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Natural Resource Stewardship and Science

Sagebrush Steppe Vegetation Monitoring in the Clarno Unit of the John Day Fossil Beds National Monument

2017 Annual Report

Natural Resource Report NPS/UCBN/NRR—2017/1571

ON THE COVER

Intact native bunchgrass community in the foreground, comprised of bluebunch wheatgrass (*Pseudoroegneria spicata),* Thurber's needlegrass (*Achnatherum thurberianum)* and western juniper (*Juniperus occidentalis*); patches of medusahead (*Elymus caput-medusea*) infested slopes seen in the midground.
Photograph by Alephair Bylund

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This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. 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.

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Abstract

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 2017 within the Clarno Unit of John Day Fossil Beds National Monument (JODA) following methods outlined in the UCBN sagebrush steppe monitoring protocol (Yeo et al. 2009). Cover of exposed soil and of principal native and non-native plants or genera were estimated in 217 1 m^2 quadrats randomly placed throughout the sampling frame. The entire unit has been surveyed in May and June each year since 2011. These survey efforts were outside of the UCBN's 3-year revisit plan, in response to the August 2011 wildfire that swept through the Clarno Unit. Approximately 98% of the vegetated portion of the unit was burned by this fire. Previous wildfires swept the monument in 1985, 1994, and 1995. The entire Monument, including the Clarno Unit, was surveyed during May-June, 2011, as part of the regular 3-year revisit schedule (Yeo and Rodhouse 2012). This created an excellent opportunity to study fire effects in Clarno. This report briefly describes the findings from 2017, and provides some comparisons in the abundances of key principal species of interest with 2011-2016 observations. This report provides some insights into the effects of the fire on the Monument's upland plant communities, a topic of critical importance to park management.

Cheatgrass (*Bromus tectorum*) and medusahead (*Elymus caput-medusae*) species continue to dominate much of the Clarno landscape, and medusahead presents a major threat to the ecological integrity of the unit. Big sagebrush (*Artemisia tridentata*) was not recorded in any of the 2017 plots (n=215), and many areas that once supported sagebrush (i.e., sage habitat category) have remained shrub cover free since the 2011 wildfire. Cover of native bunchgrasses, which define the steppe aspect of sagebrush steppe, has remained at low to moderate cover. Principal native bunchgrasses included in the study were: bluebunch wheatgrass (*Pseudoroegneria spicata*), Sandberg bluegrass (*Poa secunda*), needlegrasses (*Stipa spp.*), and sand dropseed (*Sporobolus cryptandrus*). Bluebunch wheatgrass, a foundation species in the Clarno landscape, was distributed at prefire levels in 2017 compared with initial post fire conditions. Overall, species appeared to have suffered relatively low mortality from the fire (Esposito et al. 2012), with plot cover levels in 2017 at >25% comparable to those prior to the 2011 fire. Native forb cover generally was 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. Filaree (*Erodium cicutarium*), a non-native forb, was widespread, seen at low occurrences nearly ubiquitously throughout the unit, as well as in dense patches in association with medusahead on flat benches. As is typical of the heterogeneous landscape of JODA, some of the Clarno plots represent good range condition although most of the plots indicate degraded conditions.

View of the western side of Clarno Unit, John Day Fossil Beds National Monument—bluebunch wheatgrass and cheat grass in the forefront

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Acknowledgments

We greatly appreciate the assistance of Upper Columbia Basin Network - Inventory and Monitoring team; Tom Rodhouse, ecologist, and Devin Stucki, botanist, for their guidance and resources throughout this project. We would also like to thank Matt Shinderman, Director of the HERS Lab at OSU-Cascades, for his instruction over the course of our vegetation studies. The Hancock Field Station provided food and lodging.

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 the UCBN 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 2017, the sixth year of post-fire surveys following the August 2011 fire that burned 98% of the Clarno Unit of the John Day Fossil Beds National Monument. The report discusses trends for a subset of species since the 2011 fire and reflects on management implications of those trends.

Study Area and Methods

Within Clarno, the extent of potential sagebrush steppe communities was mapped using recent soil and vegetation maps (Yeo et al. 2009). This extent was then divided into 3 strata based on NRCS ecological site descriptions and expected late succession vegetation. These strata were used for sampling during prior years (Yeo and Rodhouse 2012, Esposito et al. 2012). However, following surveys in 2011 and 2012, it became clear that the spatial error of the NRCS data was such that strata were not meaningful, and did not confer homogeneity to plots within strata nor reduce variance. In 2013-2017, an unstratified sample was drawn from the frame (Figure 1). The sample design used across all years was the Generalized Random Tessellation Stratified Design that produces spatially-balanced dispersion of sample units (Stevens and Olsen 2004). The overall footprint of the sampling frame did not change. Sample design weights will be used to account for the change from stratified to unstratified sampling in model-based trend analyses (e.g., Irvine et al. 2016).

Sampling procedures followed Yeo et al. (2009). At each plot location (Figure 1), a 1 m^2 quadrat frame was set up and within that frame the cover of exposed bare ground and principal native plants and non-native invasive plants were estimated visually using 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 common names and their scientific names are listed in Appendix A.

Weather

Weather data was extracted from the North Pole Ridge RAWS (Remote Automated Weather Station) roughly 12 miles northwest of the Clarno Unit. Precipitation was greater in the spring (March-June) of 2017 than in the four years previous, although not significantly greater than 2013, 2014, and 2016. In 2015, spring precipitation was well below average and may have contributed to cover class distributions in that and subsequent years, as discussed further below. A graphical representation of the temperature and precipitation data is in Appendix B.

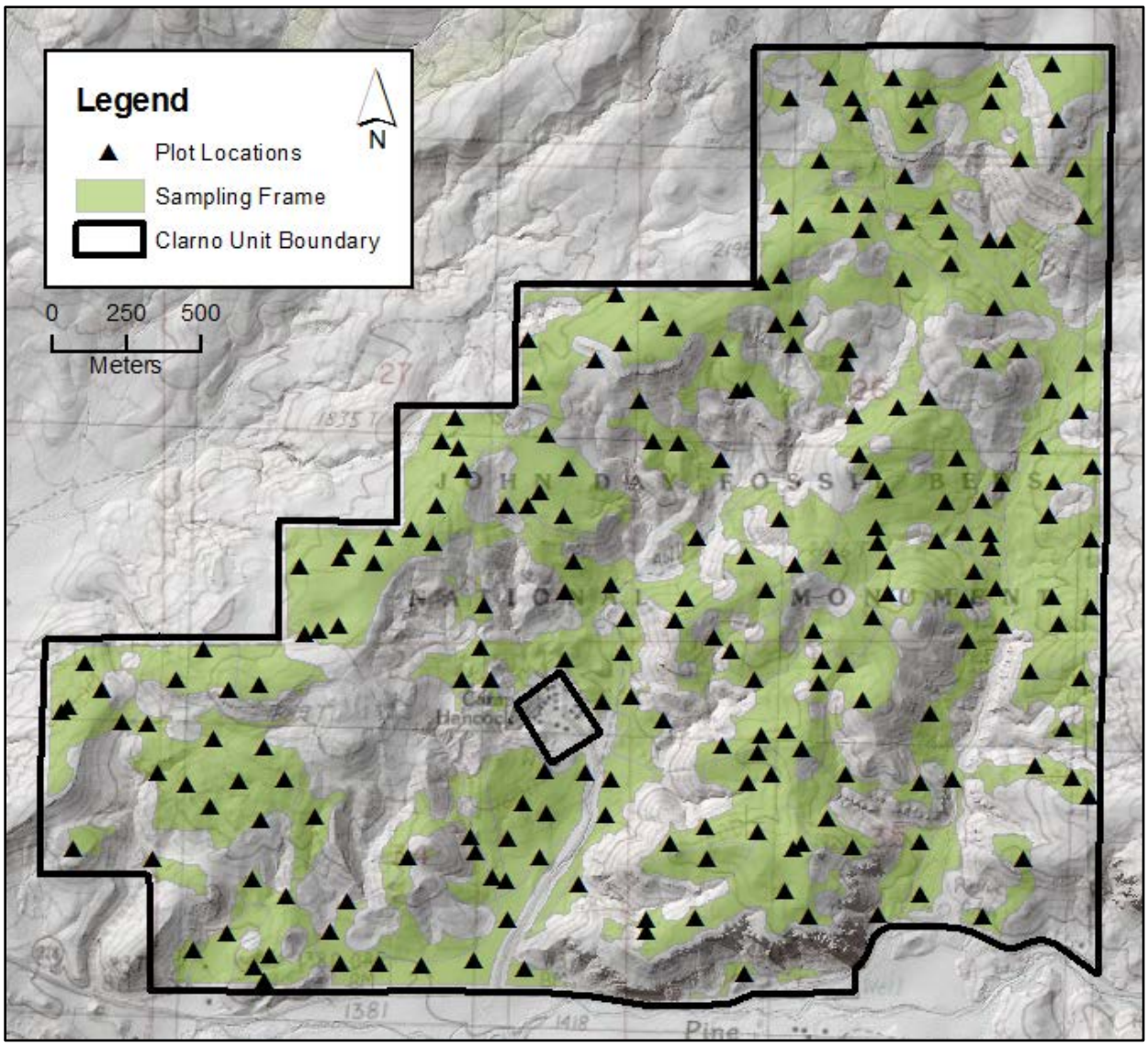

Figure 1. Map of Clarno Unit with 2017 study site plots shown.

Results

Bare Ground and Native Vegetation

A total of 217 plots identified in the sampling design were measured from June 5-7, 2017 (Table 1). The previous winter saw above average snowfall and low temperatures preserved an uncharacteristic amount of snow on the ground well into March (Appendix B). Relative absence of bare ground appears to be making a return toward pre-fire conditions; the proportion of plots with no bare ground (0% cover) fell from 52.6% in 2011 to only 2.2% in 2012 (Figure 2). That figure has been steadily rising, and 36.9% of all plots measured in 2017 had no bare ground (Table 1). Some of the least invaded sites in the Clarno Unit were located on north-facing slopes in Hancock and Indian canyons. It may be difficult to use the bare ground cover trend as it relates to native bunchgrass cover for indicating ecological condition, as such a metric would be skewed by the relative lack of bare ground cover on the aforementioned north-facing slopes. Where interstices between bunchgrasses on these slopes were largely devoid of non-native grasses, intact cryptobiotic soil crust communities were common, but the crust cover was not quantified (Figure 3).

Shrub cover remains essentially zero, with the exception of broom snakeweed, a species that resprouts after fire, since the fire in 2011 (Table 2). Antelope bitterbrush was found in only one plot, and big sagebrush was not found at all within the plots for the third consecutive year (Table 1). Broom snakeweed presence appears to be gradually increasing after the fire; in 2017, the proportion of plots with at least some broom snakeweed (>0%) had nearly quadrupled since 2012 (Table 2).

Sandberg bluegrass, needlegrasses, and bluebunch wheatgrass continue to be the most abundant native perennial grasses in the unit (Table 1). Bluebunch wheatgrass appears to have recovered to pre-fire levels, with 2017 occurrences exceeding the >25% cover classes observed in 2011 (Figure 4 and Table 3).

Table 1. Summary of the cover class percentages of the principal and most common native and nonnative species in the Clarno Unit that were encountered in survey plots.

Cover Class	Species	0%	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95%
Bare ground	–	80	119	16	2	0	0	0
Sagebrush	*Artemisia tridentata*	217	0	0	0	0	0	0
Shrubs	*Gutierrezia sarothrae*	184	24	6	2	1	0	0
	Purshia tridentata	216	0	1	0	0	0	0
Native perennial grasses	*Achnatherum spp*	128	36	41	12	0	0	0
	Festuca idahoensis	215	0	1	1	0	0	0
	Poa secunda	105	82	28	2	0	0	0
	Pseudoroegneria spicata	117	23	44	28	5	0	0
	Sporobolus cryptandrus	202	11	4	0	0	0	0

Table 1 (continued). Summary of the cover class percentages of the principal and most common native and nonnative species in the Clarno Unit that were encountered in survey plots.

Cover Class	Species	0%	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95%
New persistent forbs	*Astragalus* spp	173	28	13	3	0	0	0
	Dalea ornata	200	10	5	2	0	0	0
	Eriogonum spp	184	32	1	0	0	0	0
	Lomatium spp	187	29	1	0	0	0	0
Non-native invasive grasses	*Bromus* spp	119	83	8	7	0	0	0
	Bromus tectorum	2	64	35	51	46	17	2
	Elymus caput-medusae	77	77	8	12	16	24	3
	Poa bulbosa	188	24	5	0	0	0	0
Non-native invasive forbs	*Erodium cicutarium*	108	65	35	9	0	0	0
	Lepidium perfoliatum	203	9	4	1	0	0	0
	Tragopogon dubius	191	26	0	0	0	0	0

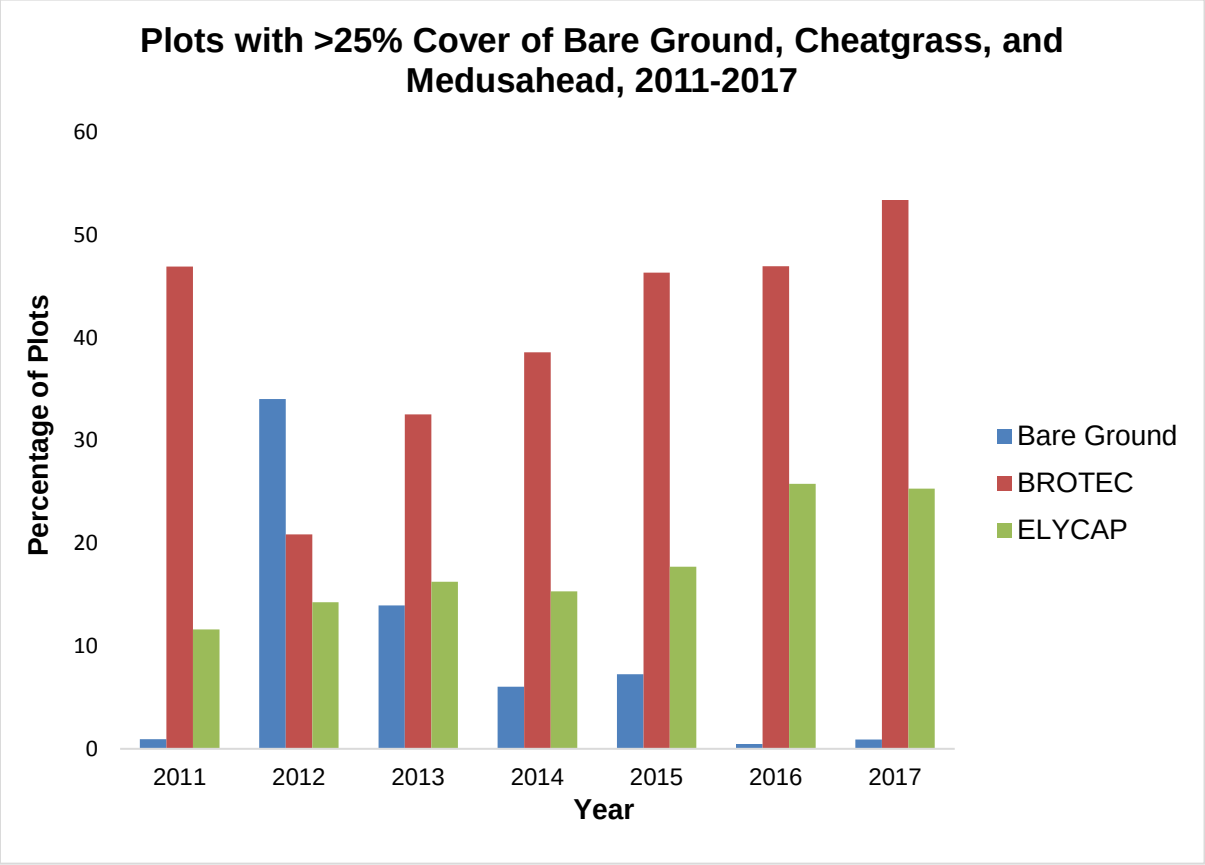

Figure 2. Depiction of the proportion of plots found with >25% cover of bare ground, cheatgrass, and medusahead from since 2011.

Figure 3. Close-up image of interstices typical of a relatively intact native bunchgrass stand on a north-facing slope in Hancock Canyon, central Clarno Unit. Medusahead, cheatgrass, and other non-native bromes were present, but most of this sample quadrat was comprised of bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue, and cryptobiotic soil crusts (not measured).

Table 2. Summary of bluebunch wheatgrass cover in the Clarno Unit from 2011 (one year pre-fire) to 2017 (six years post-fire).

Bluebunch wheatgrass (PSESPI) cover	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Total acreage sampled	988	988	988	988	988	988	988
Percentage of plots with no PSESPI	59.5	53.8	52.6	52.6	51.4	65.4	53.9
Percentage of plots with PSESPI	40.5	46.2	47.4	47.4	48.6	34.6	46.1
Percentage of plots with >25% PSESPI	14.9	9.9	8.8	14.4	17.7	12.0	15.2

Table 3. Trend in proportion of plots with broom snakeweed presence (>0% cover) since 2011.

Year	Percent
2011	32.6
2012	4.4
2013	9.3
2014	10.2
2015	13.2
2016	12.9
2017	15.2

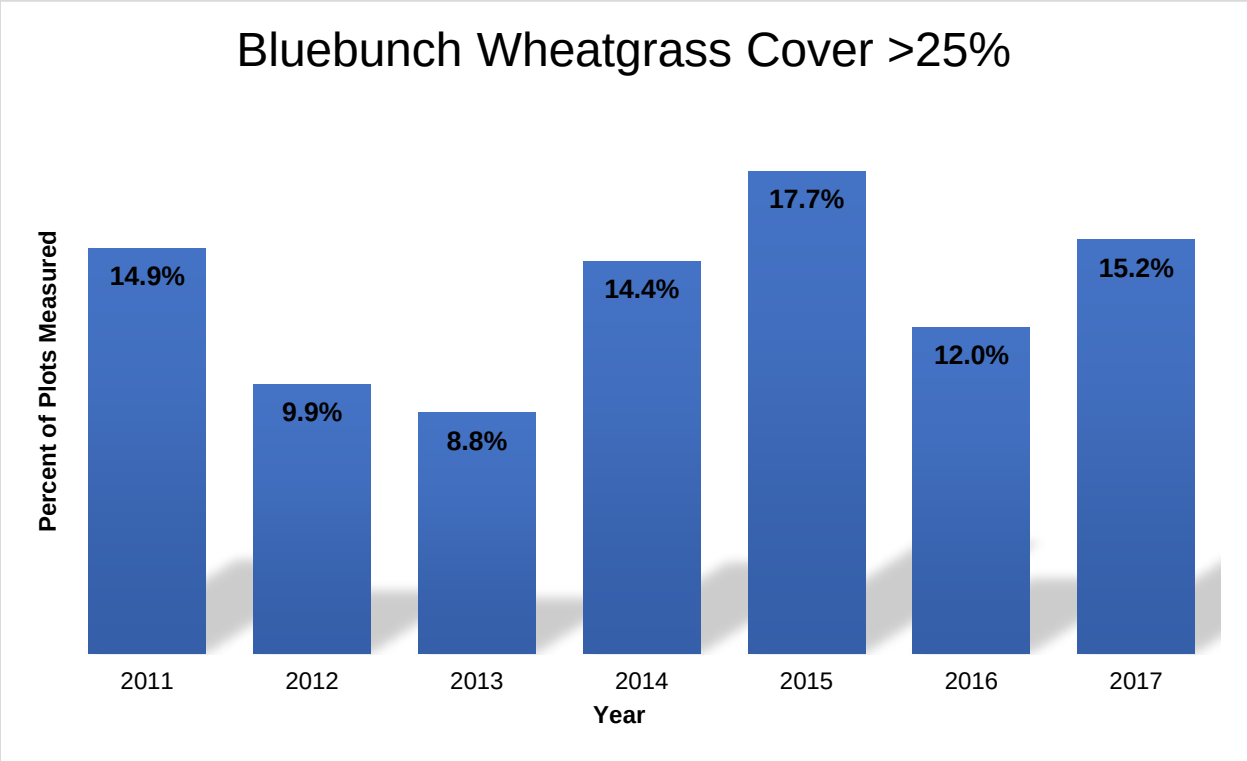

Figure 4. Percentage of sample frames that were estimated to have >25% bluebunch wheatgrass cover.

Non-native Vegetation

Although many native species have been increasing in abundance since the fire in 2011 – some equal to or above pre-fire levels (e.g., Figure 4) – they are being generally outpaced by invasive annual grasses. Cheatgrass and medusahead are, by far, the most abundant and rapidly increasing non-native species in the Clarno Unit (Figures 2, 5, 6 and Table 4). Cheatgrass was found in 99.1% of all plots in 2017 (Table 1), steadily increasing in ubiquity since 2011, when it was found in 92.6% of all plots (Figure 5). Occurrences of heavy infestation (>50% cover) are rising in both species but medusahead is especially troubling, having essentially tripled since 2011 (Figure 2 and Table 4). Given that bluebunch wheatgrass, the dominant native species in the Clarno Unit, is again occurring at rates similar to pre-fire conditions, cheatgrass and medusahead appear to be filling in gaps once occupied by bare ground and, potentially, cryptobiotic soil crusts (Figure 3). Bulbous bluegrass, non-native bromes, filaree, and salsify are also increasing in both frequency and abundance (Table 1). For the first time since monitoring began in 2011, occurrences of filaree in Clarno surpassed 50% of all plots in 2017 (Table 1).

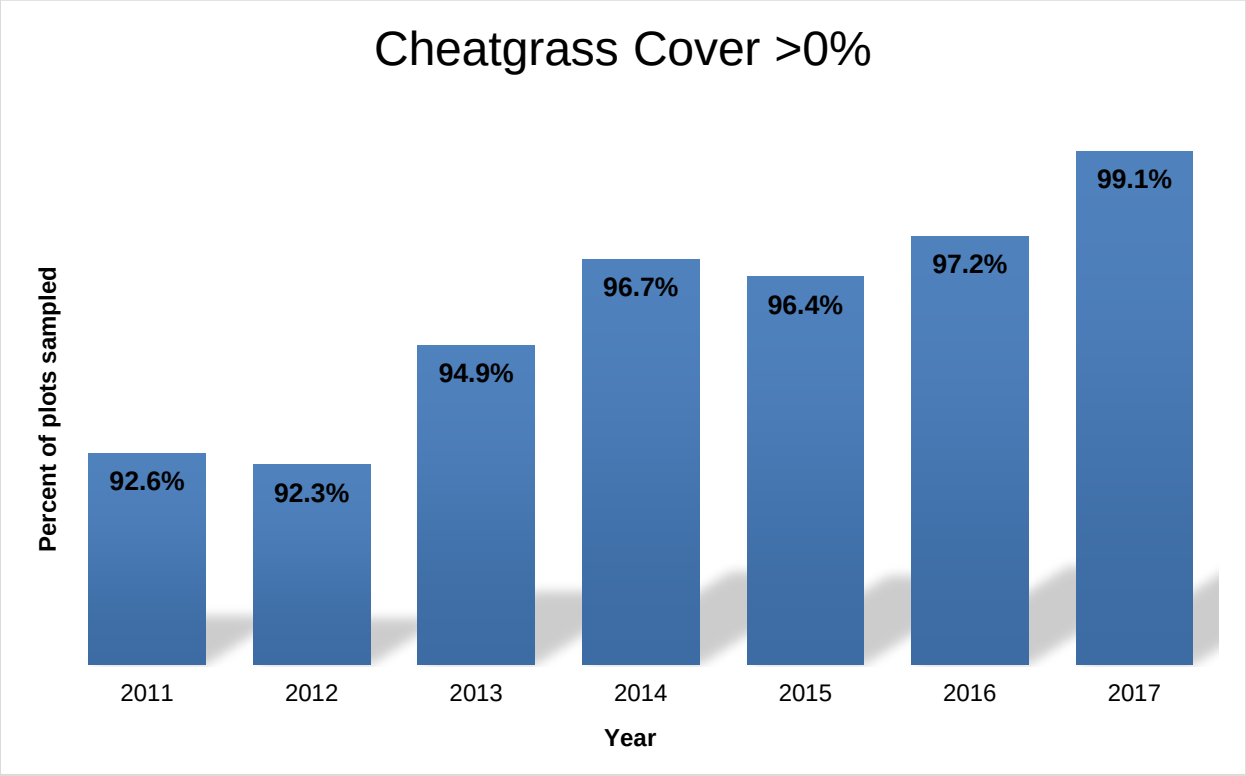

Figure 5. Percent of all sample frames (n=215) in which at least some cheatgrass was found. A steady increase in cheatgrass ubiquity appears to be occurring in the Clarno Unit from years 2011-2017.

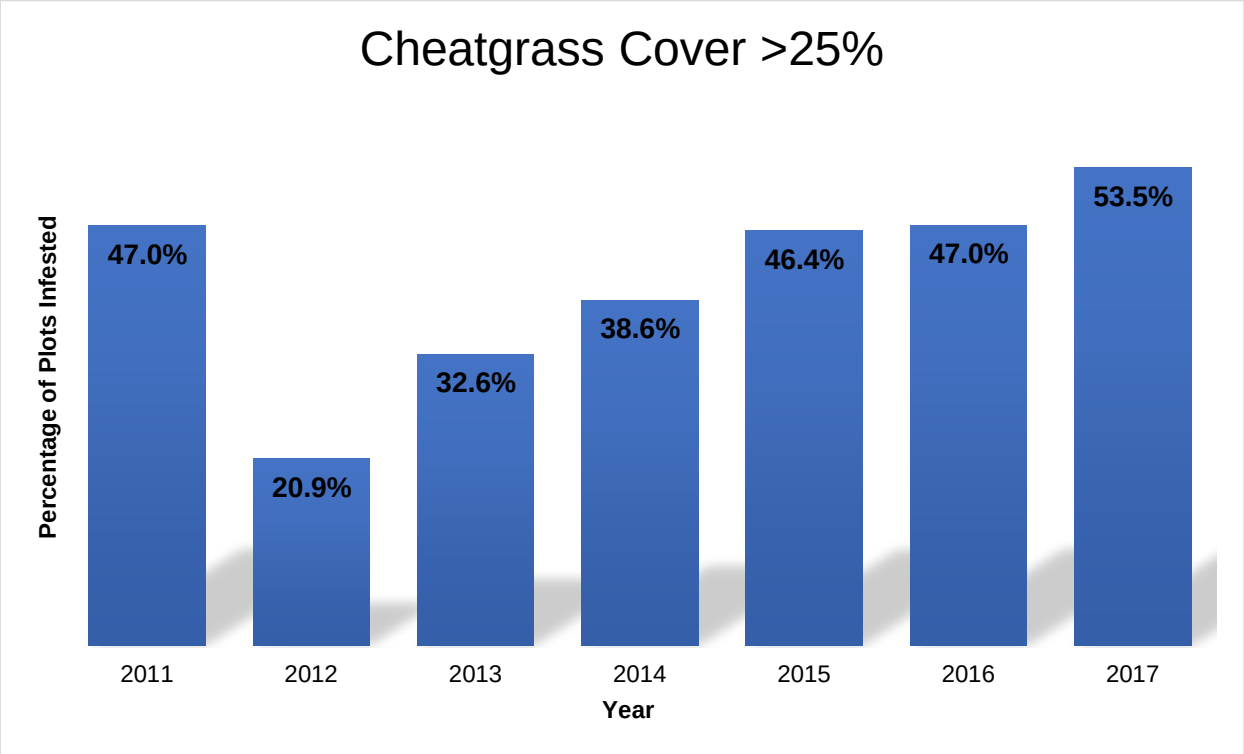

Figure 6. Percent of all sample frames (n=215) in which the Daubenmire cover class for cheatgrass was >25%.

Table 4. Summary of medusahead infestation, 2011-2017.

Medusahead (ELYCAP) cover	2011	2012	2013	2014	2015	2016	2017
Percentage of plots with no ELYCAP	34.4	42.9	34.4	48.8	43.6	58.1	64.5
Percentage of plots with >25% ELYCAP	11.6	14.3	16.3	15.3	17.7	25.8	25.3
Percentage of plots with >50% ELYCAP	7.0	6.6	9.8	12.1	13.2	21.7	19.8

Discussion

Since the 2011 fire in the Clarno unit of the John Day Fossil Beds National Monument, shifts in bare ground cover, plant community composition, and individual species abundance have been monitored and mapped annually to track establishment rates and interpret any patterns exhibited. After six years of post-fire monitoring, it is now apparent that bluebunch wheatgrass, the primary foundational native bunchgrass occurring in this region, has returned to pre-fire abundance levels. The non-native species, particularly cheatgrass and medusahead, have exhibited increases in frequency and abundance. The least invaded sites appear to be on north-facing slopes, where bluebunch wheatgrass populations are most intact. Non-native annual grasses are rapidly invading areas previously comprised of bare ground, and into other interstitial spaces that, without the influence of invasives, would likely be occupied by native forbs following a fire (Kerns & Day, 2017). These findings from Clarno are consistent with park-wide patterns of post-fire losses to fire (Reed-Dustin et al. 2016, Rodhouse et al. 2014)

The intensity of establishment of non-native annual grasses in conjunction with the trending decline of native forb species at the Clarno unit is of particular concern for management. Additional research would need to be conducted 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 will be further reduced. Additionally, the influx in fuels generated from higher rates of cheatgrass and medusahead growth promotes an undesirable positive feedback loop favoring annual grass establishment and cyclical burning, while continuing to intensify and expand the negative impacts of non-native plant communities (Brummer et al., 2016). As these shifts in species composition occur, the functionality of the entire ecosystem becomes fragmented and its ability to successfully deliver ecosystem services and support wildlife is 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 Parks Service at the Clarno unit of the John Day Fossil Beds National Monument, the establishment of a strict program to mitigate further losses of ecological diversity is warranted. Although technically and logistically difficult to achieve, the effort to promote more native species in the re-establishment phase of post-fire landscapes, while mitigating annual grass establishment would have positive impacts on the ecological health of the region (Hoh et al. 2015). Furthermore, research suggests that management for healthy pre-fire conditions in sagebrush communities has a large influence over the post fire germination response (Ellsworth & Kauffman, 2013). If more rigorous preventative management was implemented (e.g., Hoh et al. 2015, Rodhouse et al. 2014), these strategies could be used as a guide or starting point for other park managers at their own sites in the future. Special care should be taken to reduce the impacts of invasive species in sagebrush grassland ecosystems, and reseeding efforts should also be approached carefully. Targeted aerial reseeding has seen positive results in post-fire restoration (Floyd, Hanna, Romme, & Crews,

2006), though special attention should be given to protect against contaminated seed banks as they can exacerbate invasive establishment (Getz & Baker, 2008).

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Appendix A: List of plant species encountered in the John Day Fossil Beds National Monument

Table 5. Plant common and scientific names.

Lifeform	Common name	Species name
Sagebrush	Low sagebrush	*Artemisia arbuscula*
	Scabland sagebrush	*Artemisia rigida*
	Big sagebrush	*Artemisia tridentata*
Other Shrubs	Shadscale	*Atriplex* spp
	Curl-leaf mountain mahogany	*Cercocarpus ledifolius*
	Green rabbitbrush	*Chrysothanmus viscidiflorus*
	Grey rabbitbrush	*Ericameria nauseosus*
	Broom snakeweed	*Gutierrezia sarothrae*
	Bitterbrush	*Purshia tridentata*
	Purple sage	*Salvia dorrii*
	Greasewood	*Sarcobatus vermiculatus*
	Grey horsebrush	*Tetradymia canescens*
Native Grasses	Wheatgrass	*Agropyron* spp
	Basin wildrye	*Elymus cinereus*
	Idaho fescue	*Festuca idahoensis*
	Indian ricegrass	*Achnatherum hymenoides*
	Sandberg's bluegrass	*Poa secunda*
	Bluegrass	*Poa* spp
	Bluebunch wheatgrass	*Pseudoroegneria spicata*
	Squirreltail	*Elymus elymoides*
	Sand dropseed	*Sporobolus cryptandrus*
	Needlegrass	*Stipa* spp
Persistent Native Forbs	Yarrow	*Achillea millefolium*
	Pussytoes	*Antennaria* spp
	Lava aster	*Aster scopulorum*
	Milk-vetch	*Astragalus* spp
	Arrowleaf balsamroot	*Balsamorhiza sagittata*
	Indian paintbrush	*Castilleja* spp
	Native thistle	*Cirsium* spp
	Tapertip hawksbeard	*Crepis acuminata*
	Blue Mountain prairie clover	*Dalea ornata*
	Daisy	*Erigeron* spp
	Buckwheat	*Eriogonum* spp
	Western stoneseed	*Lithospermum ruderale*
	Desert parsley	*Lomatium* spp

Table 5 (continued). Plant common and scientific names.

Lifeform	Common name	Species name
Persistent Native Forbs (cont.)	Lupine	*Lupinus* spp
	Prickly pear cactus	*Opuntia polyacantha*
	Penstemon	*Penstemon* spp
	Phacelia	*Phacelia* spp
	Phlox	*Phlox* spp
	Orange globe mallow	*Sphaeralcea munroana*
Other Native Forbs	Agoseris	*Agoseris* spp
	Onion	*Allium* spp
	Rockcress	*Arabis* spp
	Douglas' brodiaea	*Brodiaea douglasii*
	Mariposa lily	*Calochortus* spp
	Cryptantha	*Cryptantha* spp
	Larkspur	*Delphinium* spp
	Bitterroot	*Lewisia rediviva*
	Woodland-star	*Lithophragma* spp
	Stonecrop	*Sedum lanceolatum*
Invasive Grasses	Crested wheatgrass	*Agropyron cristatum*
	Cheatgrass	*Bromus tectorum*
	Medusahead	*Taeniatherum caput-medusae*
	Bulbous bluegrass	*Poa bulbosa*
	Kentucky bluegrass	*Poa pratensis*
Invasive Forbs	Russian knapweed	*Acroptilon repens*
	Whitetop	*Cardaria draba*
	Diffuse knapweed	*Centaurea diffusa*
	Spotted knapweed	*Centaurea maculosa*
	Yellow star thistle	*Centaurea solstitialis*
	Tansy mustard	*Descurainia* spp.
	Filaree	*Erodium cicutarium*
	Leafy spurge	*Euphorbia esula*
	Dalmation toadflax	*Linaria dalmatica*
	Scotch thistle	*Onopordum acanthium*
	Tumble mustard	*Sisymbrium altissimum*
	Common salsify	*Tragopogon dubius*

Appendix B: Climogram near Clarno, OR, January 2011 through June 2017

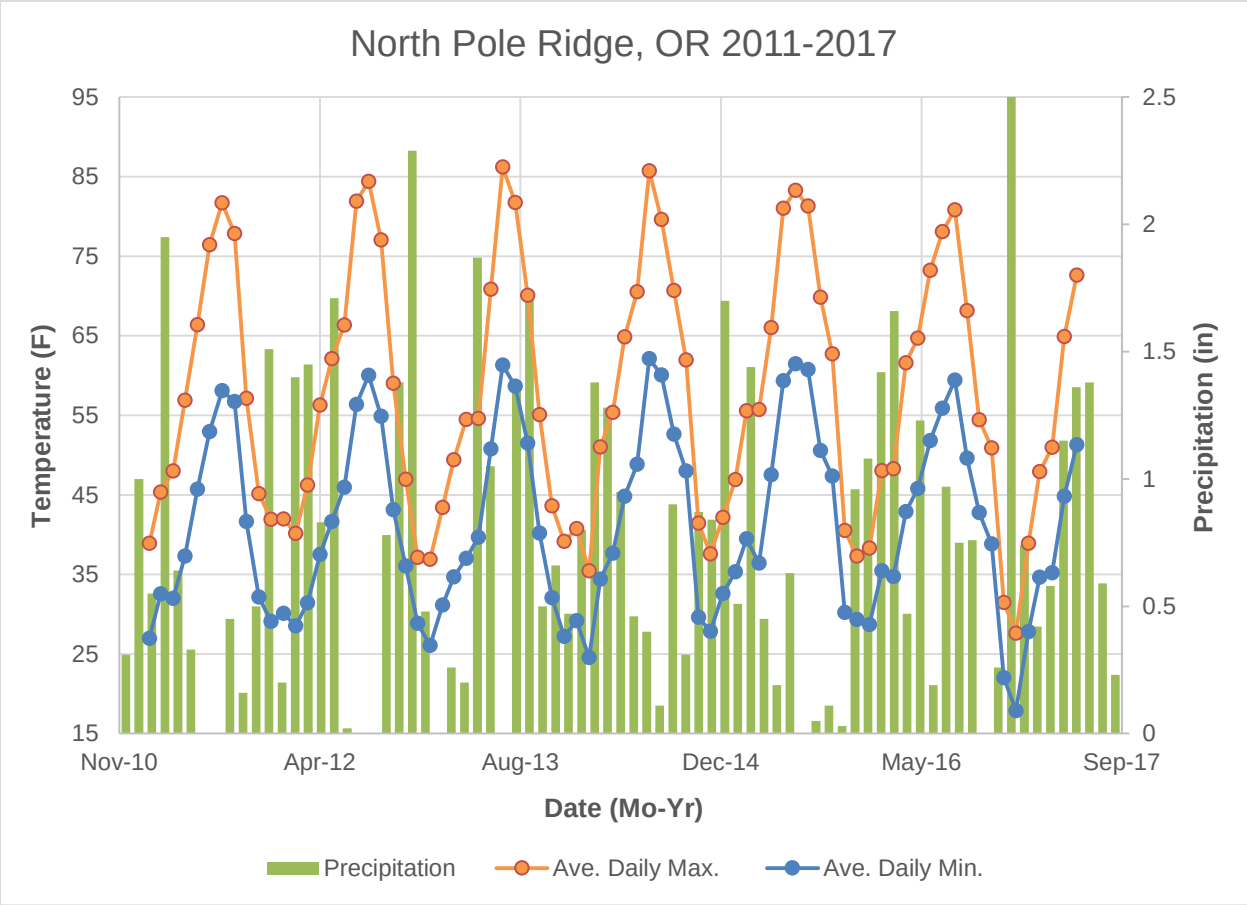

Figure 7. This chart depicts average daily minimum/maximum temperatures for each month and monthly precipitation totals between January 2011 and June 2017. Data gather by the North Pole Ridge RAWS, about 12 miles northwest of the Clarno Unit.

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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