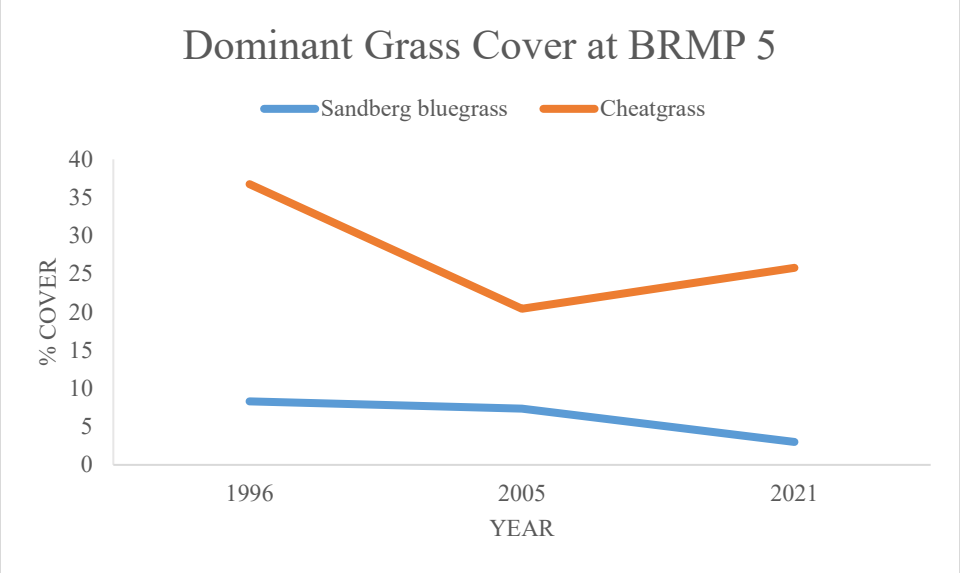

Figure 34. Changes in Dominant Grass Cover at BRMP 5 over Time.

4.2.4 BRMP Plot 6

BRMP Plot 6 (referred to as BRMP 6) is located in an area classified by HNF-61417 as a mix of bitterbrush/Bunchgrasses and Sandberg's bluegrass – cheatgrass-dominated habitat. It was characterized as having 0 to 3% cover of sagebrush, 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 35 shows the change in vegetative composition over time and Figure 36 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 12.0%. Non-native cover was still dominated by cheatgrass and tall tumblemustard had significant cover compared to 1996 levels.

BRMP 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.

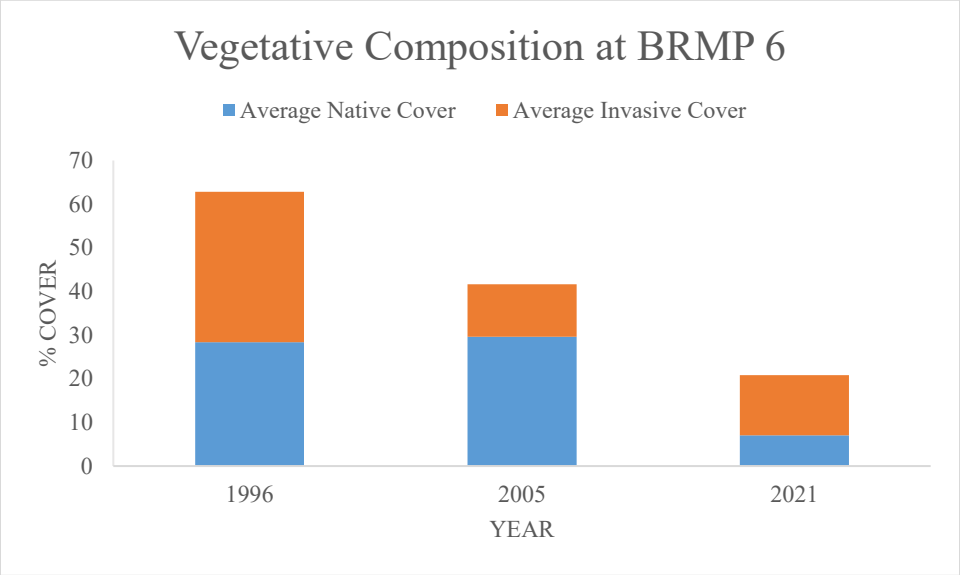

Figure 35. The Average Vegetative Composition at BRMP 6 over Time.

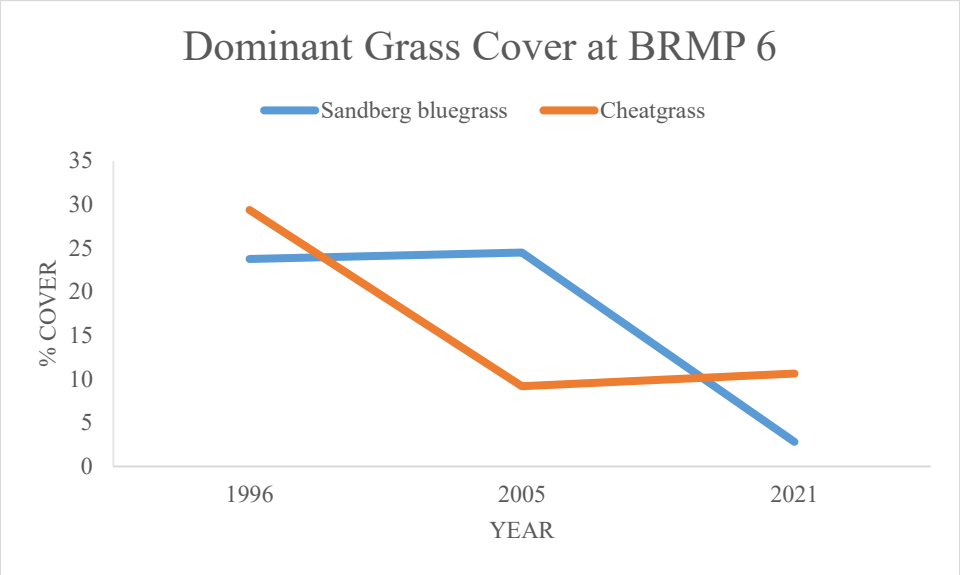

Figure 36. Changes in Dominant Grass Cover at BRMP 6 over Time.

4.2.5 BRMP Plot 10

BRMP Plot 10 (referred to as BRMP 10) is located in an area classified by HNF-61417 as a Bunchgrasses 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 37 shows the change in vegetative composition over time and Figure 38 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.

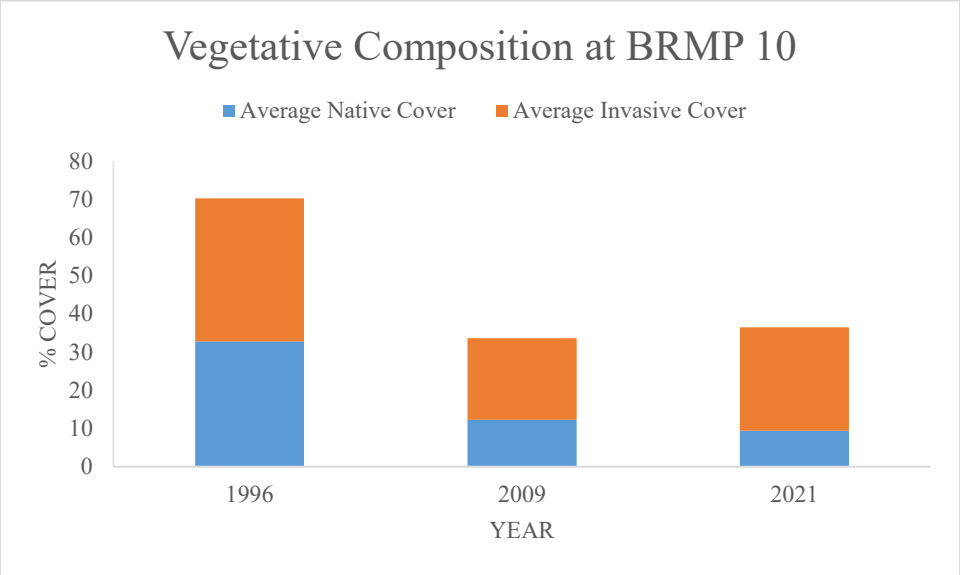

Figure 37. The Average Vegetative Composition at BRMP 10 over Time.

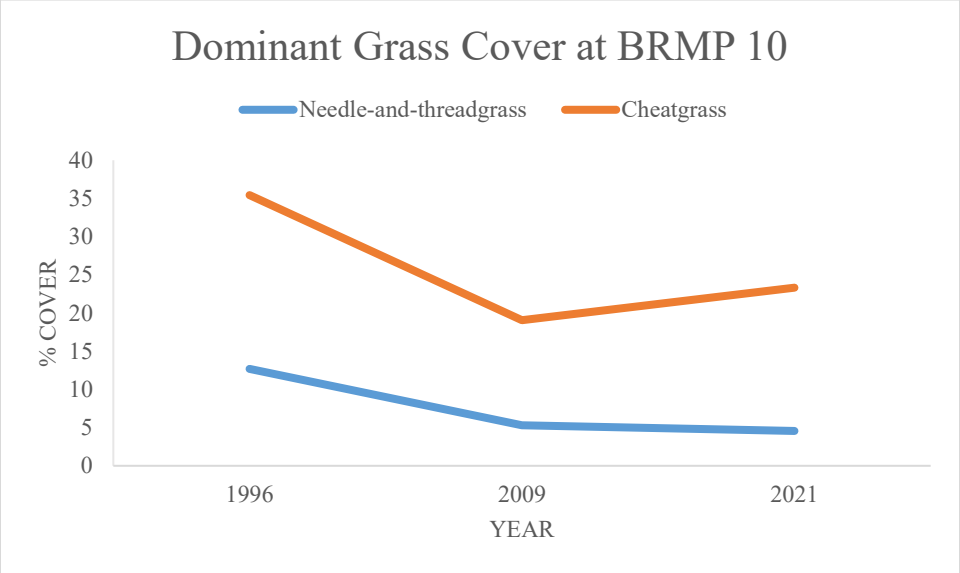

Figure 38. Changes in Dominant Grass Cover at BRMP 10 over Time.

4.2.6 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 39 shows the change in vegetative composition over time and Figure 40 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.

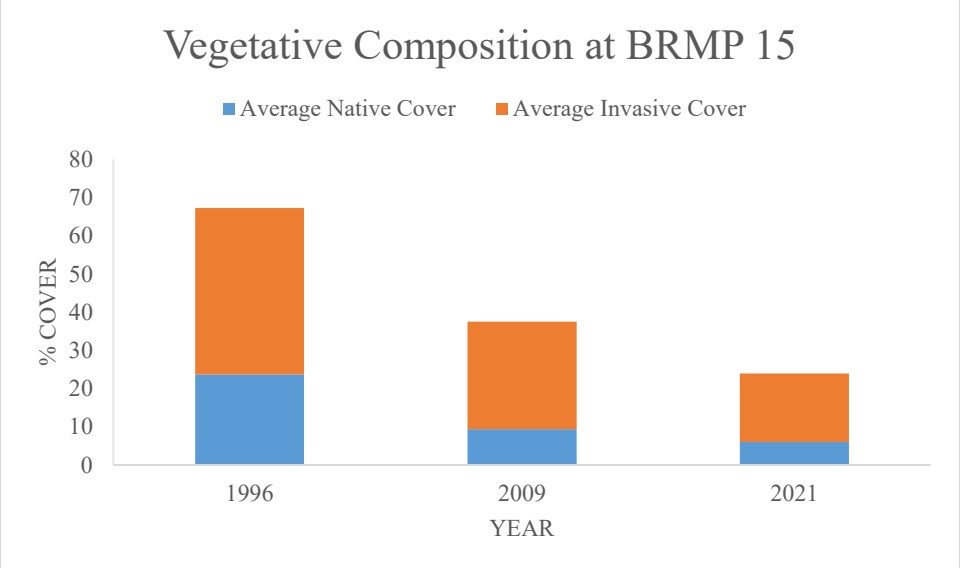

Figure 39. The Average Vegetative Composition at BRMP 15 over Time.

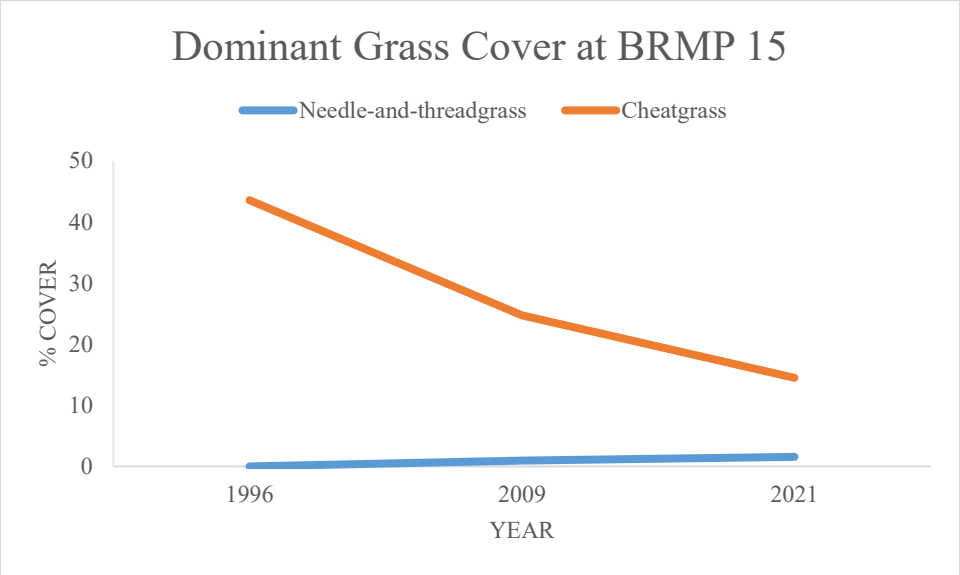

Figure 40. Changes in Dominant Grass Cover at BRMP 15 over Time.

4.2.7 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 Figure 41 and Figure 42. 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.

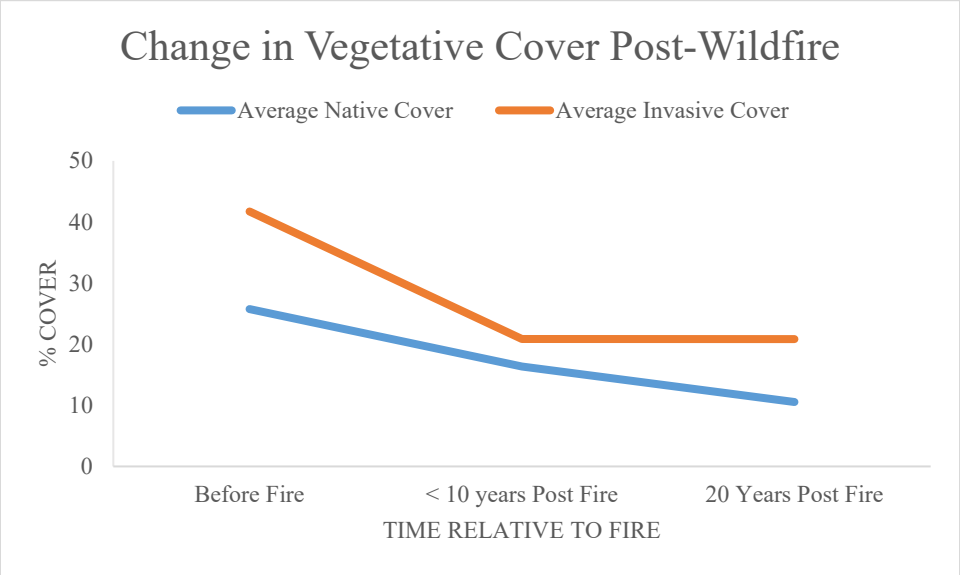

Figure 41. Change in Vegetative Cover at BRMP Plots Burned in the 24 Command Fire.

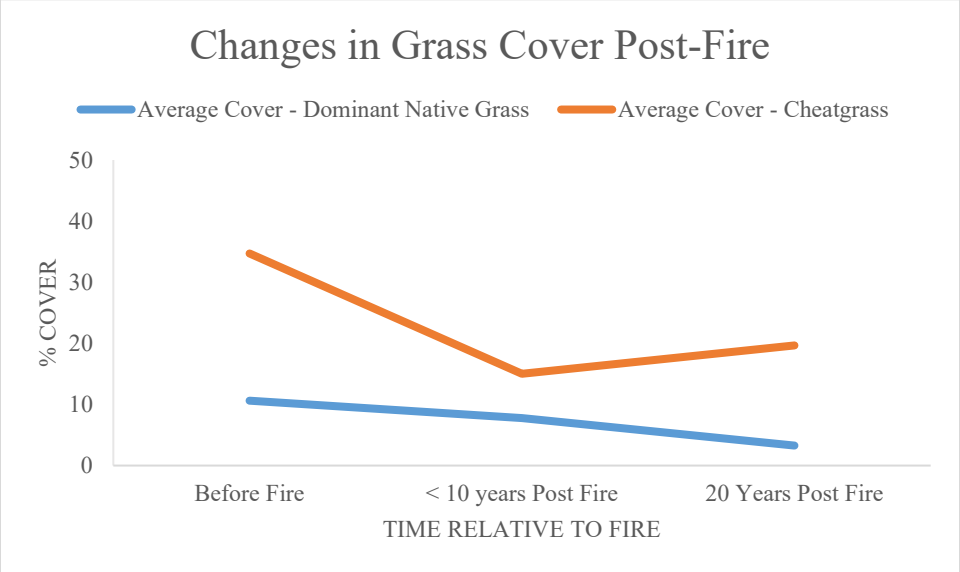

Figure 42. Change in Grass Cover in BRMP Plots Burned in the 24 Command Fire.

An additional noteworthy trend is the decrease in shrub cover after fire, as shown in Figure 43 (considering sagebrush, spiny hopsage, and 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.

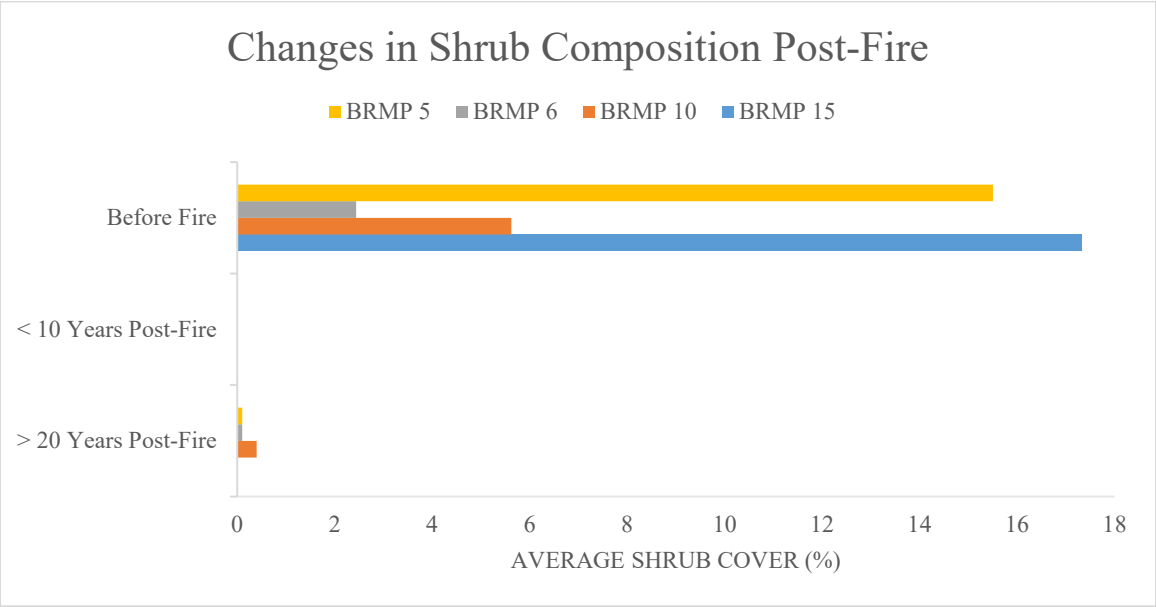

Figure 43. Changes in Shrub Composition at BRMP Plots after the 24 Command Fire.

5.0 DISCUSSION

Evaluation of how the 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.

5.1 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 Reference Area transects contained high quantities of cheatgrass in the understory with average cheatgrass cover totaling 31.4%. This suggests 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 (1.76 in.), well below the expected average level of 92.2 mm (3.63 in.) for that period (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 109.98 mm (4.33 in.), 119% of average. 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.

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 within a year 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 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, but the Gable Mountain restoration effort did not obtain authorization 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 Reference Area 1, which is

within a community of mature sagebrush shrubs, indicating that precipitation conditions were adequate for seedling germination in 2022.

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 Reference Areas 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 Reference Areas. The above average precipitation received at the Hanford Site in 2022 is a likely cause of 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. More data is needed before evaluating the effectiveness of the restoration seed mix and trending the recovery of the Gable Mountain Fire area.

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 tumbleweed plants accumulate and increase fire risk in some areas.

5.2 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 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 provides 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.

5.3 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, and 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.

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