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Natural Resource Stewardship and Science

Sagebrush Steppe Vegetation Monitoring in the Blue Basin Area of the John Day Fossil Beds National Monument

2018 Annual Report

Natural Resource Report NPS/UCBN/NRR—2019/1868

ON THE COVER

Intact native bunch grass slope occurring in the high hills above Blue Basin, JODA.
Photo by Melissa Nicolli.

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Executive Summary

As part of the Upper Columbia Basin Network (UCBN) sagebrush steppe vital signs monitoring program, the ecological condition of the sagebrush steppe within the Blue Basin Area of the Sheep Rock Unit of John Day Fossil Beds National Monument (JODA) was surveyed in late May of 2018. The surveys were conducted following methods outlined in the UCBN sagebrush steppe monitoring protocol (Yeo et al. 2009). The cover of exposed soil and the above-ground foliar cover of principal native and non-native plants or genera were estimated in one-hundred fifty-one 1 m^2 quadrats randomly placed throughout the sampling frame (Figure 1). This portion of the Monument was first surveyed in 2011 and has since been surveyed in 2014, 2016, 2017, and 2018. These recent annual survey efforts beginning in 2016 were outside of the UCBN's 3-year revisit plan, in response to the 2015 wildfire that swept through the Blue Basin area. The Blue Basin fire burned 266 acres within the Blue Basin unit and came within 25 feet of burning down a historic homestead at the Blue Basin recreation site. The Sugarloaf fire burned 48 acres within the Blue Basin unit at the same time as the Blue Basin fire. The two are considered part of the same fire complex, collectively burning almost 315 acres within the Blue Basin unit. The entire monument, including the Blue Basin Unit, was surveyed during June-July, 2014, as part of the Network's regular 3-year revisit schedule (Yeo and Rodhouse 2012). This provided an excellent opportunity to study the impact the fire had on Blue Basin. This report describes the findings from 2018, and creates comparisons among key species of interest to the 2011-2017 observations. It also makes some post fire recovery comparisons to the Clarno unit of JODA, which burned in 2011 and which has been monitored annually 2012-2017 to also examine post-fire recovery. This report provides some insights into the effects of fire and the increasing invasion of non-native plants in JODA's upland plant communities, a topic of critical importance to park management.

Cheatgrass (*Bromus tectorum*) amd medusahead (*Elymus caput-medusae*) species continue to dominate much of the Blue Basin landscape, presenting a major threat to the ecological integrity of the unit. In addition to these two invasive dangers, a fairly recent newcomer, wiregrass (*Ventenata dubia*) has been seen in larger numbers over the past few years and is a species of concern that could easily take over an already compromised landscape. Big sagebrush (*Artemisia tridentata*) was found in only 2.7% of plots surveyed in 2018 (n=151), and many areas that once supported sagebrush have remained shrub cover free since the 2015 wildfire. The cover of native bunchgrasses, which is an integral part of a healthy sagebrush steppe, has remained at low to moderate cover. Principal native bunchgrasses that were surveyed include: bluebunch wheatgrass (*Pseudoroegneria spicata*), Sandberg bluegrass (*Poa secunda*), needlegrasses (*Achnatherum spp.*), and sand dropseed (*Sporobolus cryptandrus*). Bluebunch wheatgrass, a foundation species in the Blue Basin landscape, has remained constant with initial post fire conditions, being in ~ 40% of plots surveyed. This number is actually an increase compared to pre-fire percentages, but the early surveys in 2011 and 2014 had low sample sizes (because the Blue Basin area was included in the sample size draw for the entire Sheep Rock East frame, not given special stratification focus as was done after the fire), making the numbers less representative of a whole landscape. Overall, native species appear to have recovered relatively well from the fire, with plot cover levels in 2018 comparable to those prior to the fire. Native forb cover remains low. Principal native forb species included: milk-vetch (*Astragalus*

spp.), yarrow (*Achillea millefolium*), buckwheats (*Eriogonum* spp.), Blue Mountain prairie clover (*Dalea ornata*) and desert parsley (*Lomatium* spp.). Yarrow was the most abundant native forb, encountered in 27% of all plots. Filaree (*Erodium cicutarium*) and Dalmatian toadflax (*Linaria dalmatica*), two non-native invasive forbs, were widespread and at their highest levels ever seen in 2018. As is typical of the heterogeneous landscape of JODA, some of the Blue Basin plots represent healthy sage steppe condition (especially on north-facing slopes), while most of the plots indicate degraded conditions.

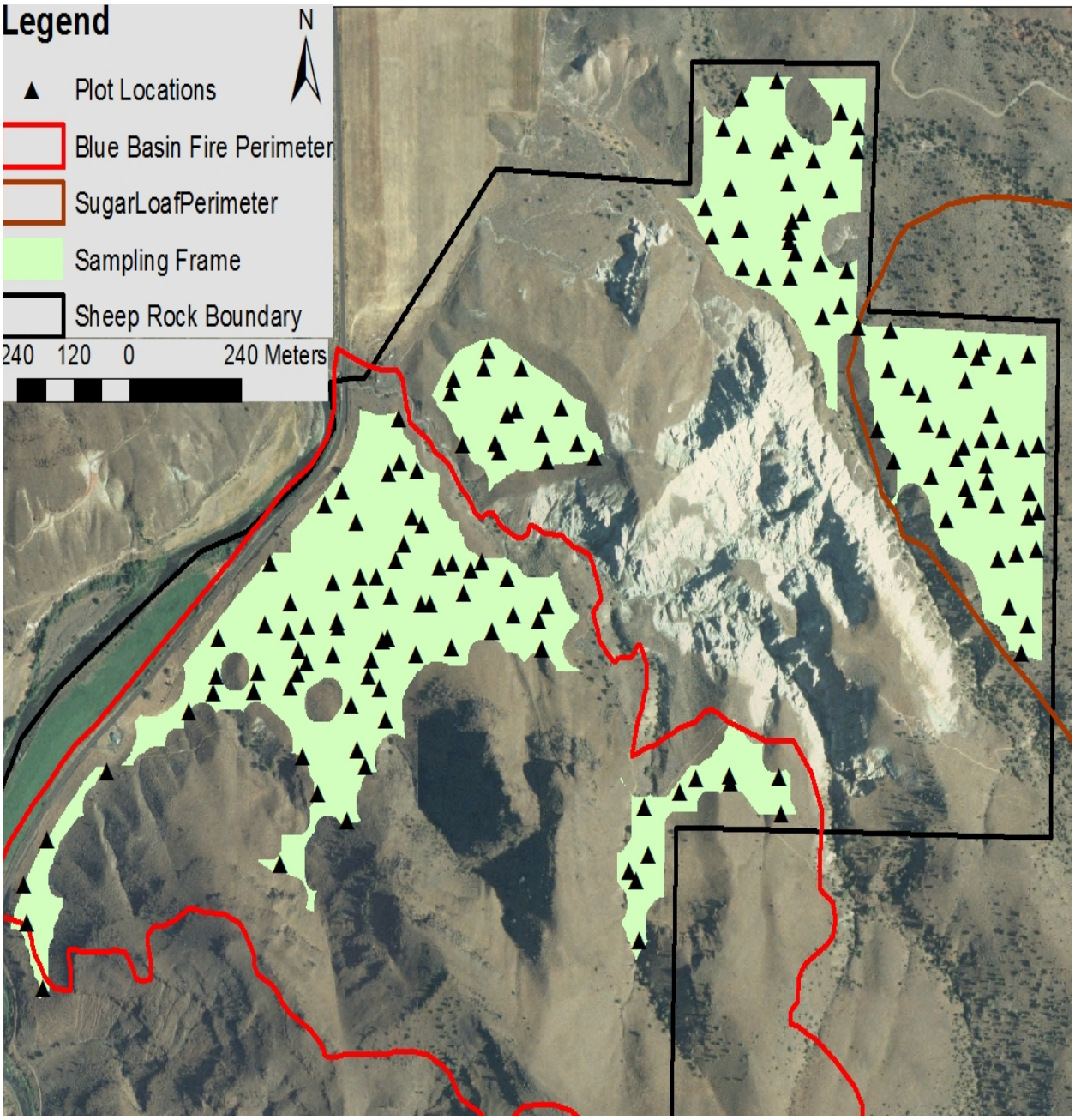

Figure 1. Blue Basin unit of the John Day Fossil Beds showing the sampling frame surveyed in 2018 and prior years, with the 2018 plot locations shown. The perimeter of the Blue Basin and Sugar Loaf fires are shown.

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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 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 John Day Fossil Beds (JODA), and discusses comparisons with data collected before and after 2015, when the Blue Basin unit of the park burned, from the Blue Basin Fire. This report discusses trends for a subset of species since the fire and reflects on the management implications of those trends.

Methods

The total sample size in 2018 included additional oversample plots from the GRTS list (Table 1). One plot was dropped from the sampling frame due to more than 75% of the plot consisting of bare soil. 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; Table 2)). 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 common names and their scientific names are listed in Appendix A.

Table 1. Sample sizes, for the sagebrush steppe monitoring in the Blue Basin unit of JODA by year. Details of frame development and target sample sizes are provided in Yeo et al. (2009).

Park	Year	Sample Size
JODA	2011	22
JODA	2014	20
JODA	2016	154
JODA	2017	152
JODA	2018	151

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 data was extracted from the John Day 35 WNM weather station roughly 3 miles north of the Blue Basin unit. Spring (March-May) precipitation of 2018 was slightly higher than the three previous springs (2015-2017), however, it still fell under the 30 year average. The 2018 winter and spring temperatures were warmer than average. Cooler winter temperatures tend to favor the native bunchgrasses and forbs, making these winter conditions preferable for invasive species. In the year or 2015, spring (March-May) precipitation was well below average and temperatures were warmer than average. These factors may have contributed to the dry conditions that allowed for the Blue Basin fire to take off. A graphical representation of the temperature and precipitation data is in Appendix B.

Results and Discussion

A total of 151 plots identified in the sampling design were measured from May 29-31, 2018 (Table 1). The previous winter saw precipitation substantially lower than the 30 year average (Appendix B). Bare ground cover appears to be making a return toward pre-fire conditions; the proportion of plots with no bare ground (0% cover) fell from 15% in 2014 to 0% in 2016 after the fire (Figure A-7 in Appendix D). That number has been steadily rising, and 13% of all plots measured in 2018 had no bare ground (Figure A-7 in Appendix D). This is the same trend that was seen in the Clarno unit after the 2011 fire (Figure A-8 in Appendix D). Some of the least invaded sites in the Blue Basin unit were located on north-facing slopes. It may be difficult to use the bare ground cover as it relates to native bunchgrass presence for indicating ecological condition, as such a measurement would be skewed by the relative lack of bare ground cover on the aforementioned north-facing slopes. Openings between bunchgrasses on these slopes were mostly devoid of non-native grasses and allowed for intact cryptobiotic soil crust communities.

Shrub cover remains extremely low after the fire, with the exception of broom snakeweed, a species that resprouts after fire (Appendix B). Antelope bitterbrush, green rabbit brush, and gray horsebrush were found in only one plot each. Big sagebrush was found in three plots, showing a very slight increase from 2016 (Appendix B). Broom snakeweed presence appears to be gradually increasing to pre-fire levels; in 2018, the proportion of plots with at least some broom snakeweed (>0%) had more than tripled compared to 2016 levels (7% up to 24%). However, this is still only about half of what it was before the fire, at 45% (Appendix B).

Sandberg bluegrass, needlegrasses, and bluebunch wheatgrass continue to be the most abundant native perennial grasses in the unit (Appendix B). Bluebunch wheatgrass appears to have been relatively unaffected by the fire in Blue Basin. Levels were immediately recovered and exceeding pre-fire numbers the first year of post fire monitoring in 2016. 2016 occurrences were exceeding the >25% cover classes observed in 2011 by 3% (Appendix B). This is a very different trend than was noted in the Clarno unit, where it took nearly 6 years for bluebunch wheatgrass to recover to pre-fire levels. There is a chance that the data is skewed due to the pre-fire surveys in Blue Basin having relatively low sample sizes, however, it appears that this particular native bunchgrass is doing relatively well in Blue Basin.

Although many native species have been increasing in abundance since the fire in 2015, some equal to or above pre-fire levels, they are overall being outcompeted by invasive annual grasses. Cheatgrass and medusahead are, by far, the most abundant and rapidly increasing non-native species in the Blue Basin unit (Table 3, Appendix B, Figure A-5 in Appendix D). Cheatgrass was found in 99% of all plots in 2018 (Table 3). There is not convincing evidence to blame this problem on fire alone, however. Small sample size could once again play a role in these results, but the two years post fire actually showed a drop in cheatgrass cover across Blue Basin, and now in 2018, the percentages seem to be once again level with pre-fire numbers. There has been a slight increase (2%), since the 2015 fire, in occurrences of heavy infestation (>50% cover) among cheatgrass. More alarming than the cheatgrass infestation is the increase in medusahead levels; the 2018 survey

revealed an approximately 500% (5 times) increase over 2014. (Appendix B). Wiregrass, a newcomer on the scene in 2016, is a dangerous non-native annual grass whose numbers have more than doubled in the 3 years that it has been included on park search lists. It has the potential to take off in the degraded portions of Blue Basin. Given that bluebunch wheatgrass, the dominant native species in the Blue Basin unit, is occurring at rates better than pre-fire conditions, cheatgrass, medusahead and wiregrass appear to be filling in gaps once occupied by bare ground and, potentially, cryptobiotic soil crusts. Bulbous bluegrass, non-native bromes, filaree, and Dalmatian toadflax are also increasing in both frequency and abundance (Appendix B). For the first time since monitoring began in 2011, occurrences of filaree in Blue Basin surpassed 50% of all plots in 2018 (Appendix B) and Dalmatian toadflax occurred in nearly 20% of all plots.

Since the 2015 fire in the Blue Basin unit of the John Day Fossil Beds National Monument, changes in bare ground, plant community composition, and individual species abundance have been monitored annually to track establishment rates and interpret any patterns exhibited. After three years of post-fire monitoring, it can be inferred that bluebunch wheatgrass, the primary foundational native bunchgrass occurring in this region, was not harshly impacted by the Blue Basin fire. It will require more years of monitoring to acquire more data and solidify this inference. The non-native species, particularly wiregrass and medusahead, have exhibited increases in frequency and abundance. The least invaded sites appear to be on north-facing slopes, where native bunchgrass populations are most intact. Non-native annual grasses are taking advantage of areas previously comprised of bare ground, and moving into other openings that, without the influence of invasives, would likely be occupied by native forbs following a fire (Kerns & Day, 2017). These behaviors of non-native annual grass invasion are consistent with park-wide patterns of post-fire losses (Reed-Dustin et al. 2016, Rodhouse et al. 2014).

The rapid establishment of non-native annual grasses, combined with the decline of native forb species at Blue Basin should be a huge alarm to park resource management. Additional research should be executed to determine specific implications of the annual grass spread regarding ecological function, but such heavy infestation usually results in biodiversity decline as well as degraded soil-carbon storage ability and hydrologic functionality (Koteen, Baldocchi, & Harte, 2011). As plant community composition shifts toward increasing annual grass dominance, ecosystem resilience to disturbances like fire and grazing could be further reduced. Large changes in species composition can affect the functionality of the entire ecosystem and its ability to provide and support wildlife can be compromised (Balvanera et al., 2006).

From the perspective of long-term stewardship of the upland native steppe community for future generations, with efforts by the National Park Service at the Blue Basin unit of the John Day Fossil Beds National Monument, the creation of a dedicated program to mitigate further losses of ecological diversity is warranted, despite being, at times, difficult to logistically achieve. The effort to promote more native species in the secondary succession phase of post-fire landscapes by reseeding, could potentially mitigate annual grass establishment and have positive impacts on the ecological health of the unit (Hoh et al. 2015). Furthermore, research suggests that management for healthy pre-fire conditions in sagebrush steppe communities has a large influence over the post fire germination

response (Ellsworth & Kauffman, 2013). If a more rigorous preventative management plan was successfully implemented (e.g., Hoh et al. 2015, Rodhouse et al. 2014), these strategies could be used as a guide for other park managers dealing with these problems on their own lands in the future.

Table 3. Summary statistics for estimated cheatgrass infestation in Blue Basin by year surveyed.

Year	Metric	Result
2018	Total acreage sampled	145.34
	Total with no cheatgrass	1.93
	Proportion of total frame area with no cheatgrass	0.01
	Total with at least some cheatgrass	143.41
	Proportion of total surveyed area with cheatgrass	0.99
	Heavily infested acreage (>25% cover)	49.09
	Proportion of heavily infested	0.34
2017	Total acreage sampled	145.34
	Total with no cheatgrass	6.69
	Proportion of total frame area with no cheatgrass	0.05
	Total with at least some cheatgrass	138.65
	Proportion of total surveyed area with cheatgrass	0.95
	Heavily infested acreage (>25% cover)	66.93
	Proportion of heavily infested	0.46
2016	Total acreage sampled	145.34
	Total with no cheatgrass	7.55
	Proportion of total frame area with no cheatgrass	0.05
	Total with at least some cheatgrass	137.79
	Proportion of total surveyed area with cheatgrass	0.95
	Heavily infested acreage (>25% cover)	33.98
	Proportion of heavily infested	0.23

Table 3 (continued). Summary statistics for estimated cheatgrass infestation in Blue Basin by year surveyed.

Year	Metric	Result
2014	Total acreage sampled	145.34
	Total with no cheatgrass	0.00
	Proportion of total frame area with no cheatgrass	0.00
	Total with at least some cheatgrass	145.34
	Proportion of total surveyed area with cheatgrass	1.00
	Heavily infested acreage (>25% cover)	65.40
	Proportion of heavily infested	0.45
2011	Total acreage sampled	145.34
	Total with no cheatgrass	0.00
	Proportion of total frame area with no cheatgrass	0.00
	Total with at least some cheatgrass	145.34
	Proportion of total surveyed area with cheatgrass	1.00
	Heavily infested acreage (>25% cover)	59.46
	Proportion of heavily infested	0.41

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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
Trees	Western juniper	*Juniperus occidentalis*
Sagebrush	Big Sagebrush	*Artemisia tridentata*
Other Shrubs	Green rabbitbrush	*Chrysothamnus viscidiflorus*
	Broom snakeweed	*Gutierrezia sarothrae*
	Antelope bitterbrush	*Purshia tridentata*
	Greasewood	*Sarcobatus vermiculatus*
	Spineless horsebrush	*Tetradymia canescens*
Native Grasses	Needlegrass	*Achnatherum spp*
	Idaho fescue	*Festuca idahoensis*
	Needle and thread grass	*Hesperostipa comata*
	Sandberg's bluegrass	*Poa secunda*
	Bluebunch wheatgrass	*Pseudoroegneria spicata*
	Sand dropseed	*Sporobolus cryptandrus*
Persistent Native Forbs	Yarrow	*Achillea millefolium*
	Aster	*Aster* spp.
	Astragalus, Milkvetch	*Astragalus* spp
	Thistle	*Cirsium* spp.
	Fleabane	*Erigeron* spp
	Buckwheat	*Eriogonum* spp
	Biscuitroot	*Lomatium* spp
	Silverleaf scorpionweed	*Phacelia hastata*
	Scorpionweed	*Phacelia* spp
Other Native Forbs	Mariposa lily	*Calochortus* spp
	Cat’s eyes	*Cryptantha* spp
Invasive Grasses	Brome	*Bromus* spp.
	Cheatgrass	*Bromus tectorum*
	Medusahead	*Elymus caput-medusae*
	Bulbous bluegrass	*Poa bulbosa*
	Wiregrass	*Ventenata dubia*

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

Plant Category	Common names	Species name
Invasive Forbs	Tansy mustard	*Descurainia* spp
	Filaree	*Erodium cicutarium*
	Clasping pepperweed	*Lepidium perfoliatum*
	Dalmatian toadflax	*Linaria dalmatica*
	Russian thistle	*Salsola kali*
	Tumble mustard	*Sisymbrium altissimum*
	Common salsify	*Tragopogon dubius*
	Moth mullein	*Verbascum blattaria*

Appendix B

2011, 2014, 2016, 2017, 2018 sage monitoring data in JODA: percentage of plots within each cover class for exposed bare ground and principal plant species organized by species guilds.

Table A-2. 2011 Blue Basin sampling frame, JODA: percentage of plots (n=22 1 m^2 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	–	41	50	9	0	0	0	0
Sagebrush	*Artemisia tridentata*	91	4.5	4.5	0	0	0	0
Shrubs	*Gutierrezia sarothrae*	63	23	14	0	0	0	0
Native Perennial Grasses	Achnatherum spp	91	4.5	4.5	0	0	0	0
	Festuca idahoensis	95.5	0	4.5	0	0	0	0
	Poa secunda	77	18	5	0	0	0	0
	Pseudoroegneria spicata	82	4.5	9	4.5	0	0	0
Native Persistent Forbs	*Achillea millefolium*	82	14	4	0	0	0	0
	Astragalus spp	86	9	0	5	0	0	0
	Erigeron spp	91	4.5	4.5	0	0	0	0
	Sphaeralcea munroana	95	0	5	0	0	0	0
Native Other Forbs	*Brodiaea douglasii*	95	5	0	0	0	0	0
Non-native Invasive Forbs	*Erodium cicutarium*	73	27	0	0	0	0	0
	Sisymbrium altissimum	64	32	4	0	0	0	0
Non-native Invasive Grasses	*Bromus* spp.	86	9	5	0	0	0	0
	Bromus tectorum	0	32	27	18	14	9	0
	Elymus caput-medusae	95	5	0	0	0	0	0
	Poa bulbosa	59	27	14	0	0	0	0

Table A-3. 2014 Blue Basin sampling frame, JODA: percentage of plots (n=20 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	–	15	60	20	5	0	0	0
Sagebrush	*Artemisia tridentata*	95	0	5	0	0	0	0
Shrubs	*Gutierrezia sarothrae*	55	25	15	5	0	0	0
Native Perennial Grasses	*Achnatherum* spp	95	5	0	0	0	0	0
	Festuca idahoensis	95	5	0	0	0	0	0
	Poa secunda	45	35	20	0	0	0	0
	Pseudoroegneria spicata	75	0	25	0	0	0	0
Native Persistent Forbs	*Achillea millefolium*	75	25	0	0	0	0	0
	Astragalus spp	85	15	0	0	0	0	0
	Cirsium spp.	95	5	0	0	0	0	0
	Crepis acuminata	95	5	0	0	0	0	0
	Erigeron spp.	90	10	0	0	0	0	0
	Eriogonum spp	90	10	0	0	0	0	0
	Lupinus spp	95	5	0	0	0	0	0
Native Other Forbs	*Calochortus* spp.	95	5	0	0	0	0	0
Non-native Invasive Forbs	*Centaurea maculosa*	95	0	0	5	0	0	0
	Erodium cicutarium	50	45	5	0	0	0	0
	Lepidium perfoliatum	85	15	0	0	0	0	0
	Linaria dalmatica	95	0	0	0	5	0	0
	Salsola kali	85	15	0	0	0	0	0
	Sisymbrium altissimum	60	25	10	5	0	0	0
	Tragopogon dubius	80	20	0	0	0	0	0

Table A-3 (continued). 2014 Blue Basin sampling frame, JODA: percentage of plots (n=20 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 Grasses	*Bromus* spp.	95	5	0	0	0	0	0
	Bromus tectorum	0	45	10	30	10	5	0
	Elymus caput-medusae	95	5	0	0	0	0	0
	Poa bulbosa	10	50	30	10	0	0	0

Table A-4. 2016 Blue Basin sampling frame, JODA: percentage of plots (n=154 1 m^2 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	–	0	52	43.5	2.5	2	0	0
Trees	*Juniperus occidentalis*	96	0	1	0	1	1	1
Sagebrush	*Artemisia tridentata*	98	1	1	0	0	0	0
Shrubs	*Atriplex* spp.	98	1	1	0	0	0	0
	Chrysothamnus viscidiflorus	99	1	0	0	0	0	0
	Ericameria nauseosa	99	0	1	0	0	0	0
	Gutierrezia sarothrae	93	4	2	1	0	0	0
Native Perennial Grasses	*Achnatherum* spp	99	0	1	0	0	0	0
	Festuca idahoensis	98	1	1	0	0	0	0
	Hesperostipa comata	99	0	1	0	0	0	0
	Poa secunda	39	44	15	1	1	0	0
	Pseudoroegneria spicata	60	13	24	3	0	0	0
	Sporobolus cryptandrus	98	1	1	0	0	0	0
Native Persistent Forbs	*Achillea millefolium*	85	7	7	1	0	0	0
	Antennaria spp	99	1	0	0	0	0	0
	Aster spp	97	3	0	0	0	0	0
	Astragalus spp	88	6	3	3	0	0	0
	Cirsium spp.	98	2	0	0	0	0	0
	Crepis acuminata	99	1	0	0	0	0	0
	Dalea ornata	99	1	0	0	0	0	0
	Eriogonum spp	99	1	0	0	0	0	0
	Lomatium spp	78	22	0	0	0	0	0

Table A-4 (continued). 2016 Blue Basin sampling frame, JODA: percentage of plots (n=154 1 m^2 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 Persistent Forbs (continued)	*Phacelia hastata*	97	3	0	0	0	0	0
	Phlox spp	99	1	0	0	0	0	0
	Sphaeralcea munroana	99	1	0	0	0	0	0
Native Other Forbs	*Agoseris* spp.	96	3	1	0	0	0	0
	Allium spp.	99	1	0	0	0	0	0
	Calochortus spp.	95	5	0	0	0	0	0
	Cryptantha spp	88	11	1	0	0	0	0
Non-native Invasive Forbs	*Descurainia* spp	97	3	0	0	0	0	0
	Erodium cicutarium	60	24	12	3	1	0	0
	Lepidium perfoliatum	75	15	5	2.5	2.5	0	0
	Linaria dalmatica	92	3	4	1	0	0	0
	Onopordum acanthium	99	0	1	0	0	0	0
	Salsola kali	99	1	0	0	0	0	0
	Sisymbrium altissimum	44	21	10	16	6	2	1
	Tragopogon dubius	82	13	4	1	0	0	0
Non-native Invasive Grasses	*Bromus* spp.	84	16	0	0	0	0	0
	Bromus tectorum	5	36	36	12	8	2	1
	Elymus caput-medusae	87	9	2	1	0	1	0
	Poa bulbosa	27	21	18	17	14	3	0
	Poa pratensis	99	0	1	0	0	0	0
	Ventenata dubia	97	2	1	0	0	0	0

Table A-5. 2017 Blue Basin sampling frame, JODA: percentage of plots (n=152 1 m^2 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	–	22	58	17	2	1	0	0
Trees	*Juniperus occidentalis*	98	1	1	0	0	0	0
Sagebrush	*Artemisia tridentata*	98	1	0	1	0	0	0
Shrubs	*Atriplex* spp.	97	1	2	0	0	0	0
	Ericameria nauseosa	99	1	0	0	0	0	0
	Gutierrezia sarothrae	83	12.5	4.5	0	0	0	0
	Sarcobatus vermiculatus	99	0	1	0	0	0	0
	Tetradymia canescens	99	1	0	0	0	0	0
Native Perennial Grasses	*Achnatherum* spp	96	3	1	0	0	0	0
	Festuca idahoensis	96	2	1	1	0	0	0
	Poa secunda	30	51	16	2	1	0	0
	Poa spp.	99	1	0	0	0	0	0
	Pseudoroegneria spicata	61	15	21	3	0	0	0
	Sporobolus cryptandrus	99	0	1	0	0	0	0
Native Persistent Forbs	*Achillea millefolium*	78	18	4	0	0	0	0
	Aster spp	99	0	1	0	0	0	0
	Astragalus spp	84	9	6	1	0	0	0
	Cirsium spp.	98	1	1	0	0	0	0
	Crepis acuminata	99	1	0	0	0	0	0
	Dalea ornata	99	1	0	0	0	0	0
	Erigeron spp	94	5	1	0	0	0	0
	Eriogonum spp	93	7	0	0	0	0	0

Table A-5 (continued). 2017 Blue Basin sampling frame, JODA: percentage of plots (n=152 1 m^2 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 Persistent Forbs (continued)	*Lomatium* spp	78	22	0	0	0	0	0
	Lupinus spp.	99	1	0	0	0	0	0
	Phacelia hastata	96	4	0	0	0	0	0
Native Other Forbs	*Agoseris* spp.	97	3	0	0	0	0	0
	Calochortus spp.	91	9	0	0	0	0	0
	Cryptantha spp	99	1	0	0	0	0	0
Non-native Invasive Forbs	*Centaurea maculosa*	99	1	0	0	0	0	0
	Descurainia spp	99	0	1	0	0	0	0
	Erodium cicutarium	53	20	9	12	4	2	0
	Euphorbia esula	97	3	0	0	0	0	0
	Lepidium perfoliatum	69	20	6	4	1	0	0
	Linaria dalmatica	83	12	4	1	0	0	0
	Onopordum acanthium	99	1	0	0	0	0	0
	Salsola kali	89	11	0	0	0	0	0
	Sisymbrium altissimum	53	38	6	1	1	1	0
	Tragopogon dubius	76	23	1	0	0	0	0
Non-native Invasive Grasses	*Bromus* spp.	90	7	1	1	1	0	0
	Bromus tectorum	4	22	27	17	17	12	1
	Elymus caput-medusae	83	10	1	1	1	3	1
	Poa bulbosa	35	22	24	7	7	5	0
	Ventenata dubia	97	1	0	1	1	0	0

Table A-6. 2018 Blue Basin sampling frame, JODA: percentage of plots (n=151 1 m^2 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	–	13	60	24	2	0	1	0
Trees	*Juniperus occidentalis*	96	1	0	0	1.5	1.5	0
Sagebrush	*Artemisia tridentata*	97	1	1	1	0	0	0
Shrubs	*Chrysothamnus viscidiflorus*	99	0	0	1	0	0	0
	Gutierrezia sarothrae	76	20	4	0	0	0	0
	Purshia tridentata	99	1	0	0	0	0	0
	Sarcobatus vermiculatus	99	0	1	0	0	0	0
	Tetradymia canescens	99	1	0	0	0	0	0
Native Perennial Grasses	*Achnatherum* spp	98	1	1	0	0	0	0
	Festuca idahoensis	93	4	2	1	0	0	0
	Hesperostipa comata	99	0	1	0	0	0	0
	Poa secunda	38	59	3	0	0	0	0
	Pseudoroegneria spicata	61	17	20	2	0	0	0
	Sporobolus cryptandrus	99	1	0	0	0	0	0
Native Persistent Forbs	*Achillea millefolium*	73	27	0	0	0	0	0
	Aster spp	99	1	0	0	0	0	0
	Astragalus spp	83	13	4	0	0	0	0
	Cirsium spp.	99	1	0	0	0	0	0
	Erigeron spp	98	1	1	0	0	0	0
	Eriogonum spp	94	6	0	0	0	0	0
	Lomatium spp	80	20	0	0	0	0	0

Table A-6 (continued). 2018 Blue Basin sampling frame, JODA: percentage of plots (n=151 1 m^2 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 Persistent Forbs (continued)	*Phacelia hastata*	97	3	0	0	0	0	0
	Phacelia spp.	99	1	0	0	0	0	0
Native Other Forbs	*Calochortus* spp.	96	4	0	0	0	0	0
	Cryptantha spp	89	11	0	0	0	0	0
Non-native Invasive Forbs	*Descurainia* spp	98	2	0	0	0	0	0
	Erodium cicutarium	44	44	8	3	1	0	0
	Lepidium perfoliatum	80	17	2	1	0	0	0
	Linaria dalmatica	81	17	1	1	0	0	0
	Salsola kali	87	13	0	0	0	0	0
	Sisymbrium altissimum	48	48	3	1	0	0	0
	Tragopogon dubius	64	33	3	0	0	0	0
	Verbascum blattaria	99	1	0	0	0	0	0
Non-native Invasive Grasses	*Bromus* spp.	85	12	3	0	0	0	0
	Bromus tectorum	1	36	29	17	14	2	1
	Elymus caput-medusae	76	17	2	2	1	2	0
	Poa bulbosa	44	36	11	5	3	1	0
	Ventenata dubia	93	4	1	0	1	1	0

Appendix C

Climate diagrams for (2015-2018) the JODA weather station, near the Blue Basin unit of the John Day Fossil Beds National Monument.

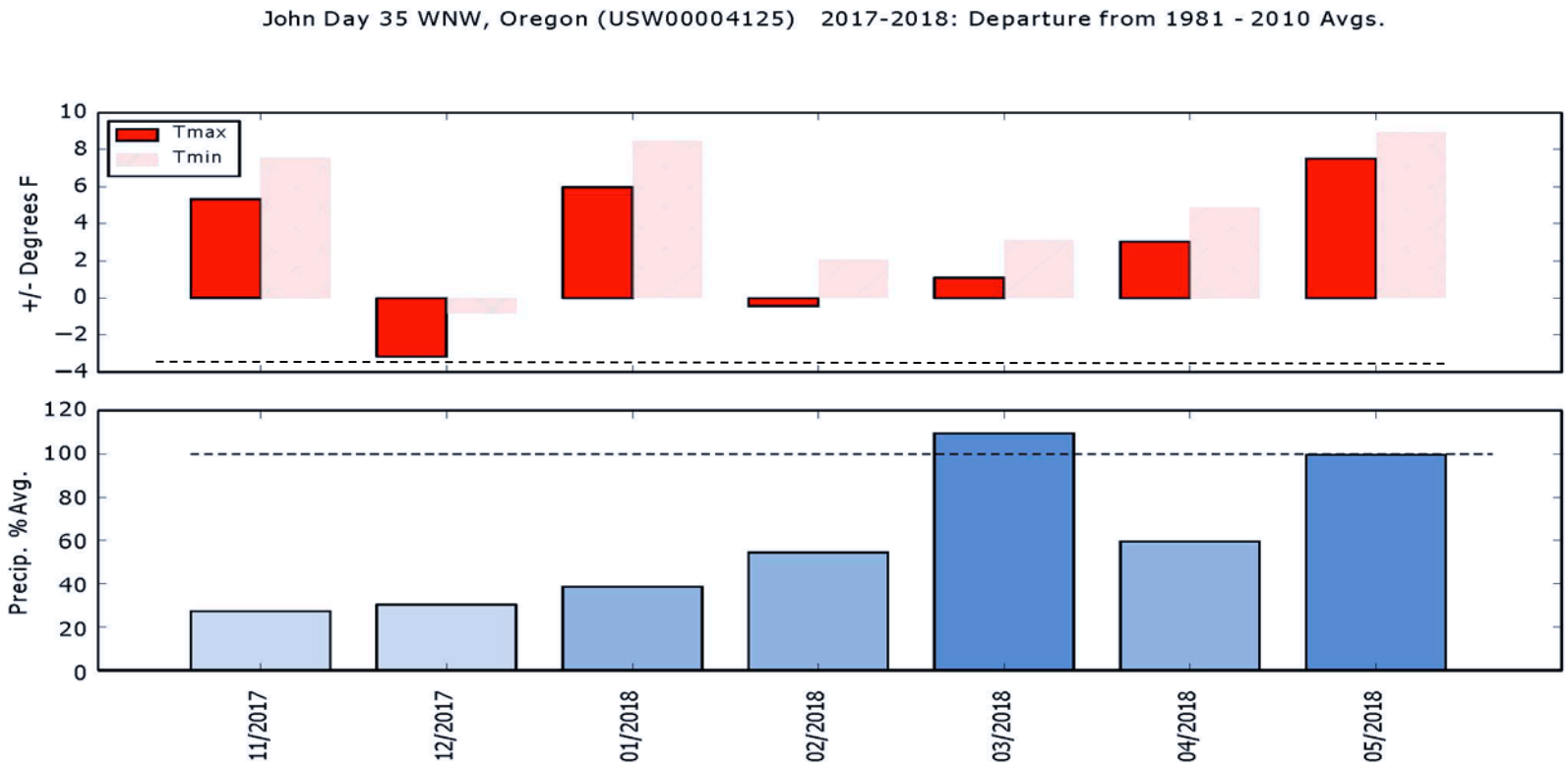

Figure A-1. This figure compares 2018 data to the long-term (30 year) averages of monthly temperatures (red boxes) and monthly precipitation (blue boxes). The dotted black line in the both graphs represents the 30 year average for temperature and precipitation.

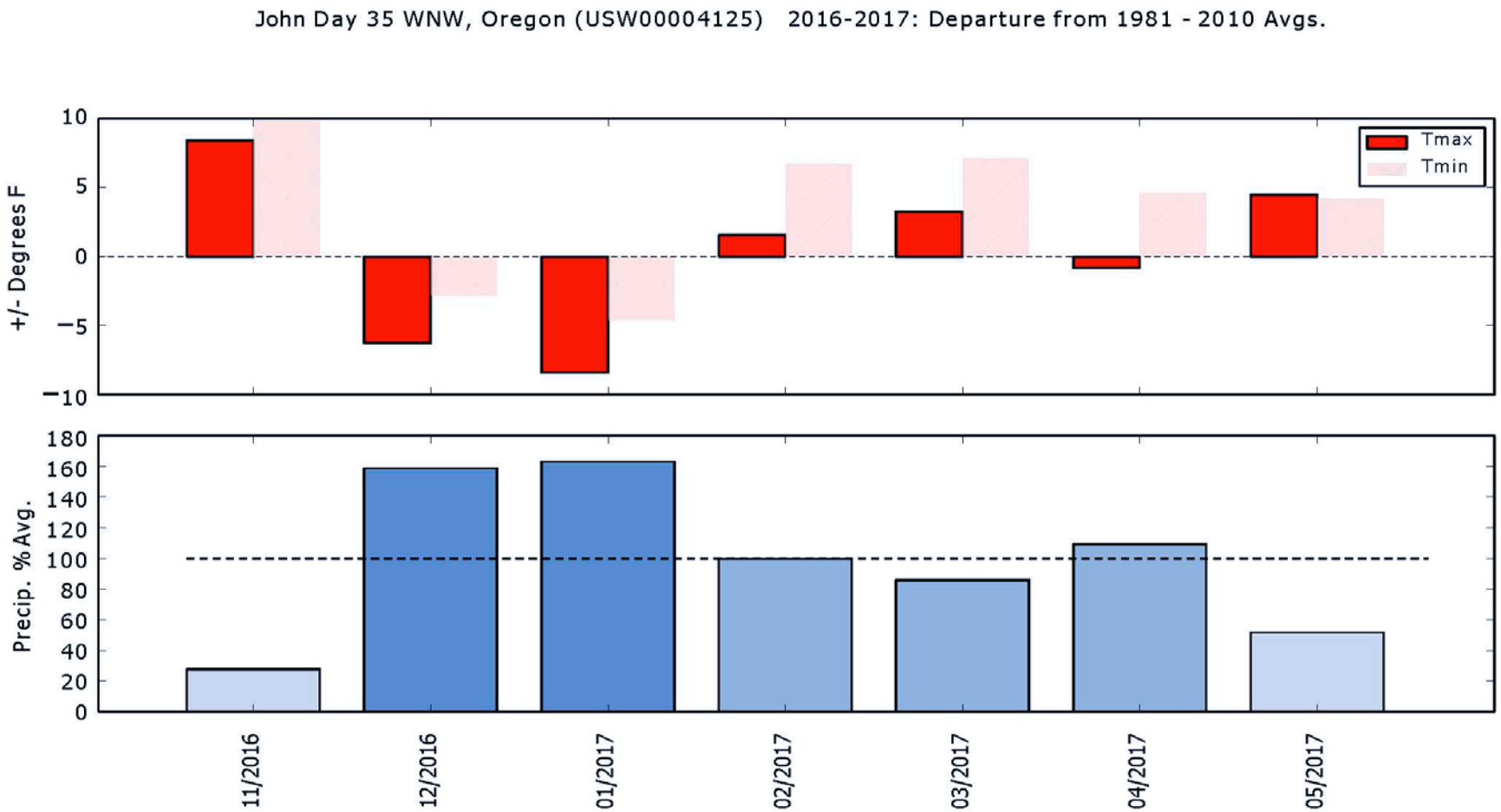

Figure A-2. This figure compares 2017 data to the long-term (30 year) averages of monthly temperatures (red boxes) and monthly precipitation (blue boxes). The dotted black line in the both graphs represents the 30 year average for temperature and precipitation.

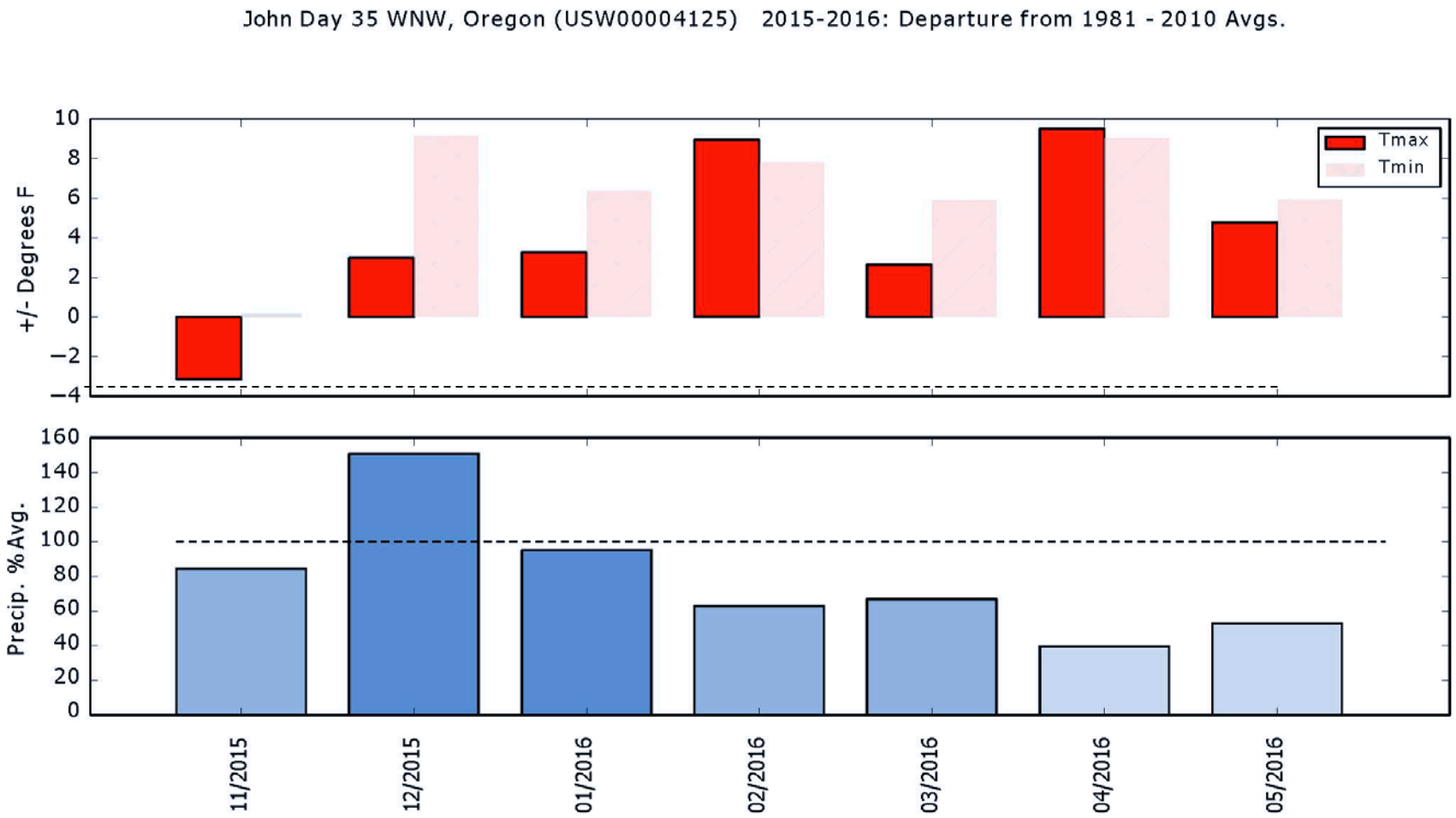

Figure A-3. This figure compares 2016 data to the long-term (30 year) averages of monthly temperatures (red boxes) and monthly precipitation (blue boxes). The dotted black line in the both graphs represents the 30 year average for temperature and precipitation.

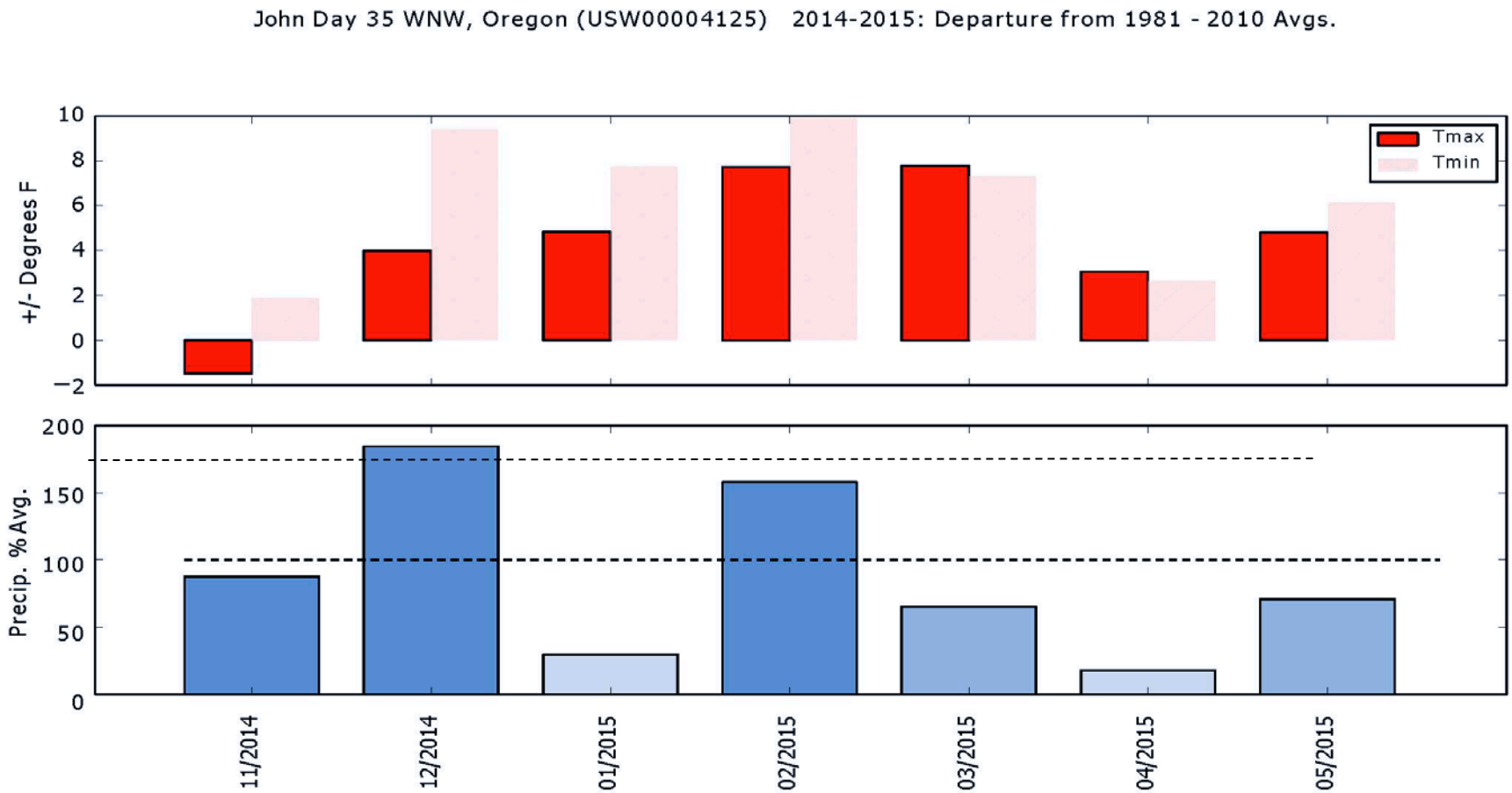

Figure A-4. This figure compares 2015 data to the long-term (30 year) averages of monthly temperatures (red boxes) and monthly precipitation (blue boxes). The dotted black line in the both graphs represents the 30 year average for temperature and precipitation.

Appendix D

Bar graphs comparing 2011-2018 cheatgrass cover estimates in the Blue Basin and Clarno units of John Day Fossil Beds National Monument

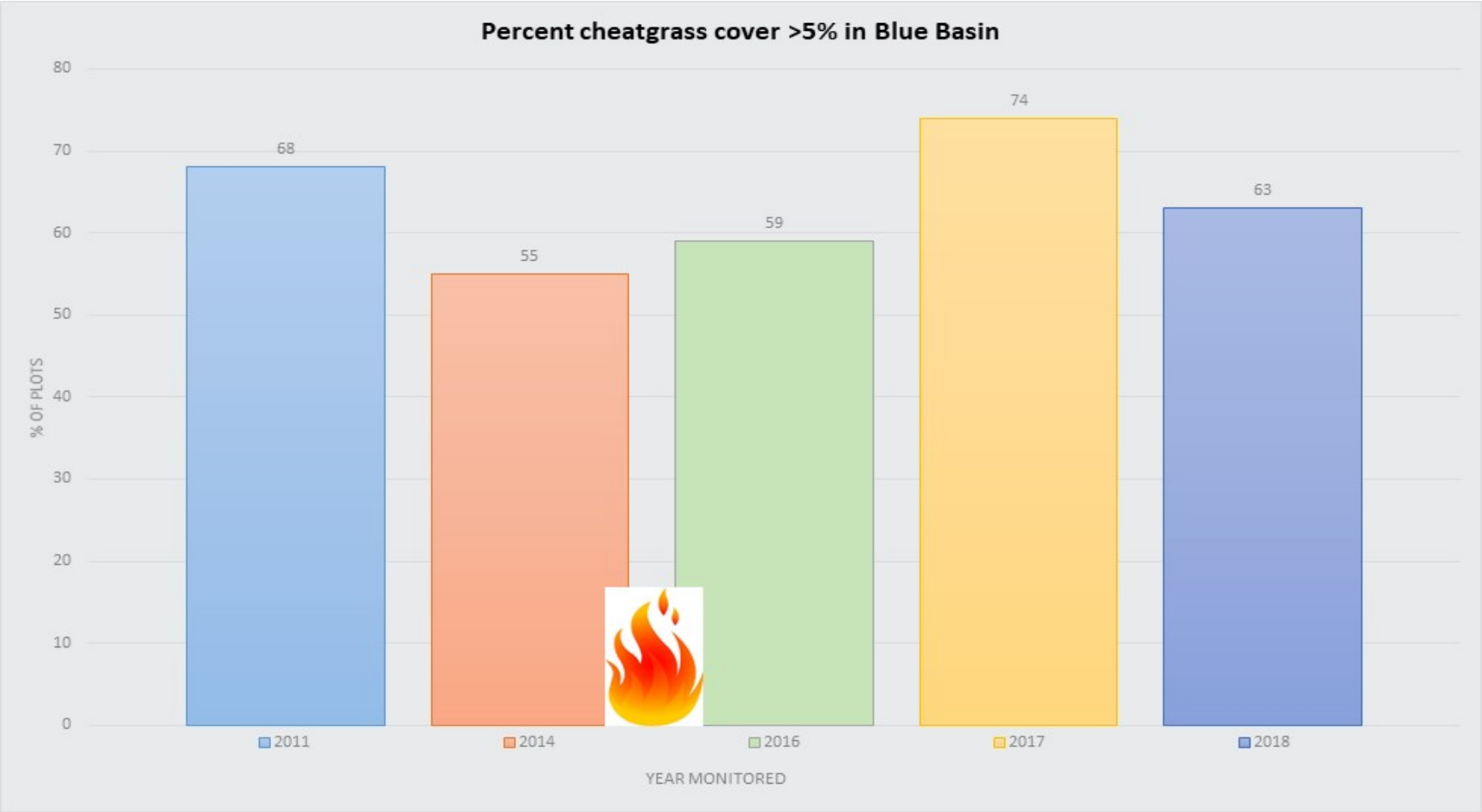

Figure A-5. Estimated percentage of cheatgrass cover (>5%) in the Blue Basin unit of JODA from years 2011-2018.

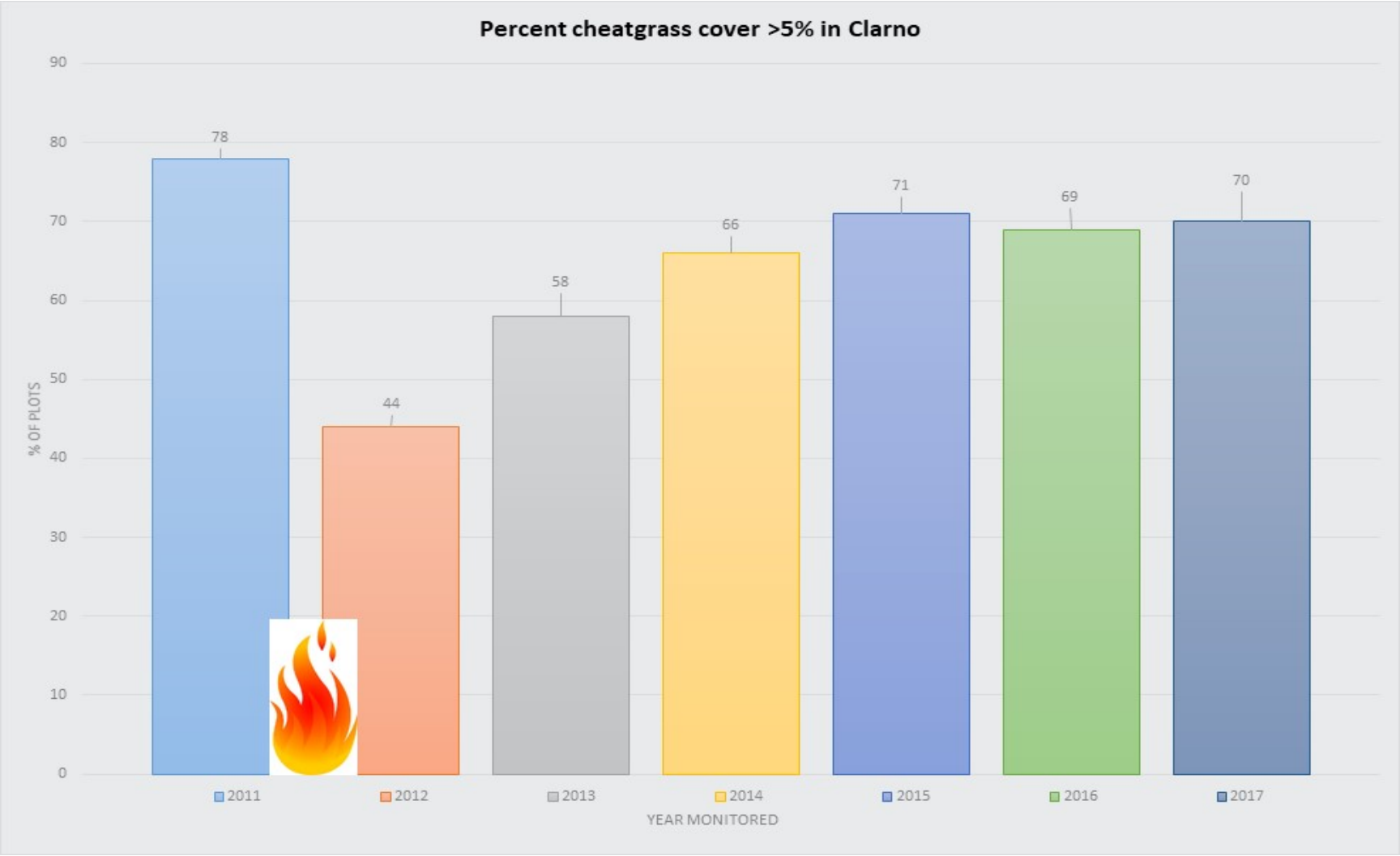

Figure A-6. Estimated percentage of cheatgrass cover (>5%) in the Clarno unit of JODA from years 2011-2017.

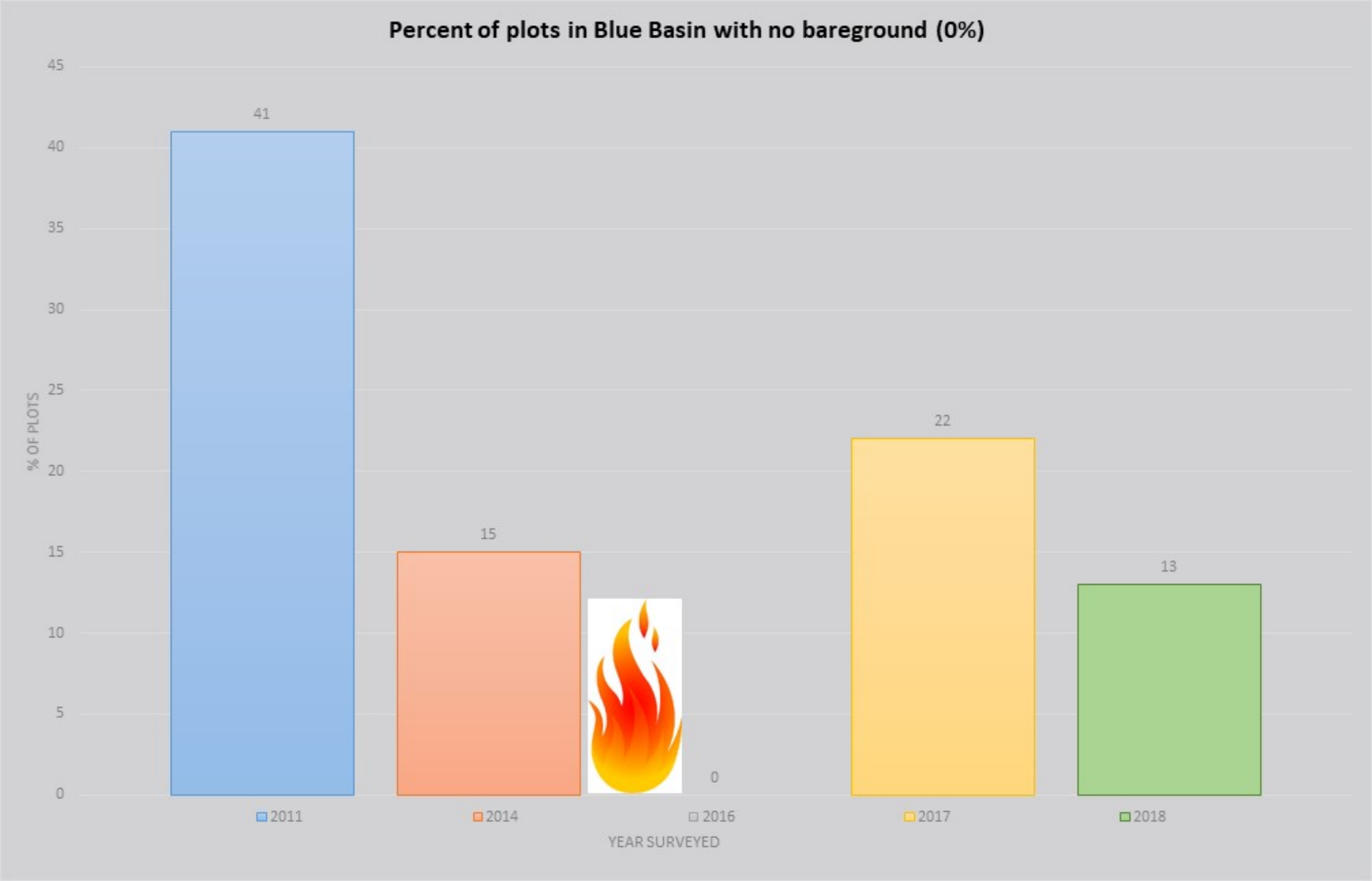

Figure A-7. Estimated percentage of bareground cover (0%) in the Blue Basin unit of JODA from years 2011-2018.

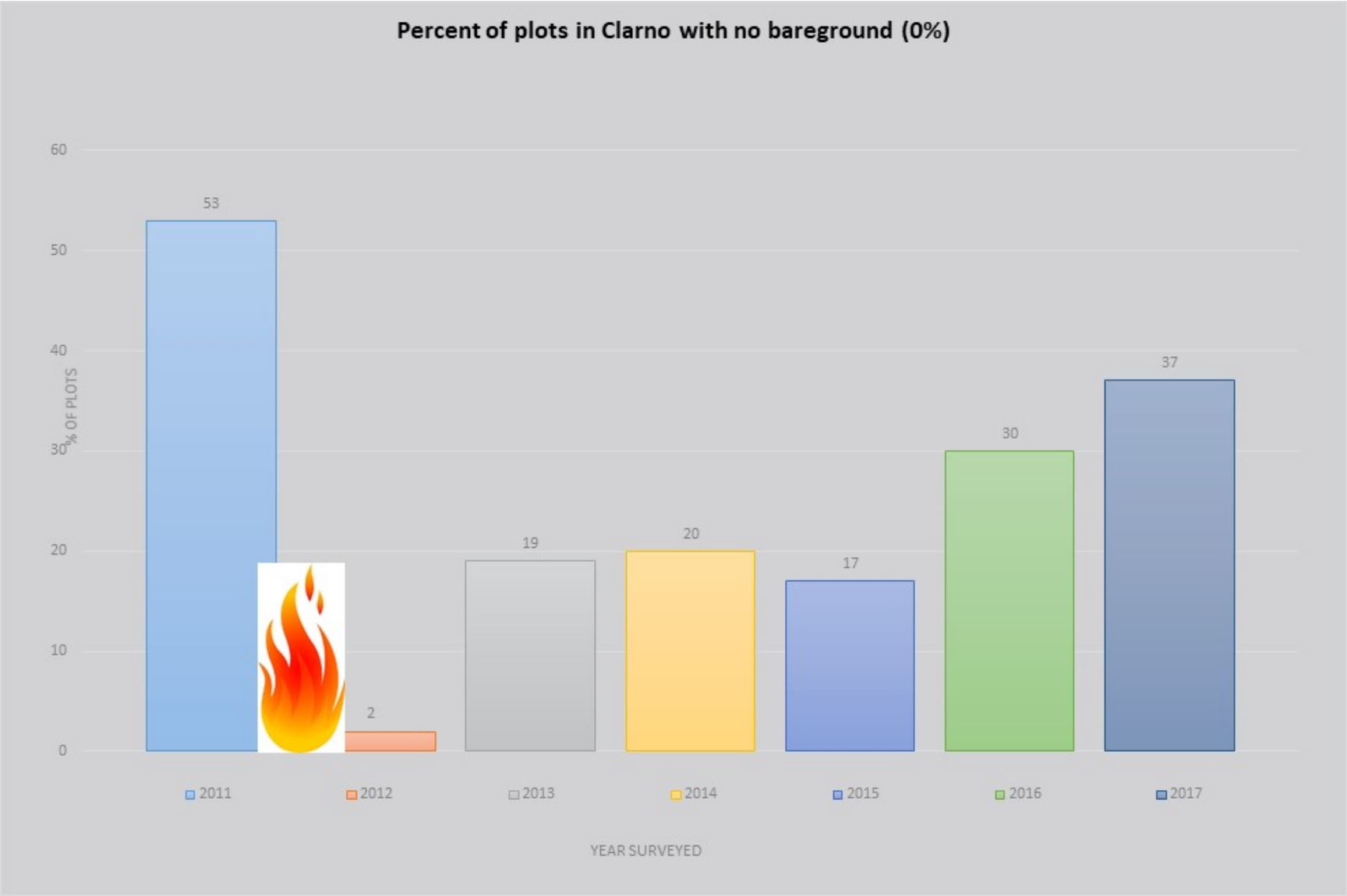

Figure A-8. Estimated percentage of bareground cover (0%) in the Clarno unit of JODA from years 2011-2017.

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National Park Service
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