



Sagebrush Steppe Vegetation Monitoring in Hagerman Fossil Beds National Monument

2018 Annual Report

Natural Resource Report NPS/UCBN/NRR—2019/1870



ON THE COVER

Sagebrush steppe vegetation, Hagerman Fossil Beds National Monument, Idaho

Photograph by: Devin Stucki, UCBN

Sagebrush Steppe Vegetation Monitoring in Hagerman Fossil Beds National Monument

2018 Annual Report

Natural Resource Report NPS/UCBN/NRR—2019/1870

Melissa M. Nicolli

National Park Service
Upper Columbia Basin Network Inventory and Monitoring Program
497 SW Century Drive Ste. 105
Bend, Oregon 97702

February 2019

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available in digital format from [Upper Columbia Basin Inventory & Monitoring Network](#) and the [Natural Resource Publications Management website](#). If you have difficulty accessing information in this publication, particularly if using assistive technology, please email irma@nps.gov.

Please cite this publication as:

Nicolli, M. M. 2019. Sagebrush steppe vegetation monitoring in Hagerman Fossil Beds National Monument: 2018 annual report. Natural Resource Report NPS/UCBN/NRR—2019/1870. National Park Service, Fort Collins, Colorado.

Contents

	Page
Figures.....	iv
Tables.....	v
Appendixes	vii
Executive Summary	viii
Acknowledgments.....	x
Introduction.....	1
Methods.....	2
Weather	3
Results and Discussion	4
Literature Cited	11

Figures

Page

Figure 1. Hagerman Fossil Beds National Monument showing the 5 sampling frames surveyed in 2009, 2012 and 2018, with the 2018 plot locations.....	ix
Figure A-1. This figure compares 2018 data to the long-term (30 year) averages of monthly temperatures (red boxes) and monthly precipitation (blue boxes).	31
Figure A-2. This figure compares 2017 data to the long-term (30 year) averages of monthly temperatures (red boxes) and monthly precipitation (blue boxes).	32
Figure A-3. This figure compares 2016 data to the long-term (30 year) averages of monthly temperatures (red boxes) and monthly precipitation (blue boxes).	33
Figure A-4. This figure compares data (years 2009-2015) to the long-term (30 year) averages of monthly temperatures (red boxes) and monthly precipitation (blue boxes).	34
Figure A-5. Estimated percentage of any bluebunch wheatgrass cover (>0%) in all sampling frames at HAFO through the last three years of surveying 2009, 2012, and 2018.....	35
Figure A-6. Estimated percentage of any cheatgrass cover (>0%) in each sampling frame at HAFO through the last three years of surveying 2009, 2012, and 2018.....	36
Figure A-7. Estimated percentage of heavily infested cheatgrass cover (>95%) in each sampling frame at HAFO through the last three years of surveying 2009, 2012, and 2018.....	37
Figure A-8. Estimated percentage of overall cheatgrass cover (>5%) found park wide at HAFO through the last three years of surveying 2009, 2012, and 2018.....	38

Tables

	Page
Table 1. Sample sizes, by frame, for 2019 sagebrush steppe monitoring in HAFO. Details of frame development and target sample sizes are provided in Yeo et al. (2009).	2
Table 2. Daubenmire's cover classes used for visually estimating vegetation cover in 1 m ² square quadrats.	2
Table 3. Summary statistics for estimated cheatgrass infestation in the North sampling frame by year.	6
Table 4. Summary statistics for estimated cheatgrass infestation in the Oregon Trail sampling frame by year.	7
Table 5. Summary statistics for estimated cheatgrass infestation in the Pump Station sampling frame by year.	8
Table 6. Summary statistics for estimated cheatgrass infestation in the South sampling frame by year.	9
Table 7. Summary statistics for estimated cheatgrass infestation in the Upper Bench sampling frame by year.	10
Table A-1. Plant common, species, and updated species names.	12
Table A-2. 2012 North sampling frame, HAFO: percentage of plots (n=50 1 m ² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.	14
Table A-3. 2018 North sampling frame, HAFO: percentage of plots (n=52 1 m ² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.	15
Table A-4. 2012 Oregon Trail sampling frame, HAFO: percentage of plots (n=76 1 m ² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.	16
Table A-5. 2018 Oregon Trail sampling frame, HAFO: percentage of plots (n=76 1 m ² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.	18
Table A-6. 2012 Pump Station sampling frame, HAFO: percentage of plots (n=55 1 m ² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.	20

Tables (continued)

	Page
Table A-7. 2018 Pump Station sampling frame, HAFO: percentage of plots (n=56 1 m ² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.....	21
Table A-8. 2012 South sampling frame, HAFO: percentage of plots (n=65 1 m ² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.	23
Table A-9. 2018 South sampling frame, HAFO: percentage of plots (n=69 1 m ² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.	25
Table A-10. 2012 Upper Bench sampling frame, HAFO: percentage of plots (n=50 1 m ² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.....	27
Table A-11. 2018 Upper Bench sampling frame, HAFO: percentage of plots (n=57 1 m ² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.....	29

Appendixes

	Page
Appendix A.....	12
Appendix B.....	14
Appendix C.....	31
Appendix D.....	35

Executive Summary

As part of the Upper Columbia Basin Network sagebrush steppe vital signs monitoring program, a survey of sagebrush steppe ecological condition was conducted in early June 2018 at Hagerman Fossil Beds National Monument following methods outlined in the Upper Columbia Basin Network monitoring protocol (Yeo et al. 2009). The plot-based surveys occurred within 5 sampling frames that are positioned along the Oregon Trail, the tops of benches, and along the bottomland adjacent to the Snake River. Much of the uplands of the park are inaccessible, consisting of steep and highly unstable unvegetated escarpments. Cover of exposed soil and of principal native and non-native plants or genera were estimated in three-hundred ten 1 m² quadrats randomly placed throughout the sampling frames (Figure 1). Sample plot locations were drawn using a spatially-balanced random sampling design, the Generalized Random Tessellation Stratified (GRTS) design, which ensures a good representative random sample with good dispersion within each sampling frame. The Monument was surveyed in 2009, reported by Rodhouse (2010), and again in 2012, reported by Stucki and Rodhouse (2012). The Long Butte Fire burned most of the vegetated uplands in HAFO in August 2010 and the 2012 survey provided the first opportunity to evaluate the effects of the fire on vegetation change in the Monument. 6 years later, in 2018, the present survey provided further insight into how the Monument is recovering since the 2010 fire. We provide some preliminary comparisons between conditions encountered in 2009 before the fire and now in 2018.

In general, there has been a shift post-fire toward increased annual grass-dominated vegetation. All frames in HAFO had very high frequency and cover estimates of cheatgrass in 2018, much higher than what was recorded in 2009 and fairly similar to the coverage in 2012. Big sagebrush cover was very low compared to 2009 pre-fire levels. Greasewood (*Sarcobatus vermiculatus*), which resprouts after fire, had the highest cover and frequency of any of the shrubs in 2018, followed by green rabbitbrush (*Chrysothamnus viscidiflorus*). In 2012, no bluebunch wheatgrass was encountered during monitoring. In 2018, bluebunch wheatgrass was found in 3 of the 5 sampling frames, showing slow recovery of this native bunchgrass species. Sandberg's bluegrass, a low-stature and very disturbance-resistant native perennial bunchgrass, had the highest bunchgrass frequency and cover estimates for all frames. Other perennial native grasses that were encountered in few plots include squirreltail (*Elymus elymoides*), indian ricegrass (*Achnatherum hymenoides*), sand dropseed (*Sporobolus cryptandrus*) and Great Basin wildrye (*Leymus cinereus*). Tumbling mustard had a higher frequency and percent cover than any other nonnative invasive forb, occurring in nearly 71% of all plots. This species appears to have greatly increased in abundance in most frames between 2012 to 2018, with a jump of 43%. The noxious weed Russian knapweed (*Acroptilon repens*) was found within 1 plot in the Upper Bench sampling frame. This area was documented and the location given to park resource management during the field season.

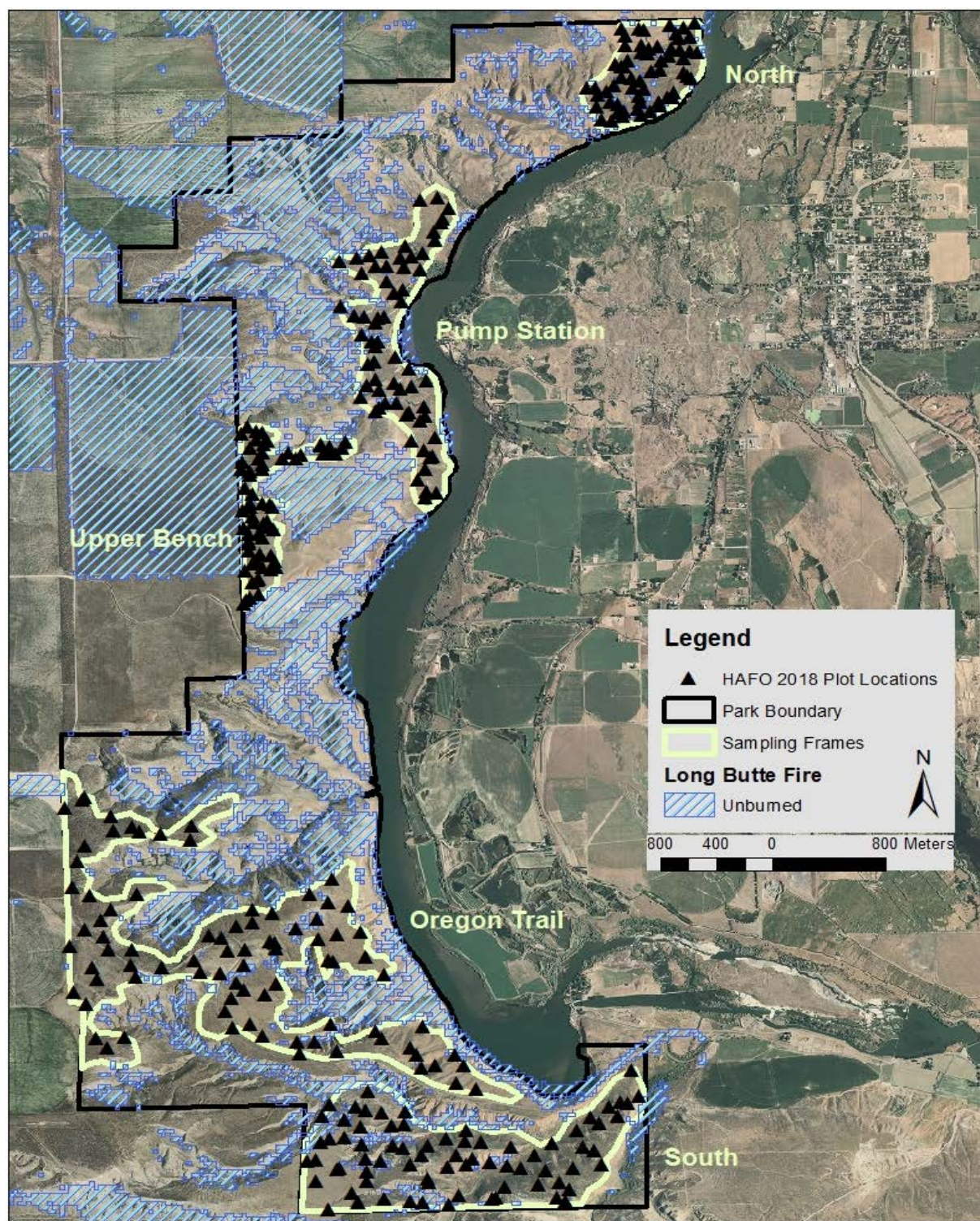


Figure 1. Hagerman Fossil Beds National Monument showing the 5 sampling frames surveyed in 2009, 2012 and 2018, with the 2018 plot locations. Areas unburned (estimated from Landsat imagery) are shown in blue.

Acknowledgments

Special thanks to Kari Prassack, HAFO paleontologist, for providing logistical support to Melissa and the crew during the field season.

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 or substantially degraded as a result of livestock grazing, fire, non-native invasive plants, and recreational use. The 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 view of ecosystem health sustained by natural succession or natural variability within communities 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 2018 for Hagerman Fossil Beds National Monument (HAFO), and discusses comparisons with data collected in 2009 (Rodhouse 2010), prior to the 2010 wildfire, the Long Butte Fire, that burned most of the sampling frame areas (Figure 1). It also makes comparisons to the first set of data collected post fire, in 2012 (Stucki and Rodhouse 2012).

Methods

Sample sizes within each stratum were proportional to the area of each frame (Table 1). The total sample size in 2018 included additional oversample plots from the GRTS list. Three plots were dropped among two sampling frames due to falling on the highway rather than in the sagebrush steppe. Sampling procedures followed Yeo et al. (2009). Within each strata, 1-m² square plots were located using the generalized random tessellation stratified (GRTS) spatially-balanced sampling design (Stevens and Olsen 2004). The GRTS approach provides for randomly located plots and good spatial dispersion across each site. Within each 1-m² plot, we estimated cover of exposed bare ground and 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). Plant 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. Plant species observed in 2018 with their common and scientific names are listed in Appendix A.

Table 1. Sample sizes, by frame, for 2019 sagebrush steppe monitoring in HAFO. Details of frame development and target sample sizes are provided in Yeo et al. (2009).

Park	Sampling Frame	Sample Size
HAFO	North	52
HAFO	Oregon Trail	76
HAFO	Pump Station	56
HAFO	South	69
HAFO	Upper Bench	57
Total	–	310

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

Weather information was compiled from data obtained from the Hagerman 2 SW (103932) Weather Station outside of Hagerman, Idaho. This station is in close proximity (approximately 2 km) to the monument. Hagerman Fossil Beds and surrounding areas, experienced temperatures from winter 2017 through early summer 2018 that were very similar to 30 year average temperatures, though with a slightly warmer January. The winter of 2017-2018 was very dry, below average winter precipitation followed by a spring with some larger than normal spikes in March and May. Warmer winters followed by wetter springs could be ideal conditions for a heavy invasive annual grass year. Weather records are presented in Appendices C for previous year's data collection between 2009 to 2018.

Results and Discussion

The UCBN sagebrush steppe monitoring program completed a third season of monitoring in HAFO during June 3-7, 2018. Sample sizes ranged from 52 to 76 plots per sampling frame. HAFO was burned in 2010 by the Long Butte Fire which affected about 1215 ha (72% of monument) within monument boundaries. All frames sampled had been burned to some degree during the fire (Figure 1). A post burn reseeding project was developed but it is unclear at this point whether that project was implemented or what management tactics have actually been employed. This second year of monitoring post-fire provides an interesting look at a landscape view of the sagebrush steppe vegetation within HAFO.

There was a shift toward decreased bare ground covers between 2012 and 2018 (Appendix B). In 2018 less plots were encountered with bare ground estimates in high cover classes (>25%) than in 2012. In 2012, 8.2% of plots had bare ground cover greater than 25%. In 2018, that percentage dropped by 4%, to 4.2%.

The proportion of plots containing native perennial grasses, native perennial forbs, and big sagebrush among the five sampling frames that were sampled in 2018 can be found in Appendix B. During 2012, big sagebrush, which does not resprout after fire, was found in only 3 of the 5 sampling frames. In 2018, big sagebrush was found in all 5 sampling frames. This could be a representation of a slow recovery of the burned area to its pre-fire vegetation. These frames each had very low numbers of plots with big sagebrush cover. The Upper Bench frame had no big sagebrush cover in 2012, however, in 2018, 7% of the plots had big sagebrush presence. The Oregon Trail and North frames had only 1.3% and 1.9% proportions of plots with big sagebrush. The Pump Station frame had 3.8% of plots with big sagebrush, with cover values between 5% and 50%. This was a 2% increase from 2012. The South frame had a big sagebrush cover of 2.9% in 2018, a 1% increase from 2012. Greasewood (*Sarcobatus vermiculatus*), which does resprout after fire, had the highest cover and frequency of any of the shrubs, followed by green rabbit brush (*Chrysothamnus viscidiflorus*). Bluebunch wheatgrass (*Pseudoroegneria spicata*), a fundamental native perennial bunchgrass species included in potential natural vegetation descriptions for all parks under the UCBN sage monitoring protocol, was not encountered in any sample frame in HAFO in 2009 or 2012. In 2018, it showed a slight recovery, appearing in 4.8% of plots and 3 out of the 5 sampling frames. The potential recovery of bluebunch wheatgrass could be attributed to a colder winter with above average winter precipitation in 2016-2017 (Appendix C), although wheatgrass recovery is likely a multi-year process. Sandberg's bluegrass, a low-stature native perennial bunchgrass resilient to disturbance, was widespread in all 5 sampling frames and had the highest frequency and cover estimates for native grasses in all frames. Proportion of plots with >5% cover of sandberg's bluegrass was 8.7%. The Oregon Trail frame had the highest percentage for sandberg's bluegrass presence with almost 40% of plots containing the grass. However, the Upper Bench frame had the highest cover percentages of sandberg's bluegrass with 15% of the plots having >25% cover. Other perennial native grasses occurring less frequently and with less abundance when found included squirreltail (*Elymus elymoides*), followed by Indian ricegrass (*Achnatherum hymenoides*), sand dropseed (*Sporobolus cryptandrus*), and Basin wildrye (*Leymus cinereus*).

Native forbs were found in 28.7% of plots in all 5 panels, which is up 6% from 2012. In 2012, there were shockingly no native forbs found in any plot in the North sampling frame. In 2018, the native forb Phlox sp. was found in 2 of the plots in the North frame. Most native vegetation was located on the tops of small ridges and swales or on mostly north facing inclines within drainages. Overall, native grass and forb presence was very low within the sampling frames in HAFO compared to monitoring data from 2009 (Rodhouse 2010, Appendix B).

The noxious weed Russian knapweed (*Acroptilon repens*) was found within 1 plot in the Upper Bench sampling frame. This occurrence was documented and the location given to the park resource management staff. Figures in Appendix D show the proportion of plots in each frame estimated to contain cheatgrass (*Bromus tectorum*) in each of the 6 Daubenmire cover classes. Cheatgrass cover was ubiquitous and occurred with > 98% frequency in all frames and the proportion of plots with > 25% cover was upwards of 84%. In general, there was a slight decrease in cheatgrass cover from 2012 to 2018. The Oregon Trail frame had the highest overall cheatgrass cover with almost 40% of plots having cheatgrass cover >75%. However, the North frame had the highest percentage of “heavily infested” with 96% of plots having cheatgrass cover >25%. The amount of plots considered heavily infested was lower than in 2012, but this does not represent a management-relevant change. The expansion in cheatgrass cover in HAFO since 2009 is likely a product of the Long Butte fire and may have been exacerbated by a warmer winter and wetter spring in the following years (Appendix C). Tumble mustard, a Eurasian annual forb indicative of rangeland degradation, had a higher frequency and percent cover than any other nonnative invasive forb, occurring with >5% cover in 2%-22% of plots in HAFO, with the North and South frames having the highest rates of tumble mustard.

The combination of very low sagebrush cover, low native grass and forb cover, and high non- native invasive grass and forb cover in HAFO are very revealing of degraded sagebrush steppe vegetation condition in the Monument. Intense and extensive wildfire contributed to this degradation. This dynamic, referred to as the “fire-cheatgrass cycle”, is typical of many areas in the Snake River Plain. Big sagebrush cover was much lower than 2009 pre-fire levels and the comparison of cheat grass abundance from 2009 to 2018 (Tables 4-7 and Appendix D) shows that the proportion of plots with cover values >25% for cheatgrass are 79-96% for the 5 frames. Overall, cheatgrass percentages are down compared to 6 years ago in 2012, but the decrease is slight (3-5%) in all sampling frames. Park wide, the overall percentage of cheatgrass cover >5% is down by 7% in 2018 compared to 2012 (Figure A-8 in Appendix A). The prominent disturbance caused by the Long Butte Fire and the loss of big sagebrush and native perennial grass and forb, as well as an increase in bareground cover, has left conditions very suitable for accelerated non-native grass and forb invasion at HAFO. As more time passes since the Long Butte Fire, the park may be able to recover some of its native steppe environment found prior to the fire, but it will likely be only in small, heavily managed and restored project sites, and also contingent upon fire prevention.

Table 3. Summary statistics for estimated cheatgrass infestation in the North sampling frame by year.

Year	Metric	Result
2018	Total acreage sampled	112.46
	Total with no cheatgrass	0.00
	Proportion of total frame area with no cheatgrass	0.00
	Total with at least some cheatgrass	112.46
	Proportion of total surveyed area with cheatgrass	1.00
	Heavily infested acreage (>25% cover)	108.14
	Proportion of heavily infested	0.96
2012	Total acreage sampled	112.46
	Total with no cheatgrass	0.00
	Proportion of total frame area with no cheatgrass	0.00
	Total with at least some cheatgrass	112.46
	Proportion of total surveyed area with cheatgrass	1.00
	Heavily infested acreage (>25% cover)	112.46
	Proportion of heavily infested	1.00
2009	Total acreage sampled	108.74
	Total with no cheatgrass	0.00
	Proportion of total frame area with no cheatgrass	0.00
	Total with at least some cheatgrass	108.74
	Proportion of total surveyed area with cheatgrass	1.00
	Heavily infested acreage (>25% cover)	100.04
	Proportion of heavily infested	0.92

Table 4. Summary statistics for estimated cheatgrass infestation in the Oregon Trail sampling frame by year.

Year	Metric	Result
2018	Total acreage sampled	536.56
	Total with no cheatgrass	21.18
	Proportion of total frame area with no cheatgrass	0.04
	Total with at least some cheatgrass	515.38
	Proportion of total surveyed area with cheatgrass	0.96
	Heavily infested acreage (>25% cover)	430.66
	Proportion of heavily infested	0.80
2012	Total acreage sampled	536.56
	Total with no cheatgrass	0.00
	Proportion of total frame area with no cheatgrass	0.00
	Total with at least some cheatgrass	536.56
	Proportion of total surveyed area with cheatgrass	1.00
	Heavily infested acreage (>25% cover)	451.84
	Proportion of heavily infested	0.84
2009	Total acreage sampled	677.73
	Total with no cheatgrass	45.18
	Proportion of total frame area with no cheatgrass	0.07
	Total with at least some cheatgrass	632.55
	Proportion of total surveyed area with cheatgrass	0.93
	Heavily infested acreage (>25% cover)	506.04
	Proportion of heavily infested	0.75

Table 5. Summary statistics for estimated cheatgrass infestation in the Pump Station sampling frame by year.

Year	Metric	Result
2018	Total acreage sampled	196.85
	Total with no cheatgrass	0.00
	Proportion of total frame area with no cheatgrass	0.00
	Total with at least some cheatgrass	196.85
	Proportion of total surveyed area with cheatgrass	1.00
	Heavily infested acreage (>25% cover)	172.24
	Proportion of heavily infested	0.88
2012	Total acreage sampled	196.85
	Total with no cheatgrass	7.16
	Proportion of total frame area with no cheatgrass	0.04
	Total with at least some cheatgrass	189.69
	Proportion of total surveyed area with cheatgrass	0.96
	Heavily infested acreage (>25% cover)	178.95
	Proportion of heavily infested	0.91
2009	Total acreage sampled	235.59
	Total with no cheatgrass	4.28
	Proportion of total frame area with no cheatgrass	0.02
	Total with at least some cheatgrass	231.30
	Proportion of total surveyed area with cheatgrass	0.98
	Heavily infested acreage (>25% cover)	209.89
	Proportion of heavily infested	0.89

Table 6. Summary statistics for estimated cheatgrass infestation in the South sampling frame by year.

Year	Metric	Result
2018	Total acreage sampled	379.24
	Total with no cheatgrass	0.00
	Proportion of total frame area with no cheatgrass	0.00
	Total with at least some cheatgrass	379.24
	Proportion of total surveyed area with cheatgrass	1.00
	Heavily infested acreage (>25% cover)	313.29
	Proportion of heavily infested	0.83
2012	Total acreage sampled	379.24
	Total with no cheatgrass	0.00
	Proportion of total frame area with no cheatgrass	0.00
	Total with at least some cheatgrass	379.24
	Proportion of total surveyed area with cheatgrass	1.00
	Heavily infested acreage (>25% cover)	332.56
	Proportion of heavily infested	0.88
2009	Total acreage sampled	405.40
	Total with no cheatgrass	18.71
	Proportion of total frame area with no cheatgrass	0.05
	Total with at least some cheatgrass	386.69
	Proportion of total surveyed area with cheatgrass	0.95
	Heavily infested acreage (>25% cover)	293.14
	Proportion of heavily infested	0.72

Table 7. Summary statistics for estimated cheatgrass infestation in the Upper Bench sampling frame by year.

Year	Metric	Result
2018	Total acreage sampled	83.18
	Total with no cheatgrass	2.92
	Proportion of total frame area with no cheatgrass	0.03
	Total with at least some cheatgrass	80.26
	Proportion of total surveyed area with cheatgrass	0.97
	Heavily infested acreage (>25% cover)	65.67
	Proportion of heavily infested	0.79
2012	Total acreage sampled	83.18
	Total with no cheatgrass	0.00
	Proportion of total frame area with no cheatgrass	0.00
	Total with at least some cheatgrass	83.18
	Proportion of total surveyed area with cheatgrass	1.00
	Heavily infested acreage (>25% cover)	69.57
	Proportion of heavily infested	0.84
2009	Total acreage sampled	130.68
	Total with no cheatgrass	2.38
	Proportion of total frame area with no cheatgrass	0.02
	Total with at least some cheatgrass	128.31
	Proportion of total surveyed area with cheatgrass	0.98
	Heavily infested acreage (>25% cover)	92.67
	Proportion of heavily infested	0.71

Literature Cited

- Daubenmire, R.F. 1959. A canopy-coverage method. *Northwest Science* 33:43-64.
- Erixson, J. A., and D. Cogan. 2009. Vegetation classification and mapping of Hagerman Fossil Beds National Monument. Natural Resource Technical Report NPS/UCBN/NRTR— 2009/212. National Park Service, Fort Collins, Colorado.
- Garrett, L. K., T. J. Rodhouse, G. H. Dicus, C. C. Caudill, and M. R. Shardlow. 2007. Upper Columbia Basin Network vital signs monitoring plan. Natural Resource Report NPS/UCBN/NRR-2007/002. National Park Service, Fort Collins, CO.
- Rodhouse, T. J. 2010. Sagebrush steppe vegetation monitoring in Craters of the Moon National Monument and Preserve, Hagerman Fossil Beds National Monument, John Day Fossil Beds National Monument, and Lake Roosevelt National Recreation Area: 2009 annual report. Natural Resource Technical Report NPS/UCBN/NRTR—2010/302. National Park Service, Fort Collins, Colorado.
- Stevens, D. L., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. *Journal of the American Statistical Association* 99:262-278.
- Stucki, D. S., and T. J. Rodhouse. 2012. Sagebrush steppe vegetation monitoring in Hagerman Fossil Beds National Monument: 2012 annual report. Natural Resource Data Series NPS/UCBN/NRDS—2012/402. National Park Service, Fort Collins, Colorado.
- Yeo, J. J., T. J. Rodhouse, G. H. Dicus, K. M. Irvine, and L. K. Garrett. 2009. Upper Columbia Basin Network sagebrush steppe vegetation monitoring protocol: Narrative version 1.0. Natural Resource Report NPS/UCBN/NRR—2009/142. National Park Service, Fort Collins, Colorado.

Appendix A

List of plant species mentioned in the report with common and scientific names

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

Plant Category	Common names	Species name	Updated Species Name
Sagebrush	Big Sagebrush	<i>Artemisia tridentata</i>	–
Other Shrubs	Saltbush	<i>Atriplex spp.</i>	–
	Green rabbitbrush	<i>Chrysothamnus viscidiflorus</i>	–
	Rubber rabbitbrush	<i>Ericameria nauseosa</i>	–
	Spiny hop sage	<i>Grayia spinosa</i>	–
	Granite prickly phlox	<i>Leptodactylon pungens</i>	<i>Linanthus pungens</i>
	Greasewood	<i>Sarcobatus vermiculatus</i>	–
Native Grasses	Basin wildrye	<i>Elymus cinereus</i>	<i>Leymus cinereus</i>
	Squireltail	<i>Elymus elymoides</i>	–
	Needle and thread grass	<i>Hesperostipa comata</i>	–
	Indian ricegrass	<i>Oryzopsis hymenoides</i>	<i>Achnatherum hymenoides</i>
	Western wheatgrass	<i>Pascopyrum smithii</i>	–
	Sandberg's steppe bluegrass	<i>Poa secunda</i>	–
	Bluegrass spp	<i>Poa spp</i>	–
	Bluebunch wheatgrass	<i>Pseudoroegneria spicata</i>	–
	Sand dropseed	<i>Sporobolus cryptandrus</i>	–
Persistent Native Forbs	Yarrow	<i>Achillea millefolium</i>	–
	Astragalus, Milkvetch	<i>Astragalus spp</i>	–
	Arrowleaf balsamroot	<i>Balsamorhiza sagittata</i>	–

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

Plant Category	Common names	Species name	Updated Species Name
Persistent Native Forbs (continued)	Tapertip hawksbeard	<i>Crepis acuminata</i>	–
	Buckwheat	<i>Eriogonum</i> spp	–
	Biscuitroot	<i>Lomatium</i> spp	–
	Lupine	<i>Lupinus</i> spp	–
	Beardtongues	<i>Penstemon</i> spp.	–
	Phlox	<i>Phlox</i> spp	–
	Desert princesplume	<i>Stanleya pinnata</i>	–
Other Native Forbs	Wild onion	<i>Allium</i> spp	–
	Mariposa lily	<i>Calochortus</i> spp	–
	Cat's eye	<i>Cryptantha</i> spp	–
	Primrose	<i>Oenothera</i> spp	–
Invasive Grasses	Crested wheatgrass	<i>Agropyron cristatum</i>	–
	Bromes	<i>Bromus</i> spp.	–
	Cheatgrass	<i>Bromus tectorum</i>	–
	Medusahead	<i>Elymus caput-medusae</i>	–
	Bulbous bluegrass	<i>Poa bulbosa</i>	–
Invasive Forbs	Russian knapweed	<i>Acroptilon repens</i>	–
	Tansy mustard	<i>Descurainia</i> spp	–
	Filaree	<i>Erodium cicutarium</i>	–
	Clasping pepperweed	<i>Lepidium perfoliatum</i>	–
	Russian thistle	<i>Salsola kali</i>	–
	Tumble mustard	<i>Sisymbrium altissimum</i>	–
	Common salsify	<i>Tragopogon dubius</i>	–

Appendix B

2012 and 2018 sage monitoring data in HAFO: percentage of plots within each cover class for exposed bare ground and principal plant species organized by species

Table A-2. 2012 North sampling frame, HAFO: percentage of plots (n=50 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	–	12	40	42	4	2	0	0
Sagebrush	<i>Artemisia tridentata</i>	100	0	0	0	0	0	0
Shrubs	<i>Sarcobatus vermiculatus</i>	94	0	2	4	0	0	0
Native Perennial Grasses	<i>Poa secunda</i>	42	10	30	16	2	0	0
Native Persistent Forbs	none	–	–	–	–	–	–	–
Native Other Forbs	none	–	–	–	–	–	–	–
Non-native Invasive Forbs	<i>Descurainia</i> spp	98	2	0	0	0	0	0
	<i>Erodium cicutarium</i>	86	14	0	0	0	0	0
	<i>Lepidium perfoliatum</i>	98	0	2	0	0	0	0
	<i>Salsola kali</i>	98	0	2	0	0	0	0
	<i>Sisymbrium altissimum</i>	52	26	16	4	2	0	0
	<i>Tragopogon dubius</i>	98	2	0	0	0	0	0
Non-native Invasive Grasses	<i>Bromus tectorum</i>	0	0	0	6	52	36	6

Table A-3. 2018 North sampling frame, HAFO: percentage of plots (n=52 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	–	60	40	0	0	0	0	0
Sagebrush	<i>Artemisia tridentata</i>	98	2	0	0	0	0	0
Shrubs	<i>Sarcobatus vermiculatus</i>	90	0	4	2	2	2	0
Native Perennial Grasses	<i>Poa secunda</i>	87	13	0	0	0	0	0
Native Persistent Forbs	<i>Phlox</i> spp.	96	4	0	0	0	0	0
Native Other Forbs	<i>Allium</i> spp.	96	4	0	0	0	0	0
	<i>Calochortus</i> spp.	96	4	0	0	0	0	0
	<i>Cryptantha</i> spp.	90	10	0	0	0	0	0
Non-native Invasive Forbs	<i>Descurainia</i> spp.	65	35	0	0	0	0	0
	<i>Erodium cicutarium</i>	88.5	11.5	0	0	0	0	0
	<i>Salsola kali</i>	98	2	0	0	0	0	0
	<i>Sisymbrium altissimum</i>	9.5	46	36.5	6	2	0	0
	<i>Tragopogon dubius</i>	69	31	0	0	0	0	0
Non-native Invasive Grasses	<i>Bromus tectorum</i>	0	4	0	15	58	23	0

Table A-4. 2012 Oregon Trail sampling frame, HAFO: percentage of plots (n=76 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	–	26	42	20	9	3	0	0
Sagebrush	<i>Artemisia tridentata</i>	99	1	0	0	0	0	0
Shrubs	<i>Atriplex</i> spp.	97	1	1	0	0	0	0
	<i>Chrysothamnus viscidiflorus</i>	92	7	1	0	0	0	0
	<i>Leptodactylon pungens</i>	99	1	0	0	0	0	0
	<i>Sarcobatus vermiculatus</i>	99	0	0	0	1	0	0
Native Perennial Grasses	<i>Agropyron smithii</i>	95	0	3	0	3	0	0
	<i>Elymus cinereus</i>	99	0	1	0	0	0	0
	<i>Oryzopsis hymenoides</i>	97	1	1	0	0	0	0
	<i>Poa secunda</i>	80	4	9	3	4	0	0
	<i>Sitanion hystrix</i>	92	3	5	0	0	0	0
	<i>Stipa</i> spp	99	0	1	0	0	0	0
Native Persistent Forbs	<i>Achillea millefolium</i>	99	1	0	0	0	0	0
	<i>Astragalus</i> spp	96	4	0	0	0	0	0
	<i>Balsamorhiza sagittata</i>	97	3	0	0	0	0	0
	<i>Crepis acuminata</i>	84	11	4	1	0	0	0
	<i>Phlox</i> spp	92	5	3	0	0	0	0
Native Other Forbs	<i>Agoseris</i> spp.	97	3	0	0	0	0	0
	<i>Allium</i> spp.	91	9	0	0	0	0	0
	<i>Delphinium</i> spp.	99	1	0	0	0	0	0

Table A-4 (continued). 2012 Oregon Trail sampling frame, HAFO: percentage of plots (n=76 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Non-native Invasive Forbs	<i>Descurainia</i> spp	96	3	1	0	0	0	0
	<i>Salsola kali</i>	97	1	1	0	0	0	0
	<i>Sisymbrium altissimum</i>	71	22	5	1	0	0	0
	<i>Tragopogon dubius</i>	92	8	0	0	0	0	0
Non-native Invasive Grasses	<i>Agropyron cristatum</i>	80	3	8	7	3	0	0
	<i>Bromus tectorum</i>	0	3	13	11	14	32	28
	<i>Poa bulbosa</i>	95	4	1	0	0	0	0

Table A-5. 2018 Oregon Trail sampling frame, HAFO: percentage of plots (n=76 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	–	39	40	17	4	0	0	0
Sagebrush	<i>Artemisia tridentata</i>	99	1	0	0	0	0	0
Shrubs	<i>Atriplex</i> spp.	99	1	0	0	0	0	0
	<i>Chrysothamnus viscidiflorus</i>	91	5	4	0	0	0	0
	<i>Leptodactylon pungens</i>	97	1.5	1.5	0	0	0	0
	<i>Ericameria nauseosa</i>	99	1	0	0	0	0	0
Native Perennial Grasses	<i>Elymus elymoides</i>	92	8	0	0	0	0	0
	<i>Hesperostipa comata</i>	96	0	4	0	0	0	0
	<i>Pascopyrum smithii</i>	88	9	3	0	0	0	0
	<i>Poa secunda</i>	61	33	5	1	0	0	0
	<i>Pseudoroegneria spicata</i>	93	4	1.5	1.5	0	0	0
	<i>Sporobolus cryptandrus</i>	97	1.5	1.5	0	0	0	0
Native Persistent Forbs	<i>Achillea millefolium</i>	97	3	0	0	0	0	0
	<i>Astragalus</i> spp	95	4	1	0	0	0	0
	<i>Balsamorhiza sagittata</i>	99	1	0	0	0	0	0
	<i>Crepis acuminata</i>	88	12	0	0	0	0	0
	<i>Penstemon</i> spp.	99	1	0	0	0	0	0
	<i>Phlox</i> spp	95	4	1	0	0	0	0
	<i>Stanleya pinnata</i>	99	1	0	0	0	0	0

Table A-5 (continued). 2018 Oregon Trail sampling frame, HAFO: percentage of plots (n=76 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Native Other Forbs	<i>Allium</i> spp.	95	5	0	0	0	0	0
	<i>Delphinium</i> spp.	96	4	0	0	0	0	0
Non-native Invasive Forbs	<i>Descurainia</i> spp	96	3	1	0	0	0	0
	<i>Erodium cicutarium</i>	95	1	3	1	0	0	0
	<i>Lepidium perfoliatum</i>	99	0	1	0	0	0	0
	<i>Salsola kali</i>	92	8	0	0	0	0	0
	<i>Sisymbrium altissimum</i>	45	54	1	0	0	0	0
	<i>Tragopogon dubius</i>	58	39.5	2.5	0	0	0	0
Non-native Invasive Grasses	<i>Agropyron cristatum</i>	80	5	6.5	6.5	0	2	0
	<i>Bromus tectorum</i>	4	13	2.5	13	20	39.5	8
	<i>Poa bulbosa</i>	99	0	0	0	1	0	0

Table A-6. 2012 Pump Station sampling frame, HAFO: percentage of plots (n=55 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	–	29	35	24	9	4	0	0
Sagebrush	<i>Artemisia tridentata</i>	98	0	2	0	0	0	0
Shrubs	<i>Atriplex canescens</i>	98	0	2	0	0	0	0
	<i>Atriplex confertifolia</i>	98	2	0	0	0	0	0
	<i>Sarcobatus vermiculatus</i>	76	11	4	5	2	2	0
Native Perennial Grasses	<i>Elymus cinereus</i>	93	2	2	0	2	2	0
	<i>Poa secunda</i>	71	11	13	2	4	0	0
	<i>Sitanion hystrix</i>	98	0	2	0	0	0	0
Native Persistent Forbs	<i>Astragalus</i> spp	98	0	2	0	0	0	0
	<i>Cirsium</i> spp	98	2	0	0	0	0	0
	<i>Crepis acuminata</i>	98	2	0	0	0	0	0
	<i>Lupinus</i> spp	98	2	0	0	0	0	0
	<i>Stanleya pinnata</i>	96	0	4	0	0	0	0
Native Other Forbs	<i>Allium</i> spp.	98	2	0	0	0	0	0
Non-native Invasive Forbs	<i>Descurainia</i> spp.	96	4	0	0	0	0	0
	<i>Lepidium perfoliatum</i>	96	0	2	0	2	0	0
	<i>Salsola kali</i>	98	2	0	0	0	0	0
	<i>Sisymbrium altissimum</i>	76	15	5	4	0	0	0
Non-native Invasive Grasses	<i>Agropyron cristatum</i>	96	0	2	0	2	0	0
	<i>Bromus tectorum</i>	4	2	4	4	20	44	24

Table A-7. 2018 Pump Station sampling frame, HAFO: percentage of plots (n=56 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	–	39	41	13	3.5	3.5	0	0
Sagebrush	<i>Artemisia tridentata</i>	96	0	2	2	0	0	0
Shrubs	<i>Atriplex</i> spp.	98	0	2	0	0	0	0
	<i>Ericameria nauseosa</i>	98	0	0	0	2	0	0
	<i>Leptodactylon pungens</i>	98	2	0	0	0	0	0
	<i>Sarcobatus vermiculatus</i>	79	7	5	3.5	2	3.5	0
Native Perennial Grasses	<i>Elymus cinereus</i>	98	0	2	0	0	0	0
	<i>Elymus elymoides</i>	93	7	0	0	0	0	0
	<i>Oryzopsis hymenoides</i>	98	2	0	0	0	0	0
	<i>Pascopyrum smithii</i>	96	0	2	2	0	0	0
	<i>Poa secunda</i>	80	18	2	0	0	0	0
	<i>Pseudoroegneria spicata</i>	95	5	0	0	0	0	0
Native Persistent Forbs	<i>Astragalus</i> spp	93	7	0	0	0	0	0
	<i>Balsamorhiza sagittata</i>	98	2	0	0	0	0	0
	<i>Crepis acuminata</i>	95	5	0	0	0	0	0
	<i>Lupinus</i> spp	98	2	0	0	0	0	0
	<i>Phlox</i> spp.	91	5	4	0	0	0	0
	<i>Stanleya pinnata</i>	96	2	0	2	0	0	0

Table A-7 (continued). 2018 Pump Station sampling frame, HAFO: percentage of plots (n=56 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Native Other Forbs	<i>Allium</i> spp.	96	4	0	0	0	0	0
	<i>Calochortus</i> spp	96	4	0	0	0	0	0
	<i>Cryptantha</i> spp	98	2	0	0	0	0	0
Non-native Invasive Forbs	<i>Descurainia</i> spp.	84	16	0	0	0	0	0
	<i>Erodium cicutarium</i>	88	12	0	0	0	0	0
	<i>Lepidium perfoliatum</i>	98	0	2	0	0	0	0
	<i>Salsola kali</i>	96	4	0	0	0	0	0
	<i>Sisymbrium altissimum</i>	34	55	11	0	0	0	0
	<i>Tragopogon dubius</i>	61	37.5	1.5	0	0	0	0
Non-native Invasive Grasses	<i>Agropyron cristatum</i>	93	2	3	2	0	0	0
	<i>Bromus tectorum</i>	0	7	5	20	30	36	2
	<i>Elymus caput-medusae</i>	98	0	0	2	0	0	0
	<i>Poa bulbosa</i>	96	2	2	0	0	0	0

Table A-8. 2012 South sampling frame, HAFO: percentage of plots (n=65 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	–	31	46	18	3	0	0	2
Sagebrush	<i>Artemisia tridentata</i>	98	2	0	0	0	0	0
Shrubs	<i>Atriplex canescens</i>	98	0	0	2	0	0	0
	<i>Atriplex confertifolia</i>	97	3	0	0	0	0	0
	<i>Chrysothamnus viscidiflorus</i>	91	5	5	0	0	0	0
	<i>Leptodactylon pungens</i>	94	3	3	0	0	0	0
	<i>Sarcobatus vermiculatus</i>	97	2	0	2	0	0	0
Native Perennial Grasses	<i>Elymus cinereus</i>	98	0	0	2	0	0	0
	<i>Oryzopsis hymenoides</i>	94	2	3	0	2	0	0
	<i>Poa secunda</i>	68	18	9	3	2	0	0
	<i>Poa</i> spp.	98	0	0	0	2	0	0
	<i>Sitanion hystrix</i>	88	8	5	0	0	0	0
Native Persistent Forbs	<i>Astragalus</i> spp	97	2	2	0	0	0	0
	<i>Castilleja</i> spp	98	2	0	0	0	0	0
	<i>Chaenactis douglasii</i>	98	2	0	0	0	0	0
	<i>Crepis acuminata</i>	97	3	0	0	0	0	0
	<i>Erigeron</i> spp	98	2	0	0	0	0	0
	<i>Phlox</i> spp	89	8	3	0	0	0	0
	<i>Senecio</i> spp	98	2	0	0	0	0	0
	<i>Stanleya pinnata</i>	98	2	0	0	0	0	0

Table A-8 (continued). 2012 South sampling frame, HAFO: percentage of plots (n=65 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Native Other Forbs	<i>Allium</i> spp	97	3	0	0	0	0	0
	<i>Calochortus</i> spp	97	3	0	0	0	0	0
	<i>Delphinium</i> spp	98	2	0	0	0	0	0
	<i>Oenothera</i> spp	98	2	0	0	0	0	0
Non-native Invasive Forbs	<i>Descurainia</i> spp	80	12	3	2	3	0	0
	<i>Sisymbrium altissimum</i>	66	18	12	3	0	0	0
	<i>Tragopogon dubius</i>	94	6	0	0	0	0	0
Non-native Invasive Grasses	<i>Agropyron cristatum</i>	98	0	0	2	0	0	0
	<i>Bromus tectorum</i>	0	5	8	11	17	29	31

Table A-9. 2018 South sampling frame, HAFO: percentage of plots (n=69 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	–	20	51	22	4	3	0	2
Sagebrush	<i>Artemisia tridentata</i>	97	1.5	0	1.5	0	0	0
Shrubs	<i>Atriplex</i> spp.	99	0	0	1	0	0	0
	<i>Chrysothamnus viscidiflorus</i>	97	3	0	0	0	0	0
	<i>Grayia spinosa</i>	99	1	0	0	0	0	0
	<i>Sarcobatus vermiculatus</i>	97	1.5	0	1.5	0	0	0
Native Perennial Grasses	<i>Elymus elymoides</i>	81	13	6	0	0	0	0
	<i>Hesperostipa comata</i>	97	1.5	1.5	0	0	0	0
	<i>Oryzopsis hymenoides</i>	97	3	0	0	0	0	0
	<i>Poa secunda</i>	65	20	12	3	0	0	0
Native Persistent Forbs	<i>Achillea millefolium</i>	99	1	0	0	0	0	0
	<i>Astragalus</i> spp.	96	4	0	0	0	0	0
	<i>Crepis acuminata</i>	96	4	0	0	0	0	0
	<i>Lomatium</i> spp	99	1	0	0	0	0	0
	<i>Penstemon</i> spp.	99	1	0	0	0	0	0
	<i>Phlox</i> spp	78	16	3	1.5	1.5	0	0
Native Other Forbs	<i>Allium</i> spp	97	3	0	0	0	0	0
	<i>Oenothera</i> spp	99	1	0	0	0	0	0

Table A-9 (continued). 2018 South sampling frame, HAFO: percentage of plots (n=69 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Non-native Invasive Forbs	<i>Descurainia</i> spp	75	22	3	0	0	0	0
	<i>Erodium cicutarium</i>	99	1	0	0	0	0	0
	<i>Lepidium perfoliatum</i>	99	1	0	0	0	0	0
	<i>Salsola kali</i>	83	17	0	0	0	0	0
	<i>Sisymbrium altissimum</i>	26	46	22	6	0	0	0
	<i>Tragopogon dubius</i>	54	45	1	0	0	0	0
Non-native Invasive Grasses	<i>Agropyron cristatum</i>	97	1.5	1.5	0	0	0	0
	<i>Bromus</i> spp.	99	1	0	0	0	0	0
	<i>Bromus tectorum</i>	0	7	10	17	41	25	0
	<i>Elymus caput-medusae</i>	97	3	0	0	0	0	0

Table A-10. 2012 Upper Bench sampling frame, HAFO: percentage of plots (n=50 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	–	9	45	38	2	2	4	0
Sagebrush	<i>Artemisia tridentata</i>	100	0	0	0	0	0	0
Shrubs	<i>Atriplex canescens</i>	98	0	2	0	0	0	0
	<i>Chrysothamnus viscidiflorus</i>	96	4	0	0	0	0	0
	<i>Leptodactylon pungens</i>	98	2	0	0	0	0	0
Native Perennial Grasses	<i>Agropyron smithii</i>	84	4	2	9	2	0	0
	<i>Oryzopsis hymenoides</i>	96	2	2	0	0	0	0
	<i>Poa secunda</i>	62	4	11	11	13	0	0
	<i>Sitanion hystrix</i>	87	4	5	4	0	0	0
	<i>Stipa</i> spp	96	0	0	4	0	0	0
Native Persistent Forbs	<i>Achillea millefolium</i>	96	4	0	0	0	0	0
	<i>Astragalus</i> spp	98	2	0	0	0	0	0
	<i>Crepis acuminata</i>	91	9	0	0	0	0	0
	<i>Erigeron</i> spp	98	2	0	0	0	0	0
	<i>Lomatium</i> spp	96	4	0	0	0	0	0
	<i>Lupinus</i> spp	98	0	2	0	0	0	0
	<i>Phlox</i> spp	87	9	4	0	0	0	0
	<i>Stanleya pinnata</i>	95	2	4	0	0	0	0
Native Other Forbs	<i>Agoseris</i> spp	98	2	0	0	0	0	0

Table A-10 (continued). 2012 Upper Bench sampling frame, HAFO: percentage of plots (n=50 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Non-native Invasive Forbs	<i>Descurainia</i> spp	98	2	0	0	0	0	0
	<i>Erodium cicutarium</i>	98	2	0	0	0	0	0
	<i>Sisymbrium altissimum</i>	93	5	2	0	0	0	0
	<i>Tragopogon dubius</i>	95	5	0	0	0	0	0
Non-native Invasive Grasses	<i>Agropyron cristatum</i>	84	2	15	0	0	0	0
	<i>Bromus tectorum</i>	0	4	13	15	27	31	11

Table A-11. 2018 Upper Bench sampling frame, HAFO: percentage of plots (n=57 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	–	28	51	19	2	0	0	0
Sagebrush	<i>Artemisia tridentata</i>	93	2	5	0	0	0	0
Shrubs	<i>Chrysothamnus viscidiflorus</i>	95	2	0	3	0	0	0
Native Perennial Grasses	<i>Elymus elymoides</i>	81	17.5	1.5	0	0	0	0
	<i>Hesperostipa comata</i>	98	2	0	0	0	0	0
	<i>Oryzopsis hymenoides</i>	96	0	2	2	0	0	0
	<i>Pascopyrum smithii</i>	89	11	0	0	0	0	0
	<i>Poa secunda</i>	55	26	12	7	0	0	0
	<i>Pseudoroegneria spicata</i>	88	5	5	2	0	0	0
Native Persistent Forbs	<i>Achillea millefolium</i>	98	2	0	0	0	0	0
	<i>Astragalus</i> spp	93	7	0	0	0	0	0
	<i>Crepis acuminata</i>	91	9	0	0	0	0	0
	<i>Eriogonum</i> spp	96	2	2	0	0	0	0
	<i>Lomatium</i> spp	98	2	0	0	0	0	0
	<i>Lupinus</i> spp	98	0	2	0	0	0	0
	<i>Phlox</i> spp	86	5	9	0	0	0	0
	<i>Stanleya pinnata</i>	95	3.5	0	1.5	0	0	0
Native Other Forbs	<i>Allium</i> spp	95	5	0	0	0	0	0

Table A-11 (continued). 2018 Upper Bench sampling frame, HAFO: percentage of plots (n=57 1 m² plots) within each cover class for exposed bare ground and principal plant species organized by species guilds.

Cover Type	Species	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Non-native Invasive Forbs	<i>Acroptilon repens</i>	98	2	0	0	0	0	0
	<i>Descurainia</i> spp	96	4	0	0	0	0	0
	<i>Salsola kali</i>	98	2	0	0	0	0	0
	<i>Sisymbrium altissimum</i>	23	65	12	0	0	0	0
	<i>Tragopogon dubius</i>	58	42	0	0	0	0	0
Non-native Invasive Grasses	<i>Agropyron cristatum</i>	77	11	7	5	0	0	0
	<i>Bromus tectorum</i>	3.5	7	10.5	12.5	21	33	12.5

Appendix C

Climate diagrams for the Hagerman 2 SW weather station, near Hagerman Fossil Beds National Monument

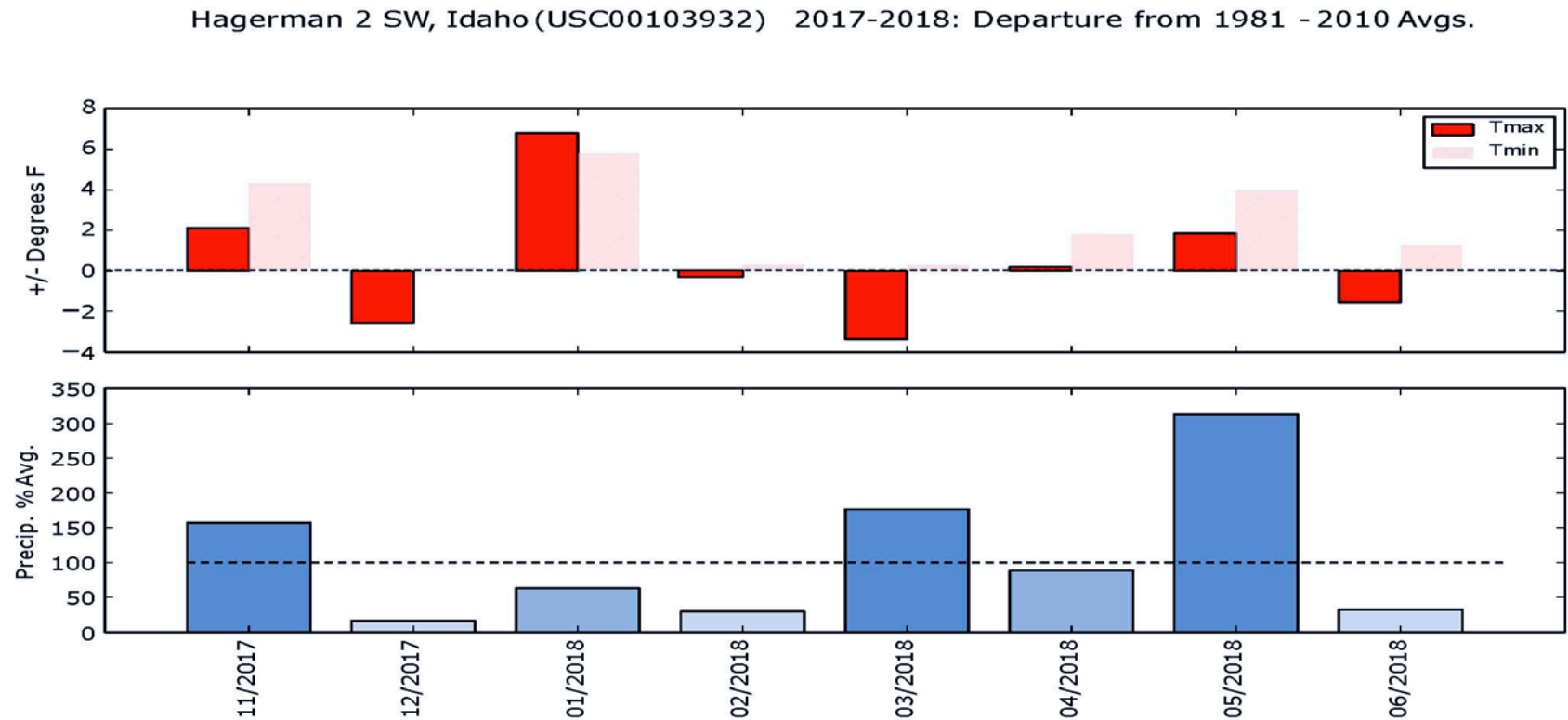


Figure A-1. This figure compares 2018 data to the long-term (30 year) averages of monthly temperatures (red boxes) and monthly precipitation (blue boxes). The dotted black line in the both graphs represents the 30 year average for temperature and precipitation.

Hagerman 2 SW, Idaho (USC00103932) 2016-2017: Departure from 1981 - 2010 Avgs.

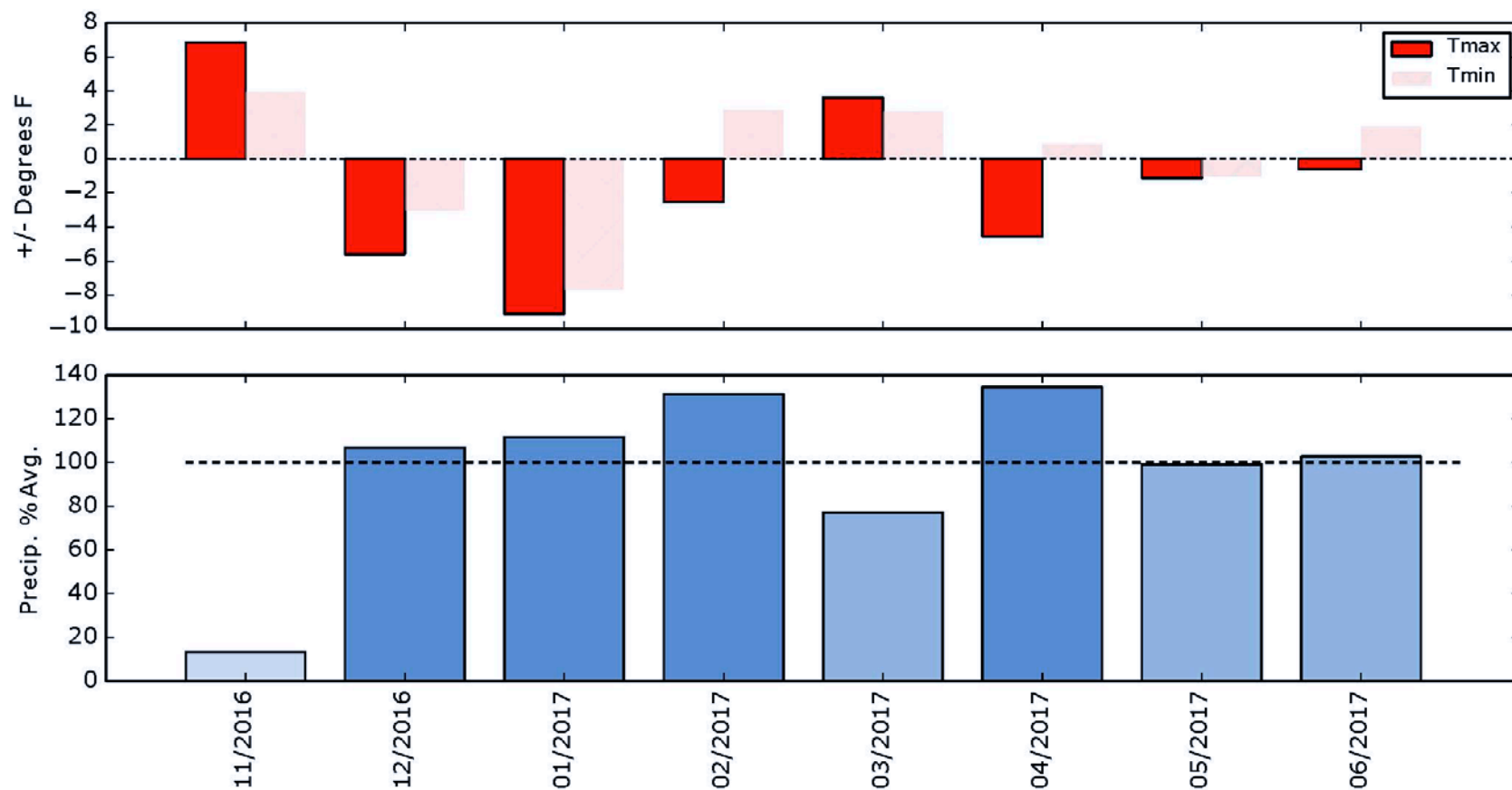


Figure A-2. This figure compares 2017 data to the long-term (30 year) averages of monthly temperatures (red boxes) and monthly precipitation (blue boxes). The dotted black line in the both graphs represents the 30 year average for temperature and precipitation.

Hagerman 2 SW, Idaho (USC00103932) 2015-2016: Departure from 1981 - 2010 Avgs.

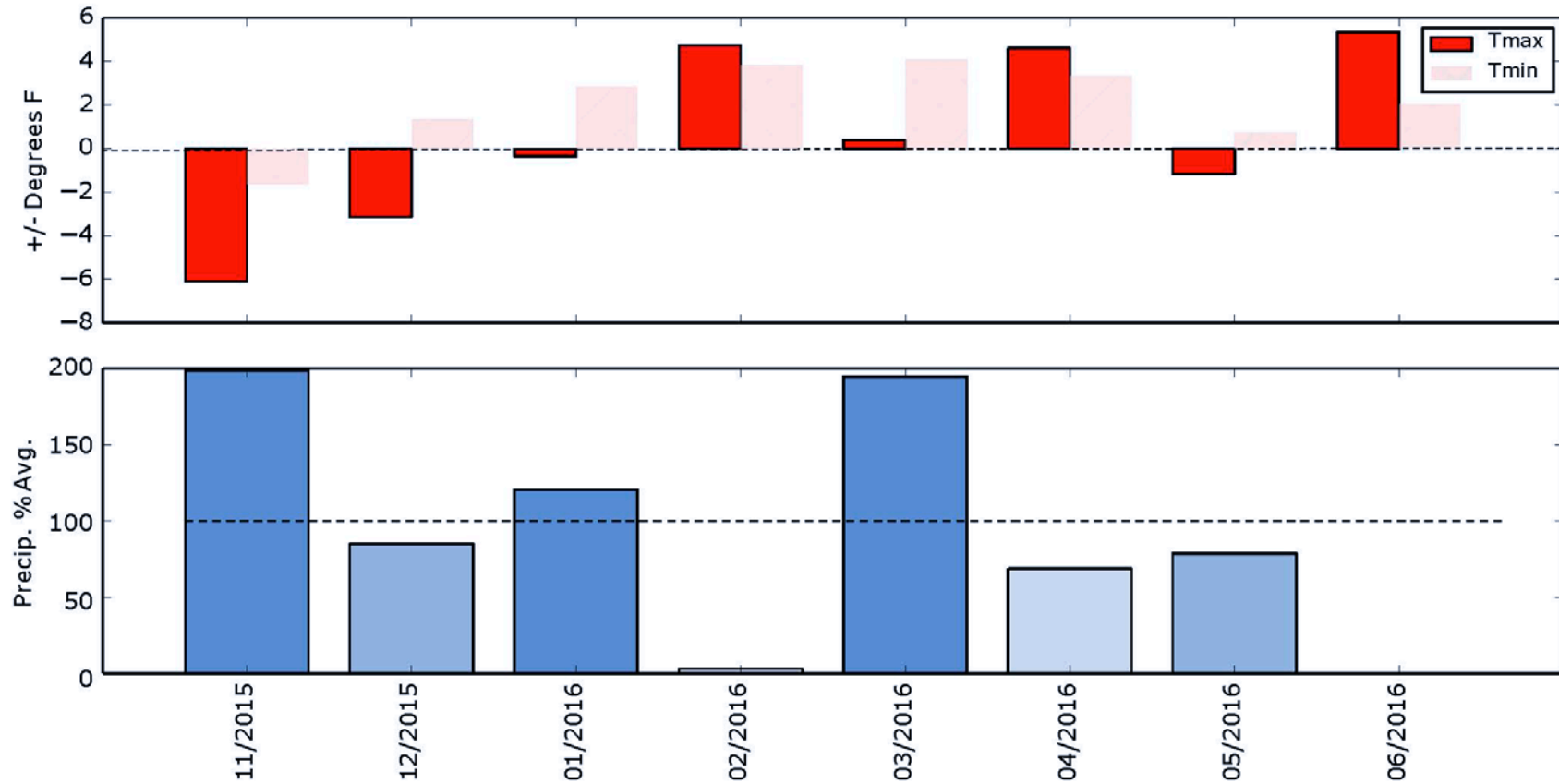


Figure A-3. This figure compares 2016 data to the long-term (30 year) averages of monthly temperatures (red boxes) and monthly precipitation (blue boxes). The dotted black line in the both graphs represents the 30 year average for temperature and precipitation.

Hagerman 2 SW, Idaho (USC00103932) 2009-2015: Departure from 1981 - 2010 Avgs.

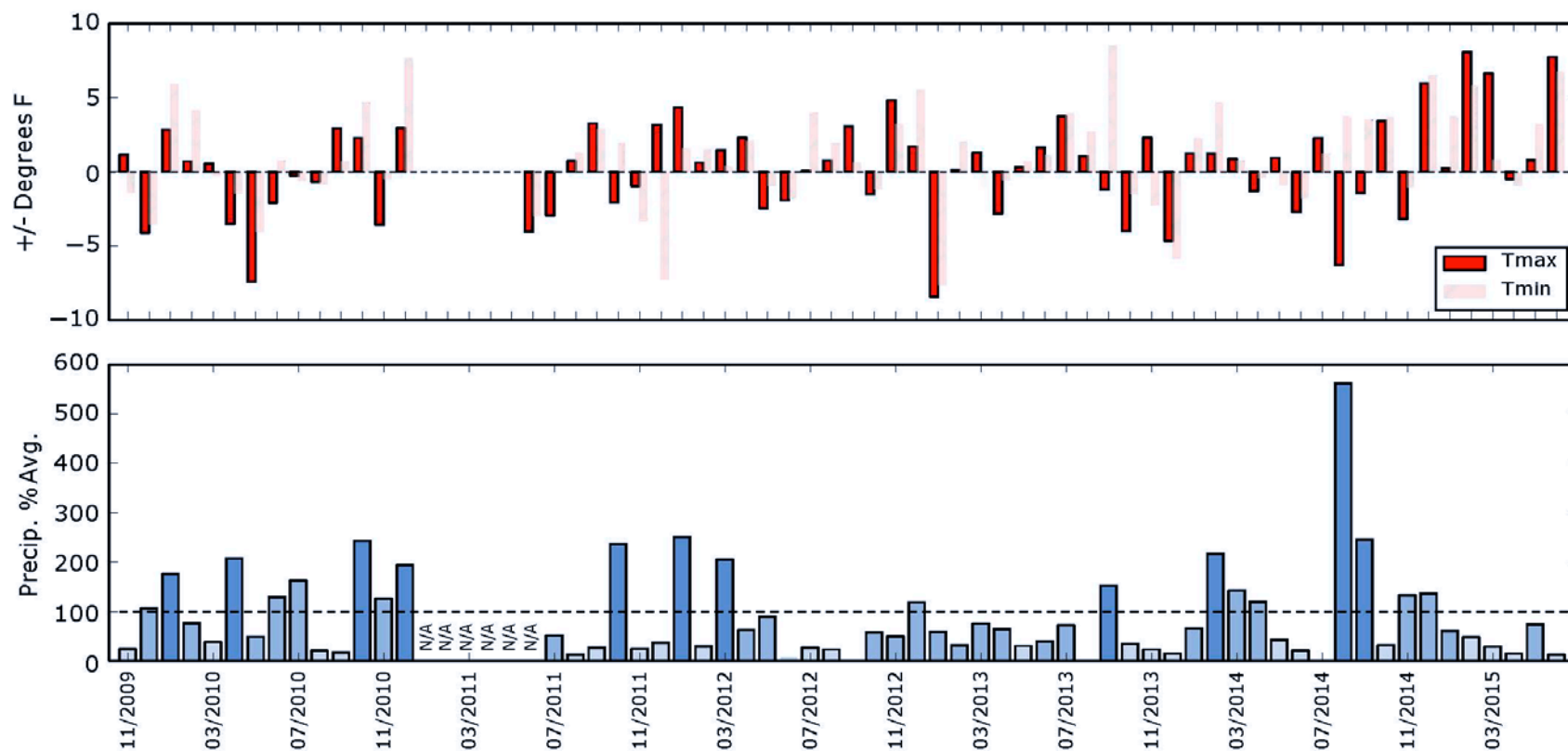


Figure A-4. This figure compares data (years 2009-2015) to the long-term (30 year) averages of monthly temperatures (red boxes) and monthly precipitation (blue boxes). The dotted black line in the both graphs represents the 30 year average for temperature and precipitation.

Appendix D

Bar graphs comparing 2009, 2012, and 2018 species cover estimates at Hagerman Fossil Beds National Monument

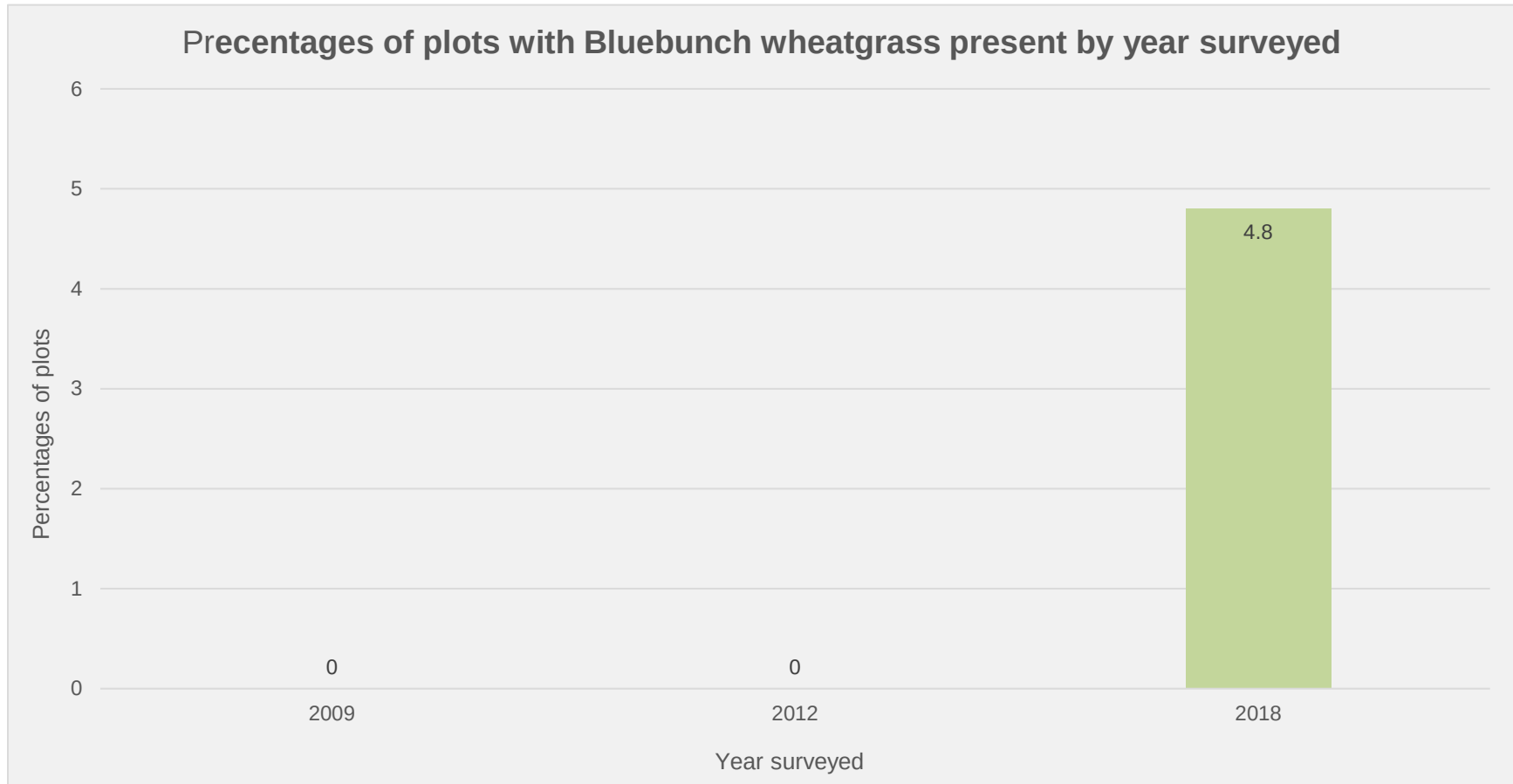


Figure A-5. Estimated percentage of any bluebunch wheatgrass cover (>0%) in all sampling frames at HAFO through the last three years of surveying 2009, 2012, and 2018.

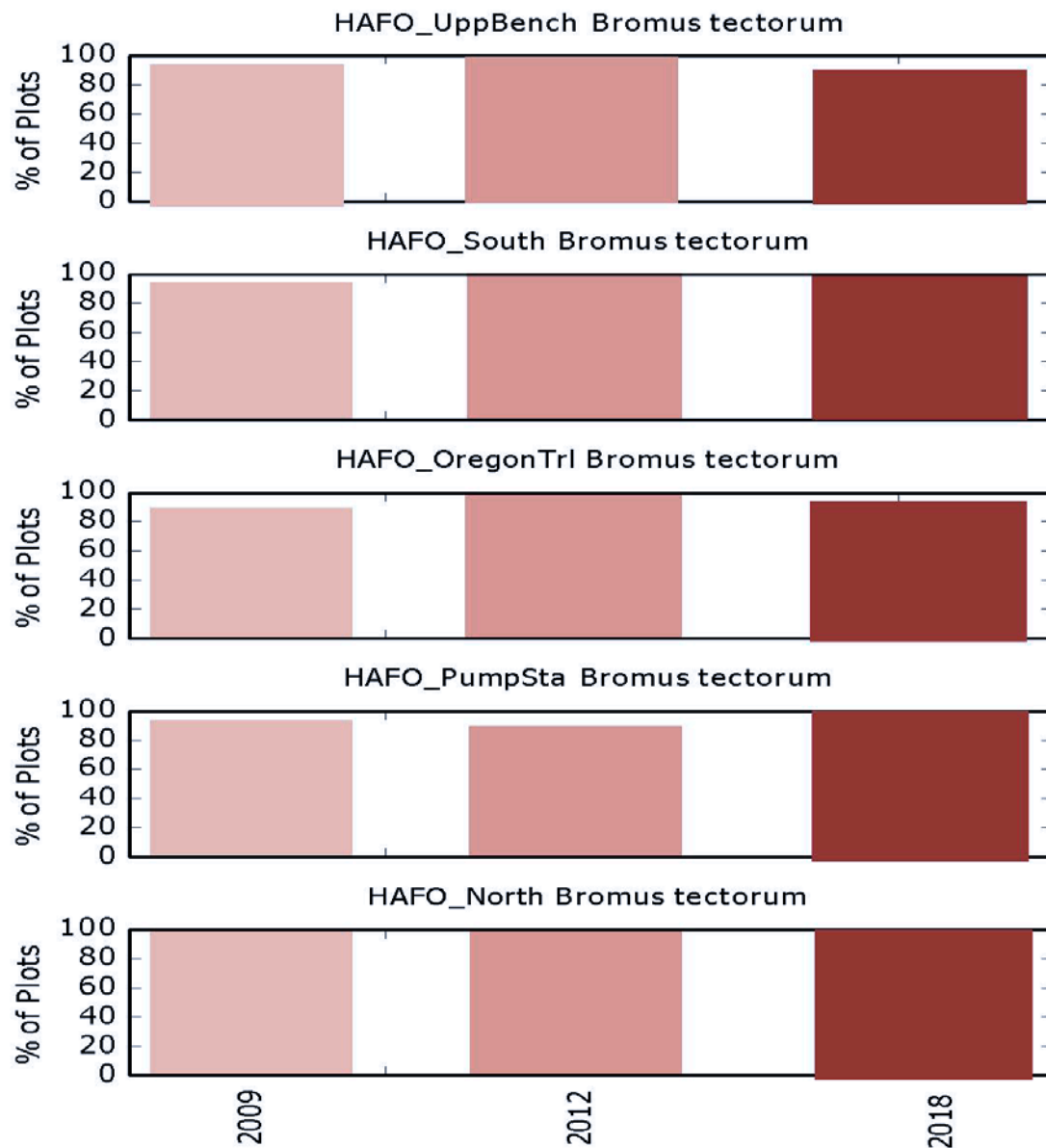


Figure A-6. Estimated percentage of any cheatgrass cover (>0%) in each sampling frame at HAFO through the last three years of surveying 2009, 2012, and 2018.

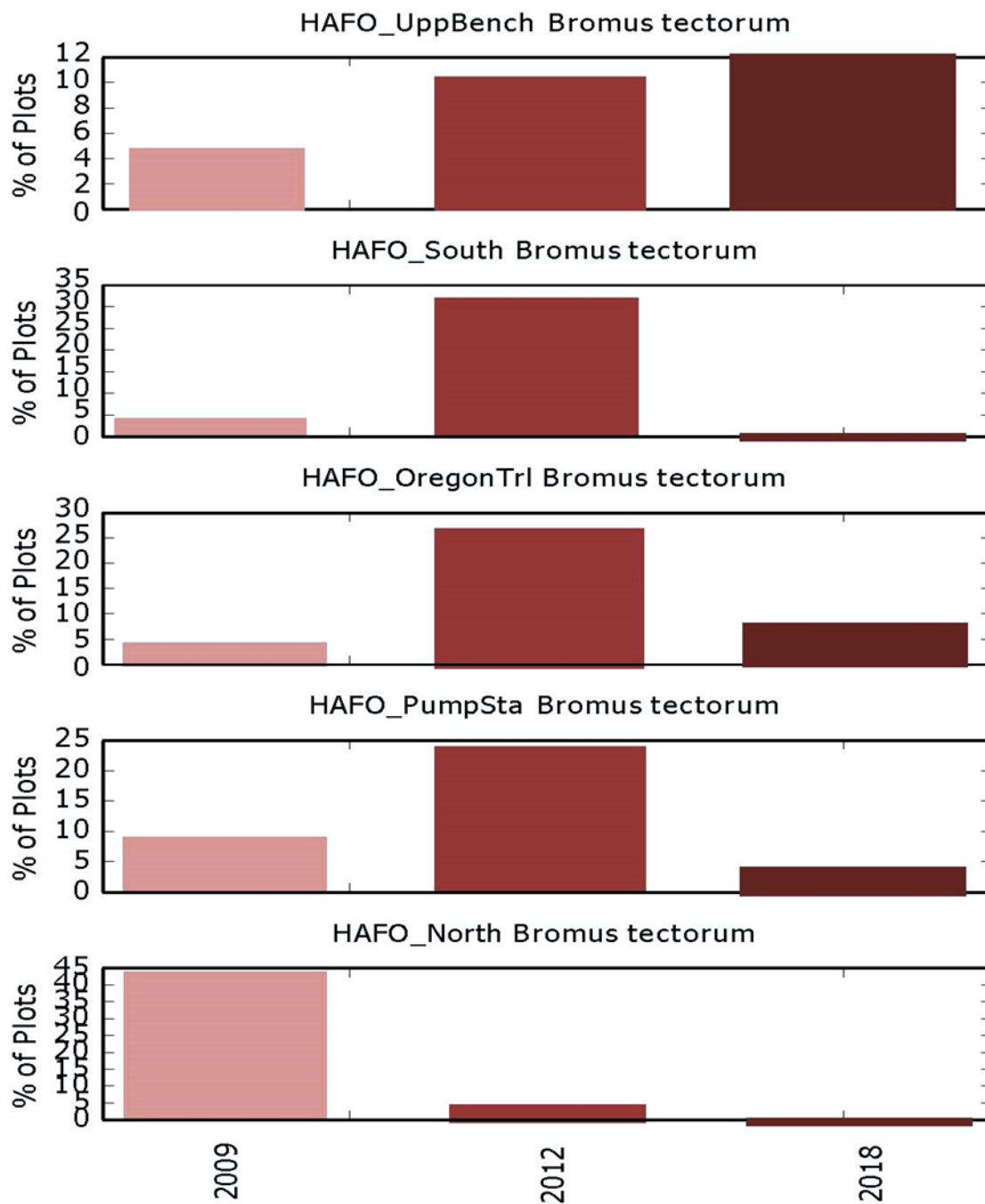


Figure A-7. Estimated percentage of heavily infested cheatgrass cover (>95%) in each sampling frame at HAFO through the last three years of surveying 2009, 2012, and 2018.

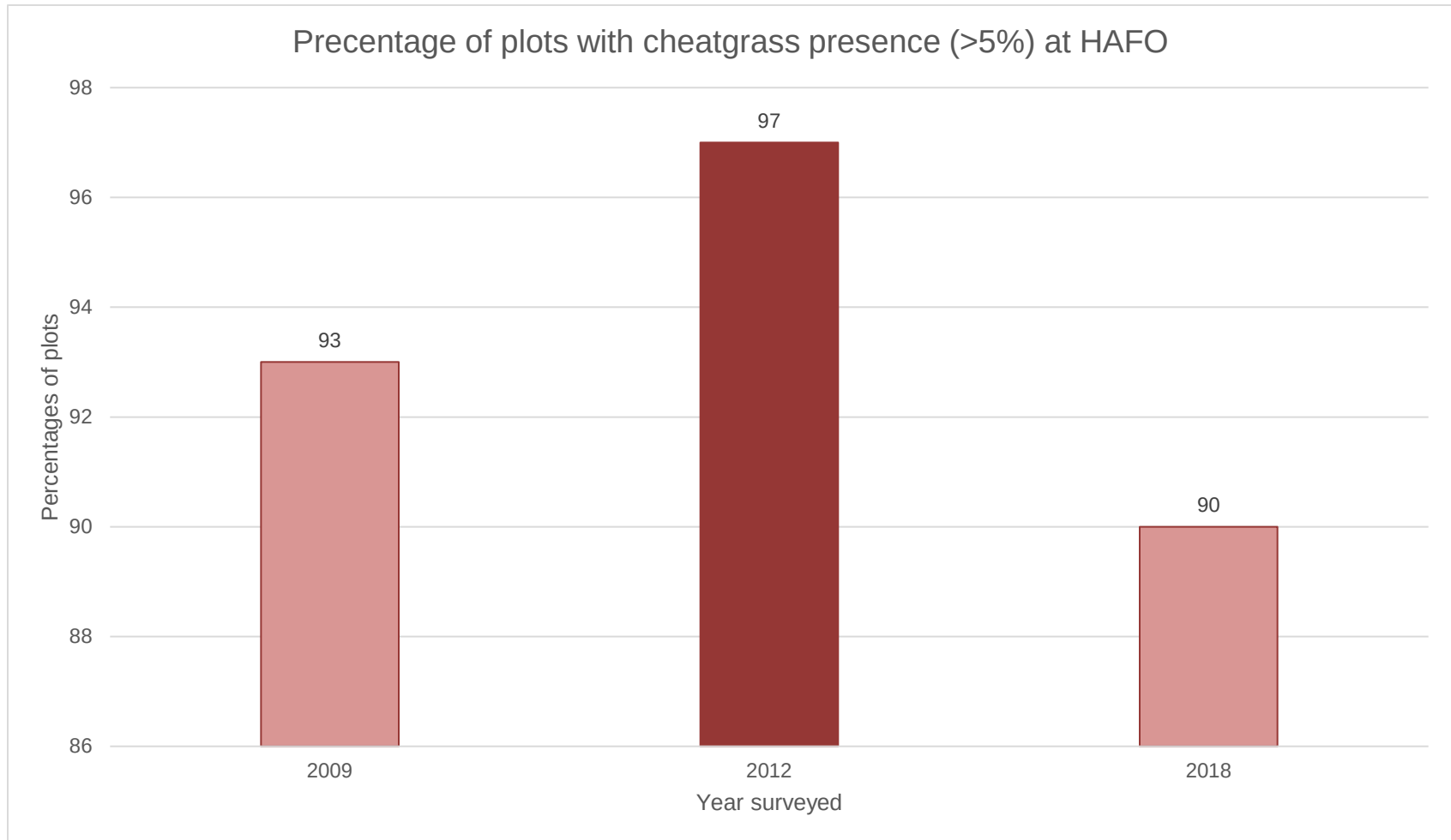


Figure A-8. Estimated percentage of overall cheatgrass cover (>5%) found park wide at HAFO through the last three years of surveying 2009, 2012, and 2018.

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.

NPS 300/150473, February 2019

National Park Service
U.S. Department of the Interior



[Natural Resource Stewardship and Science](#)

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525