



Sagebrush Steppe Vegetation Monitoring in Craters of the Moon National Monument and Preserve

2019 Annual Report

Natural Resource Report NPS/UCBN/NRR—2020/2109



ON THE COVER

Crew actively monitoring sagebrush steppe environment in Craters of the Moon National Monument and Preserve, 2019.

Photograph by: Devin Stucki

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Executive Summary

As part of the Upper Columbia Basin Network's sagebrush steppe vital signs monitoring program, a survey of sagebrush steppe ecological condition was conducted in June and July 2019 in Craters of the Moon National Monument and Preserve (CRMO) following methods outlined in the Upper Columbia Basin Network monitoring protocol (Yeo et al. 2009). The plot-based surveys occurred within 28 sampling frames and included 1527 plots, each 1 m² (Figure 1). Cover of exposed soil and of principal native and non-native plants or genera were estimated in plots randomly placed throughout the sampling frames. Plot locations were drawn using a spatially-balanced random sampling design, Generalized Random Tessellation Stratified (GRTS), which ensures a good representative random and dispersed sample within each sampling frame. Sagebrush steppe is one of the most threatened ecosystems in the intermountain west, and land use practices both within and adjacent to UCBN park steppe communities have resulted in fragmented and altered park ecosystems. Predicted climate change for the region may exacerbate these changes. This brief annual report summarizes some of the key findings from the 2019 field season including some species of particular interest, like big sagebrush (*Artemisia tridentata*), Idaho fescue (*Festuca idahoensis*) and cheatgrass (*Bromus tectorum*).

A wide range of conditions and species was encountered among sampling frames. There were 78 different species recorded, with an average of 5.5 species per plot, and 29 species per frame. Big sagebrush (*Artemisia tridentata*) was the most abundant sagebrush, occurring in all 28 sampling frames and 62% of all plots. The most dominant shrub species was antelope bitterbrush (*Purshia tridentata*), being found in almost 20% of all plots, followed by prickly phlox (*Leptodactylon pungens*), dwarf rabbitbrush (*Ericameria nana*), and rubber rabbitbrush (*Ericameria nauseosa*). Sandberg's bluegrass (*Poa secunda*), a small stature and highly resilient native perennial grass, was the most widespread and abundant native perennial grass encountered. The percentage of plots containing Sandberg's bluegrass was 74%. Needlegrass species (*Achnatherum spp.*), an important native perennial grass genera, was found in 20% of the plots. Bluebunch wheatgrass (*Pseudoroegneria spicata*) and squirrel tail (*Elymus elymoides*) were found in about 15% of all plots. Thick spike wheatgrass (*Elymus lanceolatus*), western wheatgrass (*Pascopyrum smithii*), and Idaho fescue (*Festuca idahoensis*) were less abundant native perennial grasses encountered in many plots. Buckwheats (*Eriogonum spp.*), biscuit roots (*Lomatium spp.*), and phlox (*Phlox spp.*) were the most abundant native perennial forbs. All frames in CRMO had some presence of cheatgrass (*Bromus tectorum*) with the proportion of plots containing cheatgrass cover ranging among frames from 5-100%. Four frames had all 55 plots sampled within them containing cheatgrass. Three of these frames were located in the southern end of the park within the Wapi Flow, an area that has historically been degraded and contained higher amounts of non-native invasive species. Another four frames had 96-98% of plots containing cheatgrass. Frame 25 (Brass Cap Kipuka) and Frame 33 (south of Laidlaw) had the lowest cover with only 3 occurrences of cheatgrass each and relatively few non-native species. The Brass Cap frame has historically been in good condition, dominated by native perennial grasses and forbs. Tumble mustard (*Sisymbrium altissimum*) was the most common non-native invasive forb, followed by yellow salsify (*Tragopogon dubius*) and prickly lettuce (*Lactuca serriola*). There were four occurrences of rush skeletonweed (*Chondrilla juncea*), found in

three frames, which was the only noxious weed encountered during monitoring. As one might expect, frames with high cheatgrass and non-native forb abundance showed lower native grass abundance, and vice versa.

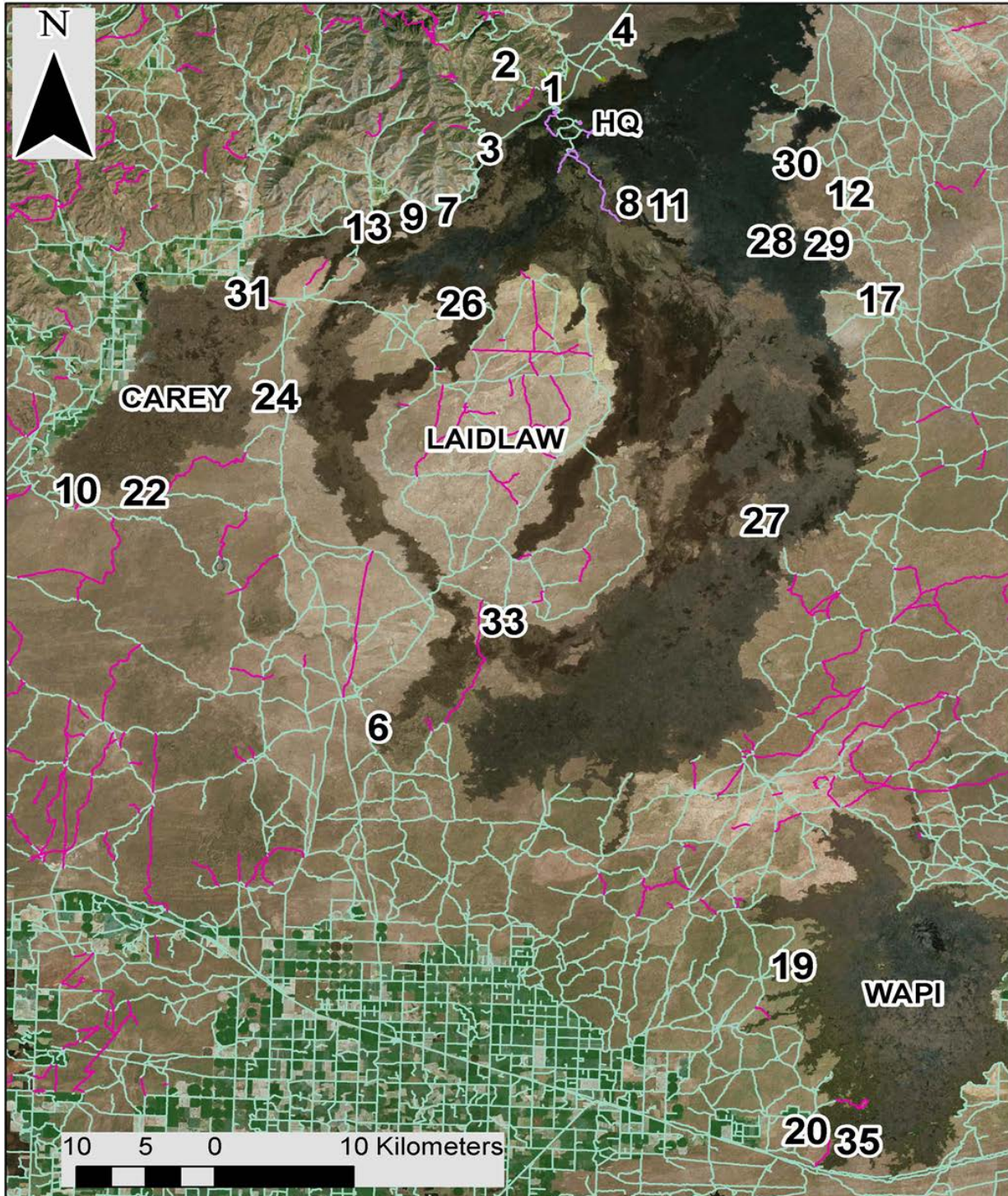


Figure 1. Map of Craters of the Moon National Monument and Preserve, showing sampling frames across the park for 2019 monitoring. Note: some frames are hidden due to expanded view.

Acknowledgments

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Introduction

Prior to Euro-American settlement, sagebrush steppe ecosystems in the Upper Columbia Basin extended across the eastern half of Washington and Oregon, and across the northern Great Basin of southern Idaho. Currently much of that ecosystem has been lost to development and agriculture or substantially degraded as a result of livestock grazing, fire, plant invasion, and recreational use. At Craters of the Moon National Monument and Preserve (CRMO), where bare lava rock comprises 81% of the total land cover, sagebrush steppe represents over 90% of the vegetation cover. The Upper Columbia Basin Network (UCBN) has identified the ecological condition of sagebrush steppe vegetation as a high priority vital sign and monitoring of its condition is central to its monitoring program (Garrett et al. 2007). A long-term monitoring program that provides for regular evaluation of the status of the health of sagebrush steppe communities, and for identification of trends of ecosystem condition over time within and among parks within the network was implemented in 2008 (Yeo et al. 2009). The foundation of the sagebrush steppe monitoring protocol is a perspective that ecological health or integrity of these steppe systems is sustained by plant communities dominated by a diverse suite of native plants. Divergence of sagebrush steppe communities from these natural states (e.g., invasion by non- native plants, increased fire frequencies, long-term trends of increasing cover of exposed soil, declines in cover of principal native plants) signifies a loss of health, and monitoring provides park managers with feedback necessary for developing effective adaptive management strategies. Simple monitoring objectives follow directly from this view:

- Determine the status (current condition) and trends (change in condition over time) in the composition and abundance (cover) of principal native plant species in UCBN sagebrush steppe communities.
- Determine the status and trends in composition and abundance (cover) of principal invasive plant species, including exotic annual grasses, in UCBN sagebrush steppe communities.
- Determine the status and trend in the amount of exposed soil (cover), a fundamental indicator of soil stability.

This report summarizes the data collected in 2019 for Craters of the Moon National Monument and Preserve. The Monument portion of the park is managed by the National Park Service and while the Preserve is co-managed by the National Park Service and Bureau of Land Management. This report represents an important contribution to the park's effort to engage in science-based adaptive management. The presentation of results in this report is primarily graphical, providing snapshots of condition within the park sampling frames as a way to help guide management decisions. By identifying not only the overall condition of park sagebrush steppe, but also areas of good and poor condition, the park will be better able to prioritize and target effective management strategies to aid in creating desired future conditions for the monument and preserve.

Methods

Sample frames in CRMO were chosen to represent the park's sagebrush steppe landscape and labeled by an arbitrary frame number, from 1-35. Frames 19, 20, 25, 26, 27, 28, and 35 are located in kipukas (Table 1). Kipukas are areas of land within the CRMO lava fields that are completely surrounded by younger lava flows. Often kipukas have well developed soils and late-successional vegetation. In CRMO, kipukas are ecologically important because many have been isolated from livestock grazing, and, in a few cases, still support quasi-pristine plant communities and are therefore of special interest to CRMO park staff. Table 1 shows the kipuka identification numbers for these 7 frames from the CRMO kipuka geodatabase and also the official or tentative descriptive names for these kipukas.

Table 1. The names and identification numbers of seven CRMO sampling frames that encompass or fall within kipukas, which are unique areas of park management interest.

Kipuka name	Sample Frame ID	Kipuka Geodatabase ID
Schodde Well	19	469
Baker Cave	20	591
Brass Cap	25	89
Carey	26	410
Bear Park	27	382
County Line	28	55
Sand	35	536

Within each frame, 1-m² plots were located using the generalized random tessellation stratified (GRTS) spatially-balanced sampling design (Stevens and Olsen 2004; Figure 1). The GRTS approach provides for randomly located plots and good spatial dispersion across each site. Each of the 28 frames aimed to sample 50 plots, with 5 oversamples. Of the 1539 plots drawn from GRTS, twelve were dropped in the field due to incorrect vegetation type or the plot falling on rock only, resulting in a total of 1527 sampled plots. Oversample plots were surveyed in each sampling frame to maintain a large enough sample size, despite having instances where plots were dropped. Sampling procedures followed Yeo et al. (2009).

Within each 1-m² plot, we estimated cover of exposed bare ground and canopy cover of principal native plants and non-native invasive plants. Cover estimates were categorized into the following cover classes: 0, 1-5%, 5-25%, 25-50%, 50-75%, 75-95%, and 95-100% (Daubenmire 1959; Table 2). Plant canopy cover was defined as the natural spread of current year's growth outlined using a minimum convex polygon with small gaps included in the cover estimate. Exposed bare ground was defined as soil surface not overlain by plant cover, litter, and rock >1/4 in size. A list of the common names and scientific names of principal plant species encountered in plots during 2019 are listed in Appendix A.

Table 2. Daubenmire's cover classes used for visually estimating vegetation cover in 1 m² square quadrats.

Cover Class	Range	Midpoint
0	0%	0%
1	1-5%	2.50%
2	>5-25%	15%
3	>25-50%	37.50%
4	>50-75%	62.50%
5	>75-95%	85%
6	>95%	97.50%

Weather

Historic weather information was compiled from data obtained from the Craters of the Moon COOP weather station located within the park boundaries. This station is the closest to the Preserve with accessible long term climate data. Station Type: COOP, ID #: USC0102260, Latitude: 43.465, Longitude: -113.558, Elevation (m): 1797 and Years Available: 1958 – 2019. The fall of 2018 had precipitation levels that fell right around average. Snow fall in January and February appeared to be well above the 30 year averages. The spring of 2019 followed a similar trend with above average spring precipitation, followed by below average summer rain. Temperatures in 2019 were cooler than the 30 year averages, with exception to a warmer than normal November (2018). A wetter and cooler spring could have played a part in cheatgrass germination but does not necessarily explain fluctuation from previous monitoring seasons. Weather records from CRMO for 2019 compared with long term averages, as well as 2019 precipitation and temperatures from Potter Butte are presented as figures in Appendix B.

Results and Discussion

The UCBN sagebrush steppe monitoring program completed a fourth season of monitoring in CRMO in 2019, following surveys in 2010, 2013, and 2016. A total of 1,527 plots were sampled in 28 different frames across a large portion of the monument and preserve. Most of the sampling frames are identical in shape and size, with a square perimeter that encompasses 11.4-11.8 hectares. However, due to boundary issues or unique kipuka shapes, some frames are larger (17.4 hectares) or smaller (10.4 hectares). The total hectares that were sampled during the 2019 season was 330.55 hectares. Sample sizes ranged from 52 to 55 plots per sampling frame, and were spatially extensive and random so that inferences can be drawn about the condition of sagebrush steppe condition for each frame (Figure 1). Of particular importance for park management are the frames bordered by BLM land with active grazing. Monitoring of these areas over time will provide the park with invaluable information about the condition of certain kipukas and the effect of grazing on border lands. Appendix C provides complete tables of bare ground and principal species cover estimates from the 2019 survey for each frame.

The amount of exposed bare soil – bare ground cover – is a fundamental measure of ecological condition in grazed rangeland. Too much bare ground indicates a loss of soil stability and hydrologic function, and also creates opportunities for weed invasion and loss of biological integrity. However, some of the frames found to be in more-favorable condition, had larger percentages of bare ground, including bare spots that had not been invaded by non-native species. 9 plots within the sampling frames had a bare ground cover greater than 50%, with 6 of those occurrences falling within Brass Cap Kipuka (Frame 25). The majority of the bare ground cover was between 1-5% with 65% of plots falling within that cover class. The proportion of plots where bare ground cover was estimated to be >5% ranged widely from 1% to 72% among frames, compared to 2-88% in 2013 (Appendix C). Another 24% of plots had no (0%) bare ground cover. Frame 33 for example, had 70% of the plots within it containing no bare ground. It also only had 3 occurrences of cheatgrass, while being dominated by native perennial grasses and forbs. Frame 25, contained just as much ecological diversity as Frame 33, with only 3 occurrences of cheatgrass and being dominated by native grasses and low sage, however it had 73% of plots with bare ground cover greater than 5%. Frames 19 and 20, in the Wapi flow, had 100% of plots containing cheatgrass and also have relatively low percentages of bare ground (85-90% of plots having 1-5% bare ground cover). It appears that bare ground cover alone is not a great indicator of ecological condition in CRMO.

Big sagebrush (*Artemisia tridentata*) dominates the over story in all sampling frames (Appendix C) except Brass Cap Kipuka (Frame 25) and County Line Kipuka (Frame 28). Brass Cap had the lowest cover estimates for big sagebrush with only one occurrence in the whole frame. This kipuka is dominated by low sagebrush (*Artemisia arbuscula*) with 85% of the plots sampled containing low sage. County Line was dominated by three-tip sagebrush (*Artemisia tripartita*) with 45% of the plots surveyed containing it. With exception to Brass Cap and County Line, big sagebrush occurrence ranged from 18-93% within the frames. Frame 13, just south of the highway and northwest of Brass Cap Kipuka, had the highest density of big sagebrush with 57% of the plots having >25%

cover. 91% of the plots in Frame 13 contained big sagebrush. There were 3 sagebrush species recorded during the monitoring of 2019.

Antelope bitterbrush (*Purshia tridentata*) was the most abundant shrub, followed by prickly phlox (*Leptodactylon pungens*), rubber rabbitbrush (*Ericameria nauseosa*) and dwarf rabbitbrush (*Ericameria nana*). Bitterbrush was found in 20% of all plots monitored and almost 30% of those occurrences having cover greater than 25%. Prickly phlox was the second most dominant shrub, being found in 17% of all the plots sampled. Dwarf and rubber rabbitbrush were fairly comparable being found in 7-8% of all plots. Less common, but still encountered species were green rabbitbrush (*Chrysothamnus viscidiflorus*), fern bush (*Chamaebatiaria millefolium*), and snowberry (*Symphoricarpos spp.*). There was a total of 14 different shrub species recorded in 2019.

In 2019, County Line Kipuka (Frame 28), was noted as having the highest amount of bluebunch wheatgrass (*Pseudoroegneria spicata*) with 82% of the plots containing the grass. Of those 45 plots containing bluebunch wheatgrass, 7% had cover estimates >25%. Frame 28 also contained the largest proportion (56%) of plots with an estimated cover >5% for bluebunch wheatgrass. In 2016, Frame 1 (in the north end of the park), had 75% of the plots with bluebunch presence. However, in 2019, only 11% of the plots in Frame 1 had bluebunch presence. It appears there was less bluebunch wheatgrass documented in the various frames in 2019 than previous years. However, there were larger amounts of thickspike wheatgrass (*Elymus lanceolatus*), with 10% of all plots containing it and only 4% in 2016. The likely explanation is that there may have been some confusion with identification of bluebunch wheatgrass versus thickspike wheatgrass and western wheatgrass (*Pascopyrum smithii*). Western wheatgrass was in only 2% of plots in 2016 and 27% of plots in 2019. The inflated numbers from 2016 of one species and decline in 2019, may just be due to misidentification, leading to the lower numbers in 2019 not actually reflecting a decline in perennial bunchgrass parkwide.

In 2013, Brass Cap Kipuka (Frame 25), was dominated by Idaho fescue (*Festuca idahoensis*), with 50% of plots having >5% cover of that species and 22% in 2016. However, during the 2019 monitoring, not a single occurrence of Idaho fescue was documented in Brass Cap. This seems like an alarming event, but it is likely another occurrence of misidentification. It is believed that what was called Idaho fescue in 2013 and 2016, was called needlegrass (*Achnatherum spp.*) in 2019. There were only 11 documented occurrences of Idaho fescue in any of the sampling frames during 2019, with 72% of those being in Carey Kipuka (Frame 26). In 2019, the perennial grasses found in Brass Cap were dominated by Sandberg's bluegrass (*Poa secunda*) and needlegrass species. This is the same trend that the park overall experienced in 2019, with Sandberg's bluegrass being nearly ubiquitous across the sample frames and comprising 52% of all native perennial grasses. Needlegrass species made up about 14% of the perennial grasses and squirrel tail (*Elymus elymoides*) fell in at 9%.

Carey Kipuka (Frame 26) had the second highest proportion of bluebunch wheatgrass within the sampling frames at 56% of the plots containing bluebunch. In this frame, 45% of the plots were estimated to contain >5% cover of bluebunch wheatgrass. Bunchgrass species that are less widely distributed and abundant but nonetheless important components of the sagebrush steppe communities in CRMO include thickspike wheatgrass, great basin wild rye, western wheatgrass, junegrass, and

needle and thread grass (Appendix C). Where several of these species are in concert with Sandberg's bluegrass, western wheatgrass, or bluebunch wheatgrass, it suggests good ecological condition. There were 13 species of native perennial grasses documented in 2019. Overall, the records of individual native perennial grasses have not gone down in CRMO, despite some confusion in species identification. In fact, 2019 saw the highest number of native grass occurrences than any other sampling year.

A wide variety of native perennial forbs were encountered during monitoring, with buckwheat (*Eriogonum spp.*), biscuit root (*Lomatium spp.*), and phlox (*Phlox spp.*) being most abundant. Buckwheat was found in 22 of the 28 sampling frames and 27% of all plots. Buckwheat had the highest frequency north of Sunset Cone at the north end of the park (Frame 1), occurring in 84% of the plots. The frames that it was not found in were in the historically degraded areas of the Wapi flow and corresponded with high cheatgrass cover, with exception to Frame 6. Biscuit root was found in 23 of the 28 sampling frames, but only 14% of all plots. Interestingly, biscuitroot frequency was highest in Sand Kipuka (Frame 35), being found in 67% of plots. Sand Kipuka also had cheatgrass in 100% of all plots. Phlox was found in 14% of the plots sampled. Balsam root (*Balsamorhiza spp.*) and penstemons (*Penstemon sp.*), important deep-rooted perennials, were also found in significant portions of the sampling frames (7-8% of all plots). Other notable forbs documented in 2019 were agoseris (*Agoseris spp.*), wild onion (*Allium spp.*), and mariposa lily (*Calochortus spp.*). As exhibited by many of the sampling frames, not a single species or even combination of species, can be a sole indicator of good ecological health within these extremely varying and isolated sampling frames at CRMO. There were 26 species of native perennial forbs and 13 species of other forbs recorded in 2019.

One noxious weed species was documented during 2019 monitoring. There were three occurrences of rush skeletonweed (*Chondrilla juncea*) documented. Park resource staff was informed of these locations and has spent much time combatting this noxious weed in other areas of the park. The invasive annual grass, cheatgrass is the most widespread and threatening non-native species in the park. As a park wide trend, there was an increase in overall cheatgrass cover in CRMO from 2010 to 2016, but the number of documented occurrences decreased in 2019 (by approx. 11%) compared to the previous sampling cycle (Figure A-3 in Appendix D). In 2019, of the 330.55 hectares sampled, 222.66 (550.2 acres) were containing cheatgrass (Table 3). And another 65.88 hectares (162.8 acres) were considered heavily infested (>25% cover; Table 3). This makes cheatgrass one of the continued largest threats to the sagebrush steppe ecosystems in CRMO.

Other non-native grasses that were documented across the park in low to moderate abundance are crested wheatgrass (*Agropyron cristatum*), bulbous bluegrass (*Poa bulbosa*), and various non-native brome species (*Bromus spp.*; Appendix C). Crested wheatgrass had only a single occurrence in Sand Kipuka (Frame 35). Bulbous bluegrass was found in 5 sampling frames, with 8 individual occurrences. Other non-native brome species were found in 16 sampling frames with higher abundance than crested wheatgrass or bulbous bluegrass, however, they are still less invasive and worrisome than the patterns of cheatgrass abundance.

Table 3. The percent of plots within each sampling frame that had cheatgrass, had >25% cover of cheatgrass, and the corresponding hectares infested.

FRAME	HECATRES	PERCENT CHEATGRASS	% HEAVILY (>25%) INFESTED	HECTARES INFESTED	HECTARES HEAVILY INFESTED (>25%)
1	11.778	31	4	3.65	0.47
2	11.778	69	2	8.13	0.24
3	11.778	47	2	5.54	0.24
4	11.778	56	0	6.6	0
6	11.778	35	13.5	4.12	1.6
7	11.778	89	5.5	10.48	0.65
8	11.778	51	2	6	0.24
9	11.778	87	13	10.25	1.5
10	11.778	27	2	3.18	0.24
11	11.778	58	0	6.83	0
12	11.778	85	9	10.01	1.06
13	11.778	87	9.5	10.25	1.12
16	11.778	44	0	5.18	0
17	11.778	93	13	10.95	1.5
19	10.339	100	69	10.339	7.13
20	11.392	100	95	11.392	10.82
22	11.346	26	0	2.95	0
24	11.378	46	4	5.23	0.46
25	11.559	5.5	2	0.64	0.23
26	11.291	98	40	11.52	4.5
27	11.38	100	56	11.38	6.37
28	11.38	73	14.5	8.31	1.65
29	11.38	96	27	10.93	3.07
30	11.778	96	22	11.31	2.59
31	11.778	69	5.5	8.13	0.65
32	11.778	96	64	11.31	7.54
33	11.47	5.6	0	0.64	0
35	17.406	100	69	17.406	12.01
SUM	-	-	-	222.657 (550.2 ACRES)	65.88 (162.79 ACRES)

Non-native invasive forbs were found infrequently in most frames and do not appear to be of major concern. Tumble mustard (*Sisymbrium altissimum*) had the highest frequency and cover of non-native invasive forbs being found in 11% of all plots monitored. Other common non-native invasive forbs encountered in 2019 included yellow salsify (*Tragapogon dubius*) and prickly lettuce (*Lactuca serriola*).

The overall patterns reflected in the data collected in 2019 suggest that much of the sagebrush steppe vegetation within CRMO remains in good ecological condition. Particularly noteworthy is the combination of high diversity and abundance of native perennial grasses and forbs and moderate abundances of big sagebrush and steppe bluegrass in the north end of the park and within certain kipukas. Brass Cap Kipuka continues to exhibit intact sagebrush steppe with good diversity and low abundance of invasive species. Frames where indicators of poor condition were consistently observed include many of the frames within the southern region of the park, with a low elevational gradient within the Wapi Flow, like Baker Cave Kipuka and Schodde Well Kipuka. These observations underscore that even areas physically isolated from past grazing are still vulnerable to degradation. The Frame with the highest species diversity was County Line Kipuka (Frame 28), with 41 recorded species (Appendix C), 12 of those being perennial forbs. Baker Cave Kipuka (Frame 20) had the lowest diversity with only 16 species recorded, 4 of those being perennial forbs. Native perennial forb cover has been attributed to ecological resistance and resilience in western sagebrush rangelands, generally (Prevey et al. 2010). On average, there were 29 species found per sampling frame.

Maintaining this component of CRMO sagebrush steppe ecosystems along with a diverse and abundant native perennial grass component will facilitate the persistence of healthy intact native sagebrush steppe in the Monument and Preserve. Continuing to monitor these communities will provide a good indication of ecological condition over time. Because of the drastic variation between frames, kipukas, and areas of the park, increasing the amount and areas of monitoring taking place at the park could be very beneficial. Adding more kipukas and increasing the sampling sizes could be beneficial to understanding what management practices will best benefit CRMO. A Kipuka Monitoring Project was previously presented by CRMO Resource Staff and should be pursued as a high priority and worthwhile endeavor.

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Appendix A. List of Plant Species Mentioned in the Report

Table A-1. Plant common, species, and updated species names.

Plant Category	Common names	Species name	Updated Species Name
Sagebrush	Low Sagebrush	<i>Artemisia arbuscula</i>	–
	Big Sagebrush Three-tip sagebrush	<i>Artemisia tridentata</i> <i>Artemisia tripartita</i>	–
Other Shrubs	Serviceberry	<i>Amerlanchier spp</i>	–
	Fern bush	<i>Chamaebatiaria millefolium</i>	–
	Green rabbitbrush	<i>Chrysothamnus viscidiflorus</i>	–
	Dwarf rabbitbrush	<i>Ericameria nana</i>	–
	Rubber rabbitbrush	<i>Ericameria nauseosa</i>	–
	Broom snakeweed	<i>Gutierrezia sarothrae</i>	–
	Oceanspray	<i>Holodiscus spp.</i>	–
	Prickly phlox	<i>Leptodactylon pungens</i>	<i>Linanthus pungens</i>
	Mock orange	<i>Philadelphus lewisii</i>	–
	Chokecherry	<i>Prunus virginiana</i>	–
	Bitterbrush	<i>Purshia tridentata</i>	–
	Currant	<i>Ribes spp.</i>	–
	Snowberry	<i>Symphoricarpos spp.</i>	–
Spineless horsebrush	<i>Tetradymia canescens</i>	–	
Native Grasses	Needlegrass	<i>Achnatherum spp.</i>	–
	Squirreltail	<i>Elymus elymoides</i>	–
	Thickspike wheatgrass	<i>Elymus lanceolatus</i>	–
	Idaho fescue	<i>Festuca idahoensis</i>	–
	Needle and thread grass	<i>Hesperostipa comata</i>	–
	Prairie junegrass	<i>Koeleria macrantha</i>	–
	Great Basin wildrye	<i>Leymus cinereus</i>	<i>Elymus cinereus</i>
	Oniongrass	<i>Melica bulbosa</i>	–
	Indian ricegrass	<i>Oryzopsis hymenoides</i>	–
	Western wheatgrass	<i>Pascopyrum smithii</i>	<i>Achnatherum hymenoides</i>

Table A-1 (continued). Plant common, species, and updated species names.

Plant Category	Common names	Species name	Updated Species Name
Native Grasses (continued)	Sandberg's steppe bluegrass	<i>Poa secunda</i>	–
	Bluegrass spp	<i>Poa spp</i>	–
	Bluebunch wheatgrass	<i>Pseudoroegneria spicata</i>	–
Persistent Native Forbs	Pussytoes	<i>Antennaria spp</i>	–
	Sandwort	<i>Arenaria spp</i>	–
	Aster	<i>Aster spp.</i>	–
	Astragalus, Milkvetch	<i>Astragalus spp</i>	–
	Balsamroot	<i>Balsamorhiza spp.</i>	–
	Indian paintbrush	<i>Castilleja spp</i>	–
	Douglas' chaenactis	<i>Chaenactis douglasii</i>	–
	Native thistle	<i>Cirsium spp</i>	–
	Tapertip hawksbeard	<i>Crepis acuminata</i>	–
	Daisy	<i>Erigeron spp</i>	–
	Buckwheat	<i>Eriogonum spp</i>	–
	Common wooly sunflower	<i>Eriophyllum lanatum</i>	–
	Stemless mock goldenweed	<i>Haplopappus spp.</i>	–
	Western stoneseed	<i>Lithospermum ruderale</i>	–
	Biscuitroot	<i>Lomatium spp</i>	–
	Lupine	<i>Lupinus spp</i>	–
	Bluebells	<i>Mertensia spp</i>	–
	Prickly pear	<i>Opuntia polyacantha</i>	–
	Sweet cicely	<i>Osmorhiza occidentalis</i>	–
	Beardtongues	<i>Penstemon spp.</i>	–
	Silverleaf scorpionweed	<i>Phacelia hastata</i>	–
	Phlox	<i>Phlox spp</i>	–
	Cinquefoil	<i>Potentilla spp.</i>	–
Ragwort	<i>Senecio spp</i>	–	
Munro's globemallow	<i>Sphaeralcea munroana</i>	–	
Wirelettuce	<i>Stephanomeria spp.</i>	–	

Table A-1 (continued). Plant common, species, and updated species names.

Plant Category	Common names	Species name	Updated Species Name
Other Native Forbs	Mountain dandelion	<i>Agoseris spp</i>	–
	Wild onion	<i>Allium spp</i>	–
	Rockcress	<i>Arabis spp</i>	–
	Mariposa lily	<i>Calochortus spp</i>	–
	Bird's beak	<i>Cordylanthus spp.</i>	
	Cat's eye	<i>Cryptantha spp.</i>	–
	Spring parsleys	<i>Cymopterus spp.</i>	
	Larkspur	<i>Delphinium spp</i>	–
	Yellowbells	<i>Fritillaria pudica</i>	–
	Woodland stars	<i>Lithophragma spp</i>	–
	Monkey flower	<i>Mimulus nanus</i>	–
	Violets	<i>Viola spp.</i>	–
	Death camas	<i>Zigadenus spp</i>	–
Invasive Grasses	Crested wheatgrass	<i>Agropyron cristatum</i>	–
	Bromes	<i>Bromus spp.</i>	–
	Cheatgrass	<i>Bromus tectorum</i>	–
	Bulbous bluegrass	<i>Poa bulbosa</i>	–
Invasive Forbs	Rush skeletonweed	<i>Chondrilla juncea</i>	–
	Tansymustard	<i>Descurainia sophia</i>	–
	Prickly lettuce	<i>Lactuca serriola</i>	–
	Tumble mustard	<i>Sisymbrium altissimum</i>	–
	Salsify	<i>Tragopogon dubius</i>	–

Appendix B. Climate diagrams

Climate diagrams for Craters of the Moon National Monument and Preserve (Figures A-1 and A-2).

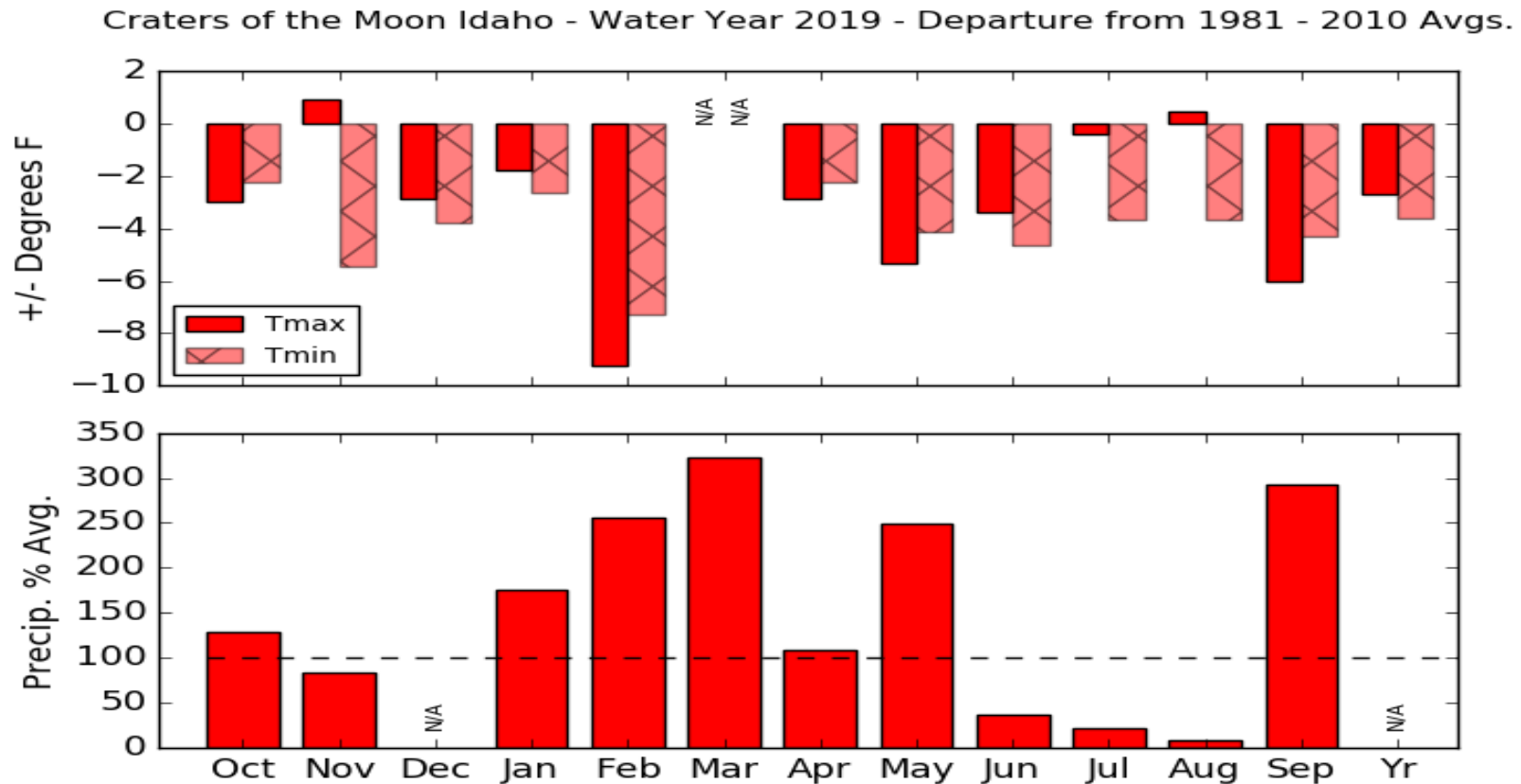


Figure A-1. This figure compares 2019 data to the long-term (30 year) averages of monthly temperatures (red boxes) and monthly precipitation (blue boxes). The dotted black line in the both graphs represents the 30 year average for temperature and precipitation.

Potter Butte (Automated Station) - Water Year Ending 2019

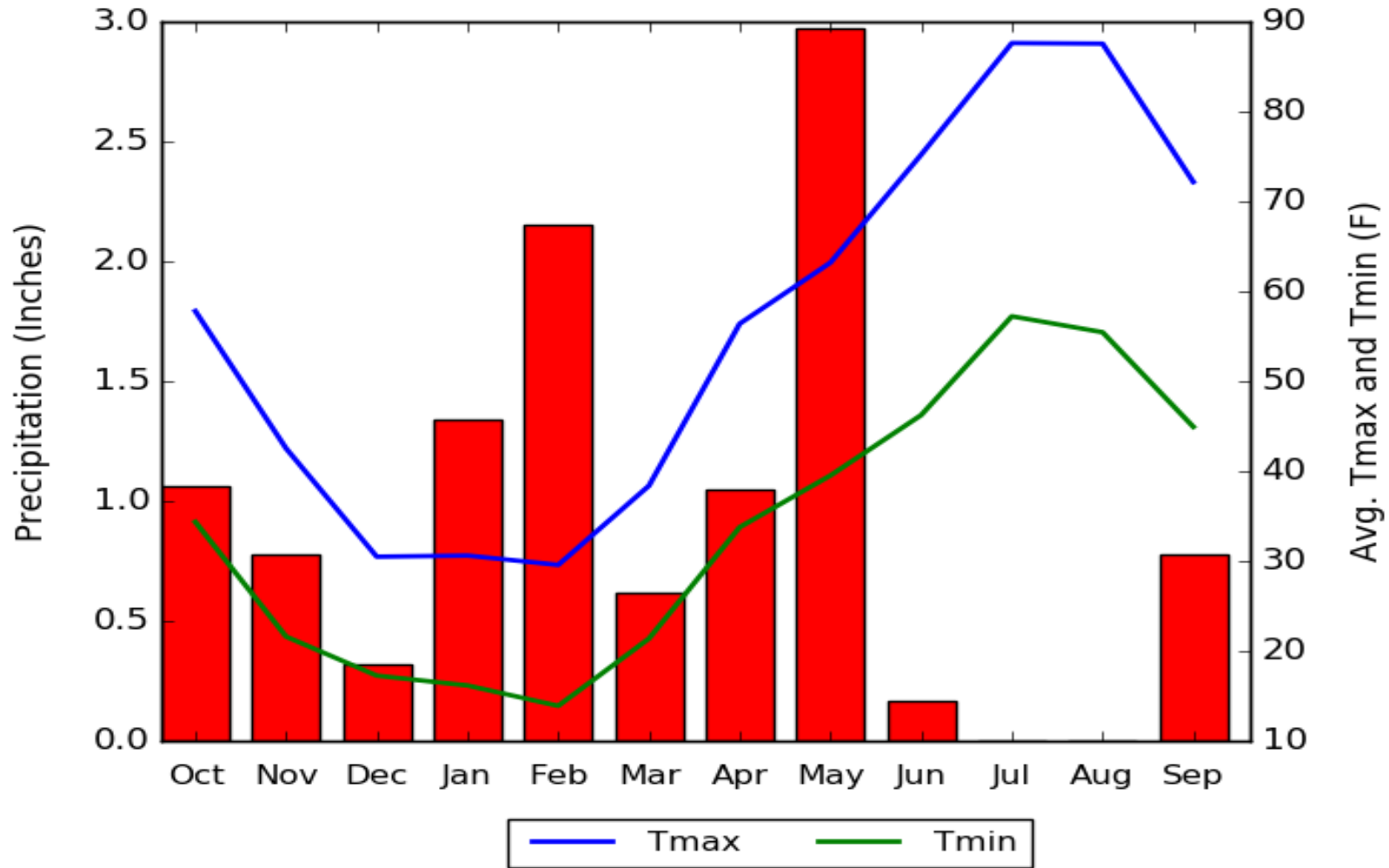


Figure A-2. This figure shows 2019 temperatures (red boxes) and monthly precipitation (blue boxes).

Appendix C. Cheat Grass Cover Estimates Over the Past 4 Monitoring Cycles

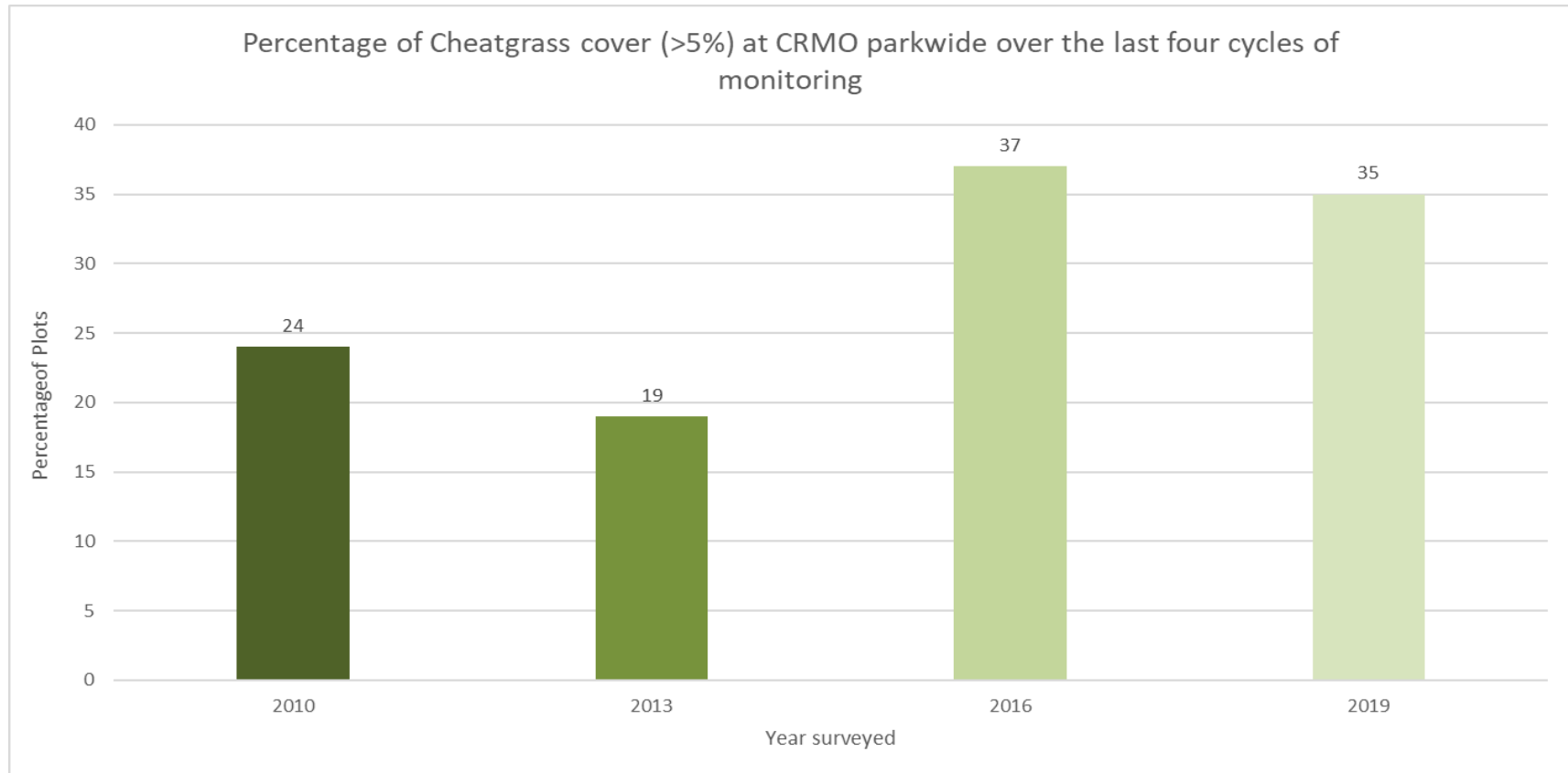


Figure A-3. Estimated percentage of cheatgrass cover (>5%) parkwide at CRMO through the last four seasons of surveying 2010, 2013, 2016, and 2019.

Appendix D. 2019 Sage Monitoring Results

Table A-2. The proportion of plots (%) in CRMO sampling frames estimated to have >5% cover for selected principal native species and for the non-native annual grass cheatgrass.

Frame ID	Big Sagebrush	Arrowleaf Balsamroot	Green Rabbitbrush	Lupine Species	Sandberg Bluegrass	Bluebunch Wheatgrass	Cheatgrass
1	87	2	9	0	15	2	7
2	53	20	0	7	0	0	11
3	69	0	0	0	33	0	13
4	76	0	0	0	35	4	11
6	35	0	0	0	37	2	23
7	64	0	0	0	13	0	40
8	67	0	0	0	0	0	9
9	62	0	0	0	62	0	45
10	37	0	0	0	17	0	4
11	47	0	2	0	5.5	0	5.5
12	47	0	0	0	35	5.5	18
13	75	0	0	0	42	0	21
16	63	0	0	0	24	0	13
17	47	0	0	0	40	0	36
19	20	2	0	0	40	0	93
20	22	0	0	2	7	0	100
22	35	0	0	0	30	0	4
24	31	0	0	0	22	0	13
25	2	0	0	0	38	0	4
26	29	5.5	13	15	16	25	71
27	47	2	9	13	44	0	91
28	4	66	0	2	16	45	27
29	15	0	2	0	27	2	56
30	55	0	0	0	31	4	53
31	64	0	0	0	27	0	16
32	9	0	7	0	47	4	84
33	43	0	0	0	11	0	0
35	24	24	9	2	7	0	100

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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National Park Service
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