National Park Service
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Natural Resource Stewardship and Science

Upland Vegetation Monitoring in Bighorn Canyon National Recreation Area

2012 Data Summary

Natural Resource Data Series NPS/GRYN/NRDS—2013/469

ON THE COVER
Sagebrush steppe in the south district of Bighorn Canyon NRA
NPS photo

Upland Vegetation Monitoring in Bighorn Canyon National Recreation Area

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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. This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

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Contents

Figures

Page

Figures (continued)

Page

Figures (continued)

Page

Tables

Page

Tables (continued)

Page

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Introduction

This annual report summarizes results from sagebrush steppe and woodland monitoring at Bighorn Canyon National Recreation Area (Bighorn Canyon). Summarized fieldwork was completed in 2012 by the Greater Yellowstone Inventory & Monitoring Network (GRYN). Sagebrush steppe and woodland communities are emphasized for long-term monitoring due to their importance as wildlife habitat in arid and semi-arid environments. Results from 2012, the second year of data collection, provided important information regarding the sample design, which aided in the final development of the GRYN Upland Vegetation Monitoring Protocol (Tercek et al. 2013).

In Bighorn Canyon, sagebrush steppe is a shrubland community comprised of a mix of Wyoming big sagebrush (*Artemisia tridentata* var. *wyomingensis*) and black sagebrush (*Artemisia nova*) with patches of grasslands dominated by bluebunch wheatgrass (*Pseudoroegneria spicata*). Adjacent woodland communities are composed of Utah juniper (*Juniperus osteosperma*) and curl-leaf mountain-mahogany (*Cercocarpus ledifolius* var. *ledifolius*). These upland communities are among the most common vegetation types in Bighorn Canyon and occur on over 60% of the land area inside the park (Knight et al. 1987).

Utah juniper and curlleaf mountain-mahogany are important cover and shelter species for several large mammals, including mule deer (*Odocoileus hemionus*), bighorn sheep (*Orvis canadensis*), wild horses (*Equus caballus*) (BLM 2009) and mountain lion *Puma concolor*). Curlleaf mountain-mahogany is also good forage for many species of browsing animals in both summer and winter. Its highly nutritional leaves and stems provide protein to wintering big game animals (Gucker 2006). Utah juniper is used by many birds and mammals, both wildlife and livestock, for cover and food (Zlatnik 1999). Sagebrush steppe provides habitat for ungulates and sagebrush obligate birds such as the sage sparrow (*Amphispiza belli*) and Brewer's sparrow (*Spizella breweri*), which often require stands of specific density for successful nesting to occur.

These vegetative communities occur on habitats that are characterized by deep, steep-walled canyons, isolated grassy plateaus, extremely rocky, shrub-dominated foothill slopes and benches above the main canyon formed by the Bighorn River. Many of the sample frames used for monitoring sagebrush communities are in proximity to important habitat features such as water and/or steep walled cliffs used as escape habitat for bighorn sheep.

The south district of Bighorn Canyon is influenced by past and present grazing, fire, and by more recent climatological changes. Prior to the establishment of the national recreation area in 1967, several large cattle ranches operated in the area and cattle grazing is still permitted adjacent to the road that passes through the National Recreation Area (NRA) and in two holding pastures located within Bighorn Canyon. Wild horses roam freely in the Pryor Mountain Wild Horse Range (PMWHR) and several areas in the south district have degraded and are invaded by cheatgrass (*Bromus tectorum*; Ricketts et al. 2004, BLM et al. 2008). Juniper communities have significantly expanded since settlement of the western United States (U.S.). Several factors have contributed to this expansion, and we have anecdotal evidence suggesting that densities of juniper within the park are increasing (NPS 2009). Decreases in annual precipitation also favor juniper expansion

because junipers compete more efficiently for soil moisture than do herbaceous understory plants. Once established, trees eventually dominant the site and outcompete the herbaceous and shrub species (Zlatnik 1999).

Monitoring Objectives

For monitoring purposes, we focus on a subset of ecological indicators commonly used to assess rangeland vegetation and soil condition. Range indicators such as new and/or expanding non-native annual grass populations, increases in the amount of exposed soil subject to erosion, and declines in frequency of key forage plants signal a deteriorating condition (Pellant et al. 2000, Stoddart et al. 1955). Increases in the amount of protective ground cover and desirable forage species generally signify improving conditions. Routine data on these key features of plant community health will assist with the detection of long-term changes resulting from climate change, fire, biological invasions, grazing, and human use at Bighorn Canyon.

This protocol (Tercek et al. 2013) addresses the following monitoring objectives:

1. Determine the status (i.e., current condition) and trends (i.e., change in condition over time) in the composition and abundance of principal native plant species in targeted communities that contain Utah juniper-curlleaf mountain mahogany woodlands, sagebrush shrubland, and/or grasslands. Each principal species will be quantified separately.
2. Determine the status and trends in composition and abundance of principal invasive plant species, including annual grasses, in targeted communities that contain Utah juniper-mountain mahogany woodlands, sagebrush shrubland, and/or grasslands. Each invasive species will be quantified separately.
3. Determine the status and trend in the amount of exposed soil, a fundamental indicator of soil stability, in targeted communities that contain Utah juniper-mountain mahogany woodlands, sagebrush shrubland, and/or grasslands.
4. Determine the status and trend in the amount of cryptobiotic crust in targeted communities that contain Utah juniper-curlleaf mountain mahogany woodlands, sagebrush shrubland, and/or grasslands.

Photo caption: The photo on the left shows a Utah juniper–curlleaf mountain mahogany woodland on June 19, 2012; photo on the right shows a sagebrush shrubland on June 22, 2012.

Methods

Methods for this study follow the GRYN Upland Vegetation Monitoring Protocol (Tercek et al. 2013) and Standard Operating Procedures (SOP) (Jean et al. 2013). The target plant communities for monitoring are the Utah juniper and curlleaf mountain mahogany woodlands, sagebrush shrublands, and grasslands in the south district of Bighorn Canyon (refer to Figure 1). The monitoring design uses temporary 1 m^2 and 3.16 m^2 quadrats that are randomly assigned each year within permanent sampling frames geographically delineated to meet long-term monitoring objectives (see a "never revisit" design [1-n] *sensu* McDonald 2003). In this design, quadrat locations change from year to year, but the areas of inference (the sample frames) remain constant.

The temporary quadrats are located within each sample frame by a Generalized Random Tessellation Stratified (GRTS) spatially-balanced sampling design (Stevens and Olsen 2004). The randomly located points provide the location for subsequent quadrat-based estimation of cover (Figure 2).

The principal monitoring metric is estimated plant and ground cover recorded in cover classes developed by Daubenmire (1959), herein referred to as "Daubenmire's cover class" (Table 1).

Within each quadrat, live canopy cover, or in the case of annuals, current year's foliage, is estimated for all target indicator plant species and soil cover attributes. In this approach, cover estimates are made within the 1 m^2 quadrats for all but tree species in which cover is estimated within the 3.16 m^2 quadrat.

Table 1. Daubenmire cover classes used during the 2012 sampling and analysis year.

Cover Class	Cover Range
0	0%
1	>0-5%
2	>5-25%
3	>25-50%
4	>50-75%
5	>75-95%
6	>95%

Canopy cover and ground cover attributes are defined in Table 2.The list of plants targeted for this monitoring protocol include a mix of grasses, shrubs, and trees and many non-native invasive or state listed noxious weeds, several of which are on the park non-native watch list. Refer to Appendix A for a complete list of target plant species.

The monitoring design includes 15 permanent sampling frames located within one of three target plant communities: sagebrush steppe, Utah juniper woodland, or Utah juniper–curlleaf mountain mahogany woodland. Nine of 15 sample frames, three from each of the target vegetation types, were selected for monitoring in 2012. These sample frames are distributed along a north to south axis in the south district of Bighorn Canyon. Refer to Figure 1 for a map showing all 15 sample frame locations.

The number of sample quadrats within each frame ranged from 50 to 100, with larger sample sizes for frames of greater spatial extent, following the methods outlined in the GRYN Upland Vegetation Monitoring Protocol (Tercek et al. 2013).

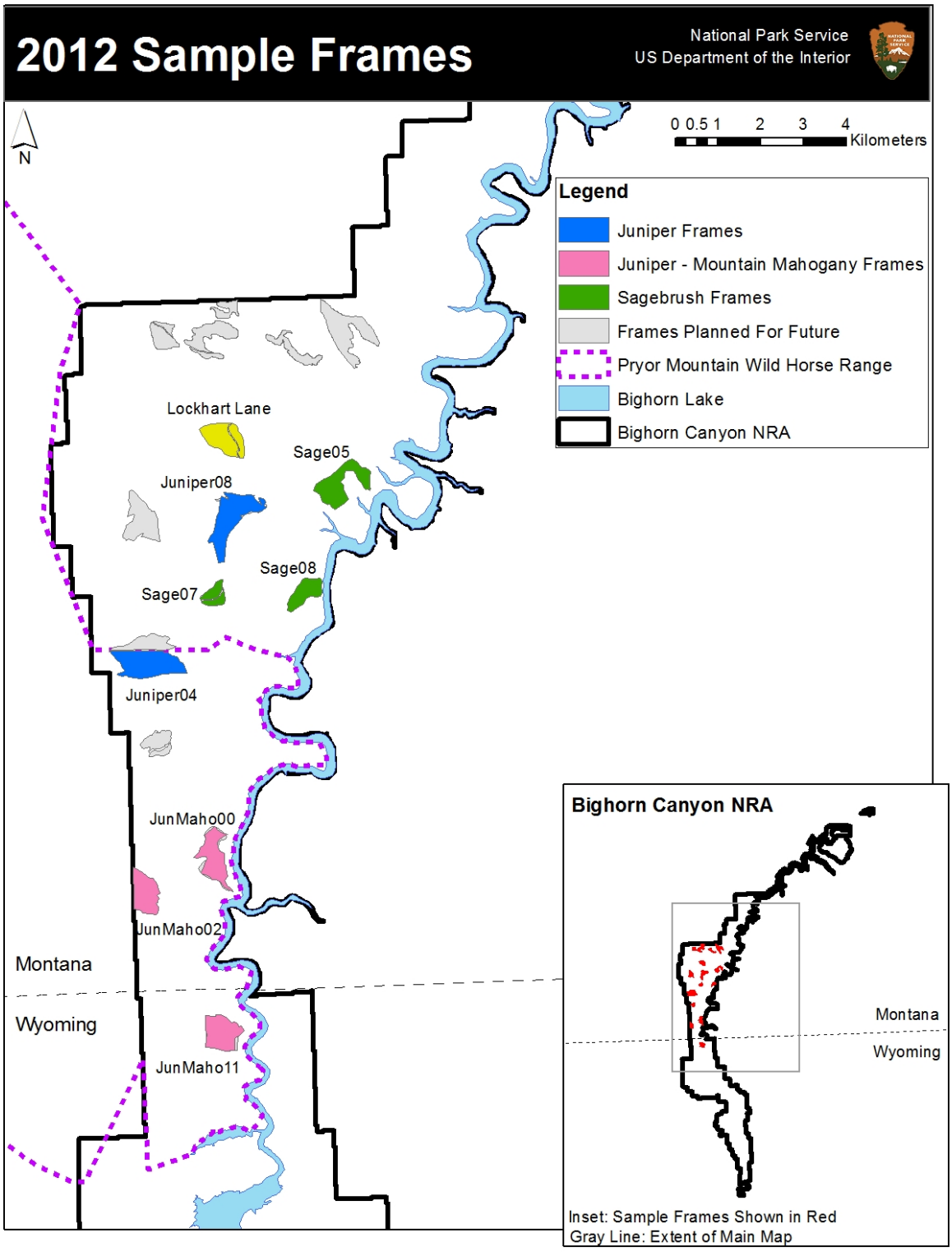

Figure 1. Map showing the sample frames that were visited during summer 2012 (colors) and sample frames planned for future years (grey). Inset shows the location of the sample frames (red) relative to the boundary of Bighorn Canyon NRA.

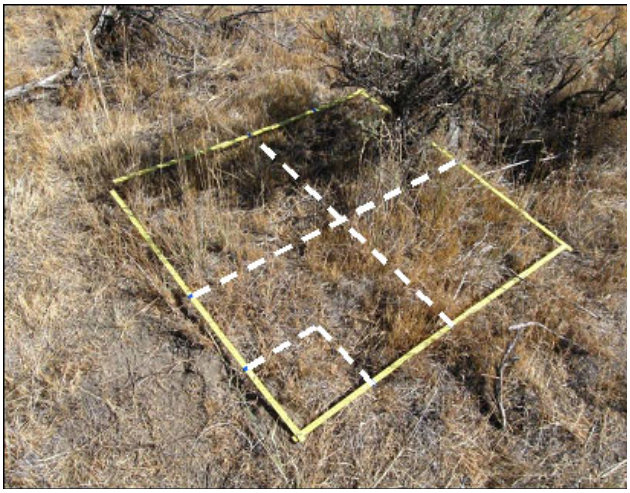

Figure 2. The 1 m² quadrat sample unit used to measure species cover. Dashed white lines depict 5% area (smallest square in lower portion of quadrat), and 25% areas (larger four squares covering quadrat).

Field and safety training took place in May and consisted of a week in Bozeman learning network office and field operations, safety and field communications, and a week at Bighorn Canyon focused on practicing the field data collection procedures and plant identification. After the training, field sampling was completed by one or more, two- person field crew(s). Field data were recorded directly into a database with built-in quality controls on a tablet computer which was backed up frequently throughout the day. This eliminated the need to write down observation data and later enter the values manually into the database.

Sample frame boundaries were validated by the field crew, who had the option to reject sample quadrats within each frame if they occurred within the wrong vegetation type or contained human development. Rejected quadrats were replaced with quadrats from a list of oversample locations. Maps of rejected sample quadrats are used to refine the sample frame boundaries, if needed.

Following the field season, data were evaluated for quality, documented with metadata, and certified prior to analysis. Routine summary statistics involved calculating the frequency of quadrats in each Daubenmire cover class and presenting the results in graphical, spatial, and tabular formats. Analyses were performed in Microsoft ™ Excel and with the spsurvey GRTS package using the R statistical platform (R Development Core Team 2011). Margins of errors, computed with a GRTS local variance estimator were calculated with the spsurvey package.

Ecological indicators such as new and/or expanding populations of non-native plants, increases in area of exposed soil, and declines in the cover of native indicator plants signify a deteriorating condition. Increases in cryptograms and desirable forage species generally signify improving conditions. Annual monitoring of indicators of rangeland condition will aid in the detection of vegetative cover or composition changes over time and support effective adaptive management strategies

Data collected in the early years of monitoring will also assist in documenting baseline conditions from which future conditions will be compared. Although we do not yet have a long term data-set to characterize trends for each indicator, careful documentation of each indicator will aid in documenting variation among and within our sample frames.

Table 2. Indicators for rangeland health and their quantitative attributes for Bighorn Canyon. Refer to Appendix A for a complete list of principal plant species targeted for monitoring in this protocol (Tercek et al. 2013).

Indicator	Quantitative attributes	Interpretation
Hydrologic function	Percent exposed bare ground, defined as bare soil (mineral soil) not covered by plant canopies. Gravel greater than 6.35 mm (¼"), rock, cryptogamic crust, and litter are excluded from bare ground cover estimates	Bare ground is positively correlated with run-off and erosion Non-native plants colonize and increase on bare ground
Soil/site stability	Percent litter cover defined as detached dead stems, leaves, and other woody debris in contact with the ground Percent cryptogamic crust ground cover. Cryptogams include cryptobiotic soil crusts and/or other non-vascular plants (e.g., mosses, lichens, and fungi) growing on the soil surface.	Litter and cryptogamic crust cover protect soil from erosion
Biotic integrity	Percent plant (foliar) cover of principal trees and shrubs, including, but not limited to Utah juniper, sagebrush, and curlleaf mountain mahogany and native grasses, including but not limited to, bluebunch wheatgrass, needle and thread, and Sandburg's bluegrass. Plant cover is the percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage of plants. The visual cover estimate is for current year's growth, including senescent annual grasses of the year.	Changes in species composition can signal a direction of change in ecological status
	Stem counts of juniper, limber pine and curlleaf mountain mahogany shrubs/trees less than 10 cm (3") in height Percent (foliar) cover of principal non-native and invasive species	The number of non-native plant species and their cover signify a deteriorating condition.

Results

In 2012, we completed the annual monitoring of nine sample frames; three of each dominated by Utah juniper woodland, Utah juniper-curlleaf mountain mahogany woodland, or sagebrush shrubland and/or grassland. Within these sample frames, visual estimates of ground and vegetation cover were reported for 600 sample quadrats. Refer to Table 3 for the number of samples per sample frame.

Of the 600 sample quadrats assessed, only 20 (roughly 3.3%) were rejected by the field crew. Most sample quadrats were rejected due to either landing on an old roadbed, active road prism or within a recently disturbed power line right-away. One quadrat was rejected for safety reasons. Table 2 shows the number of rejected points for each sample frame.

Table 3. Sample size and number of quadrats rejected in each sample frame during the 2012 field season.

Sample Frame	Sample Size	# Rejected
Juniper04	100	0
Juniper08	100	5
Lockhart Lane	100	5
JunMaho00	50	2
JunMaho02	50	0
JunMaho11	50	0
Sage05	50	0
Sage07	50	8
Sage08	50	0
Total	**600**	**20**

Rejection rate=approximately 3.3%.

Sampling took place between 19 May and 24 June 2012. Precipitation leading up to this period was mostly below average, however both minimum and maximum temperatures were above average from January through April. In June, when most of the plant growth normally takes place, precipitation was only 15% of average and maximum temperatures were 6 degrees F above average (refer to Figure 3).

These weather conditions indicate drought and by June the U.S. Drought Monitor was reporting abnormally dry conditions in the Bighorn Basin (U.S. Drought Monitor 2012).

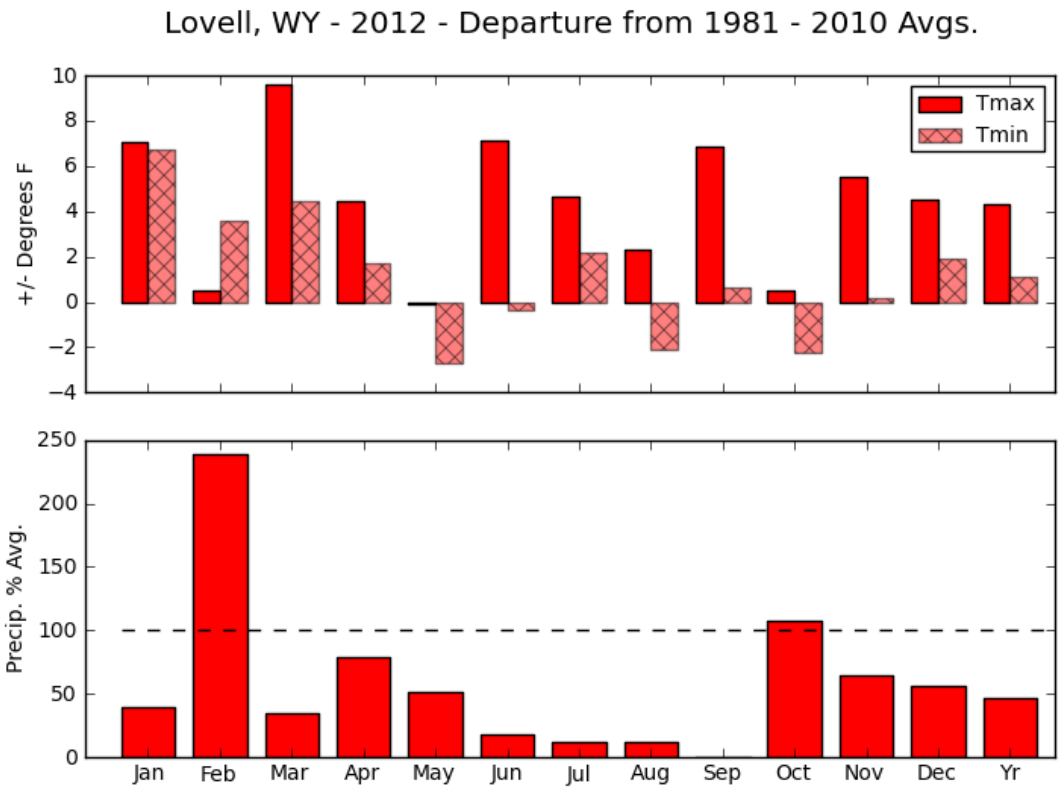

Figure 3. Departure of 2012 average minimum (Tmin) and average maximum (Tmax) daily temperatures and precipitation from 1981-2010 average at the COOP station in Lovell, WY. Horizontal line depicts average condition

Three non-native plants, cheatgrass, salt-lover (*Halogeton glomeratus*), and Russian thistle (*Salsola tragus*) were documented in 2012. Cheatgrass was found in all nine sample frames whereas Russian thistle was found in the JunMaho11, Sage5, and Lockhart Lane sample frames, and salt-lover was found only in the JunMaho11 sample frame

Two potentially new non-native plant species to the park, yellow toadflax (*Linaria vulgaris*) and dalmation toadflax (*L. dalmatica)* were reported in the Lockhart Lane sample frame in 2012.

Identification of these species was based on immature plants and no voucher specimens were collected. Since neither of these plants has been documented in Bighorn Canyon in the past, we are calling these observations provisional until proper identification can be made. Refer to sample frame results for more information on non-native plant species.

While each sample frame has a unique history of human and natural disturbance, the sample frames generally, with some exceptions, shared the following characteristics:

(1) Forage species were widespread but represented a limited amount of cover within our sample frames. Sixty-percent or more of sample quadrats contained at least one forage species (Figure 4). Forage species include Indian ricegrass (*Achnatherum hymenoides*), bluebunch wheatgrass, needle and thread (*Hesperostipa comata* var. *comata*), western wheatgrass (*Pascopyrum smithii)*, sedges (*Carex* spp.), and drop seed (*Sporobolus* spp.).

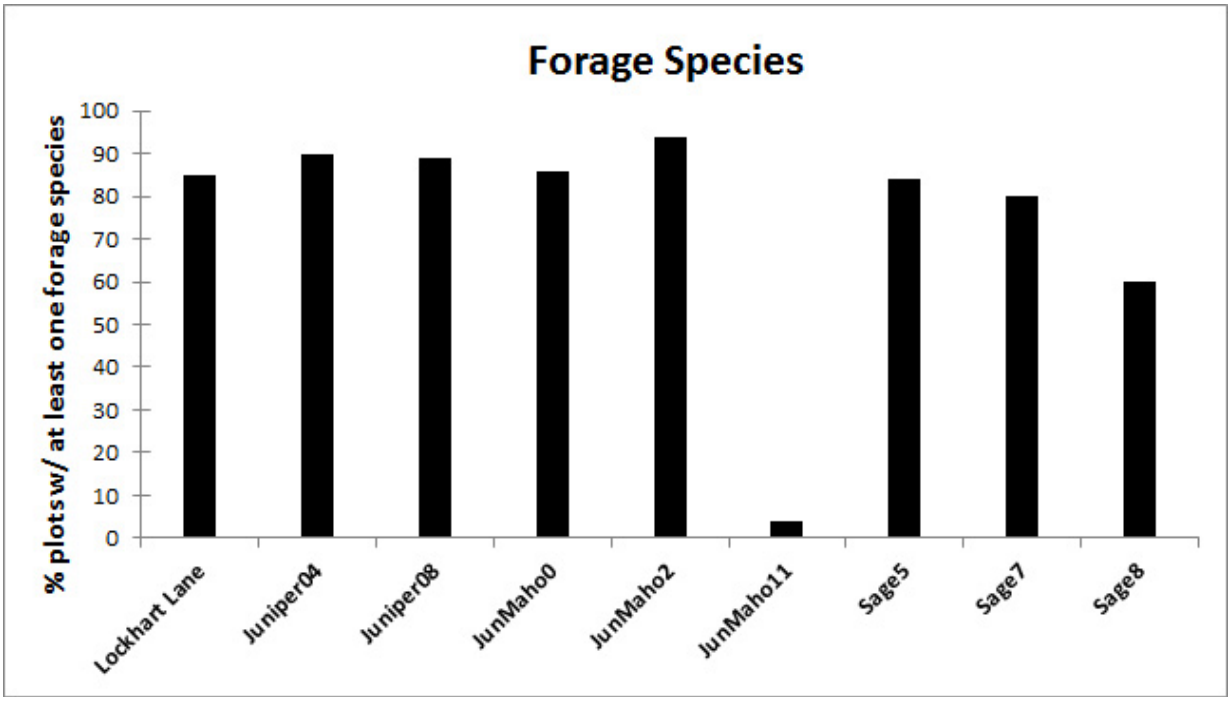

Figure 4. Percent frequency of quadrats (plots) in each sample frame that contained at least one forage species. Key forage species (see BLM 2008) were Indian ricegrass, bluebunch wheatgrass, needle and thread, western wheatgrass, sedges, and drop seed.

(2) Non-native plants, especially cheatgrass, were recorded in all the sample frames but were represented by low cover categories.

As many as four non-native plant species (counting the two unconfirmed species of toadflax) were reported; the frequency of occurrence ranged from 1-34% of the sample quadrats (Figure 5), depending on the sample frame.

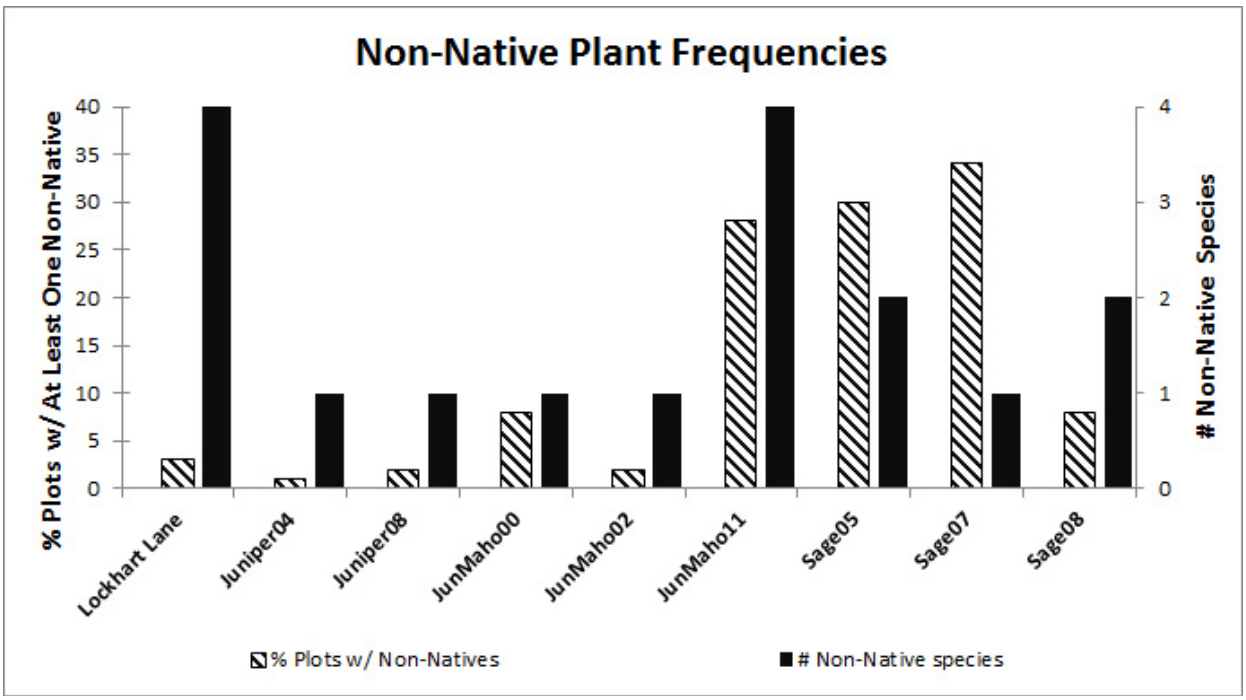

Figure 5. Non-native plant frequencies in 2012 sample quadrats. Left axis, hatched bars: percent of quadrats (plots) in each sample frame with at least one non-native plant species present. Right axis, solid bars: number of non-native plant species in each sample frame.

(3) Nearly all the quadrats (99.5%) had litter on the soil surface, however half 52% of the estimated coverage of litter at each quadrat was in the lowest (>0-5%) category. A low frequency of quadrats (0-2%) lacked litter altogether (Figure 6).

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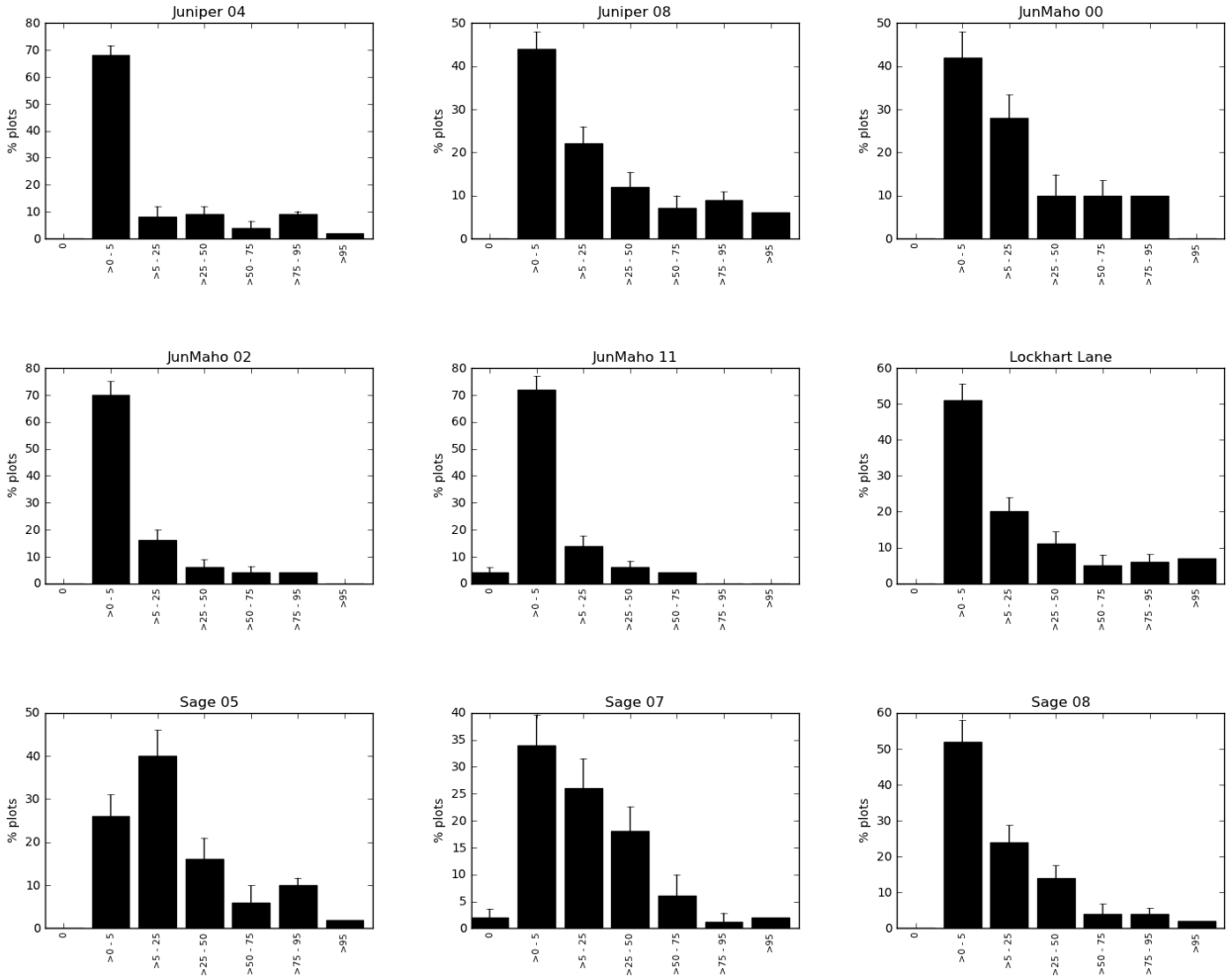

Figure 6. Percent of quadrats (plots) summarizing the estimated cover of litter in each of the 2012 sampling frames. Cover estimates were made using Daubenmire cover class categories.

(4) Across the sample frames, bare ground was not extensive. Sixty-seven percent of the sampled quadrats characterized bare ground using the lowest (>0-5%) cover classes. Another 26% of the quadrats were characterized as having between >5-25% bare ground (Figure 7).

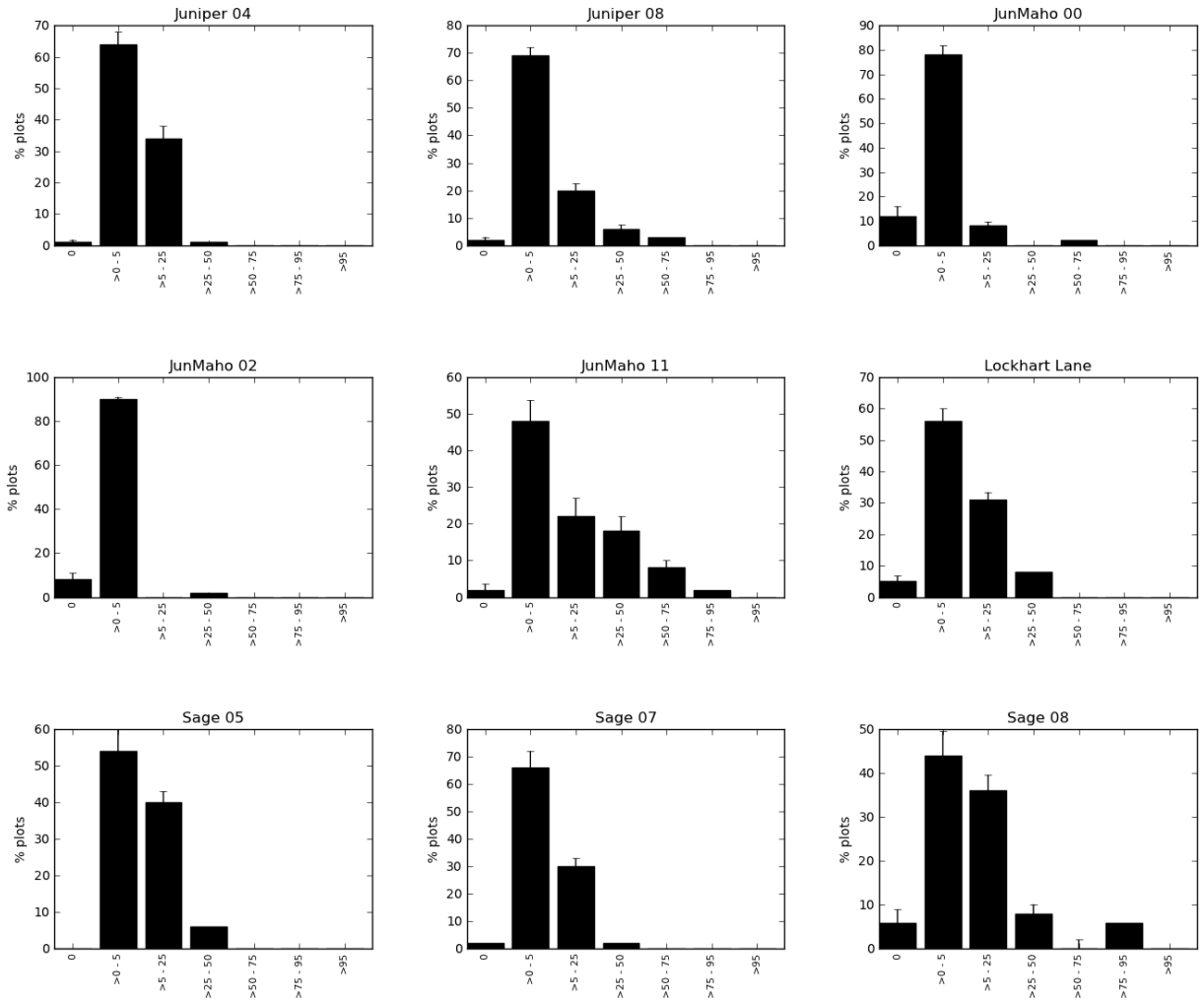

Figure 7. Percent of quadrats (plots) summarizing the estimated amount of bare ground in each of the 2012 sampling frames. The estimates of bare ground within each quadrat were made using Daubenmire cover class categories.

(5) Cryptograms were relatively well represented, but provided limited amounts of total cover. In the majority of quadrats (>79%), cryptogram cover was estimated as either >0-5% or >5-25% cover (Figure 8).

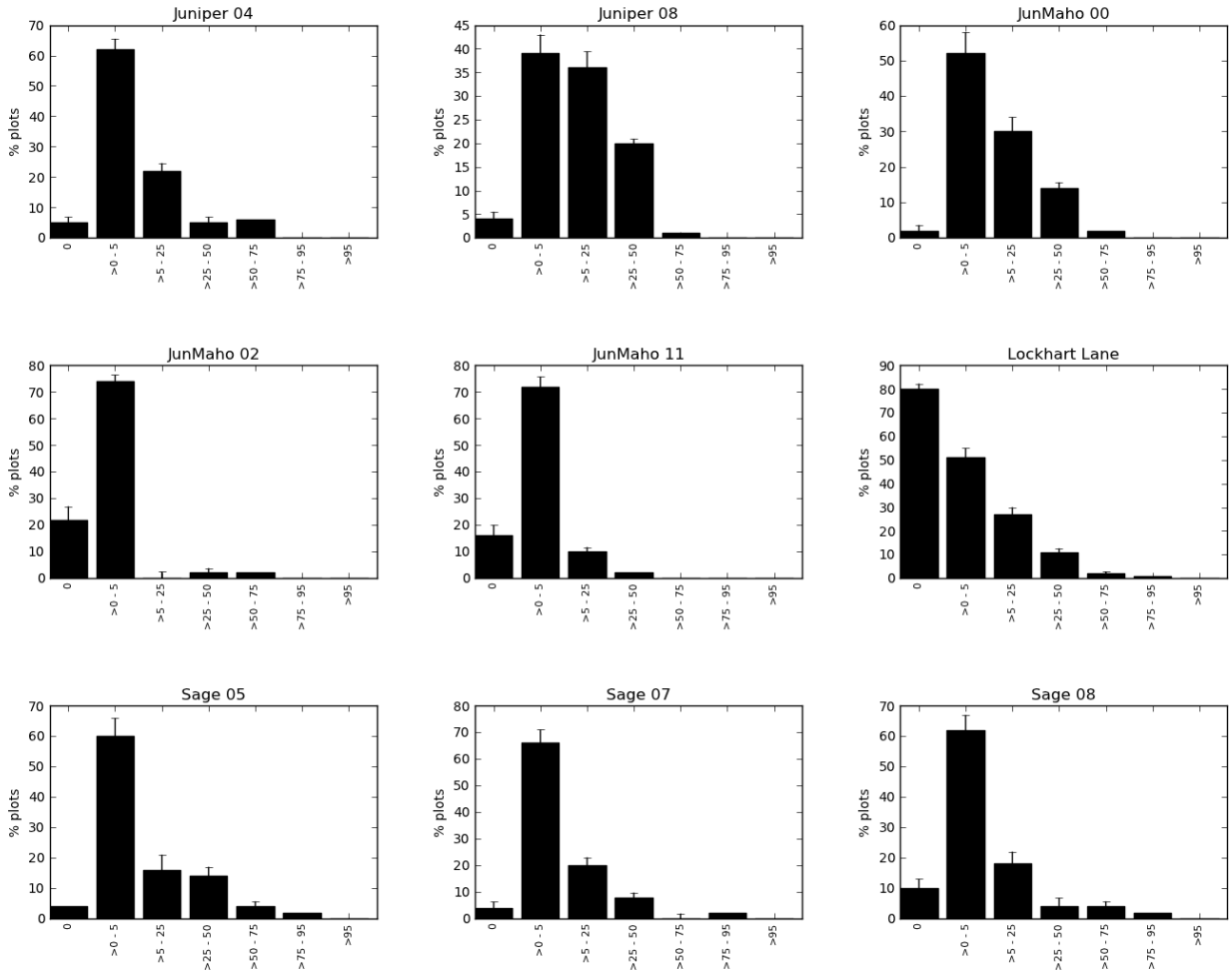

Figure 8. Percent of quadrats (plots) summarizing the estimated cover of cryptograms in each of the 2012 sampling frames. Cover estimates were made using Daubenmire cover class categories.

The ecological indicators for the JunMaho11 sample frame appeared to be particularly affected by prescribed fires that have been initiated by NPS staff during the last decade. Only 4% of the quadrats contained forage species, in contrast with the 60-94% frequency in the other frames. This frame also contained three non-native plant species (cheatgrass, Russian thistle, halogeton) and a relatively high frequency of quadrats with no cryptogam cover (16%). While this information is available only from a single frame, it does suggest that documenting the vegetative response and condition of habitats managed by fire should be considered.

The Lockhart Lane sample frame was notable for its mixed results; some metrics indicated "healthy" conditions and others indicating an "unhealthy" range condition. In addition, this sample frame contained four non-native plant species (cheatgrass, Russian thistle, dalmation toadflax, yellow toadflax), but unlike some frames that had as much as 34% non-native plant frequency, non-native plants occurred in only 3% of the sample quadrats at Lockhart Lane (Figure 4). The vegetation community is predominantly juniper woodland, and consequently, litter cover is relatively high and cryptogamic crust cover relatively low.

Among all the sample frames visited during 2012, the percentage of sample quadrats with no cryptogamic cover was highest at Lockhart Lane, and the frequency of these cryptogam-free quadrats (80%) was about four times greater than the second highest cryptogam-free quadrat count at JunMaho2 (22%; Figure 26). However, Lockhart Lane did not have unusually high bare ground scores (Figure 25) and it contained a relatively large number of quadrats with high litter cover (Figure 24), ranking the highest among all frames for the frequency of quadrats with >95% litter cover (7%).

Following is a short summary for each sample frame completed in 2012.

Sample Frame: JunMaho00

This sample frame is located north of Devil's Canyon overlook in the PMWHR. The frame is 74 ha (183 ac) in size and the elevation ranges between 1,301 m (4,269') and 1,375 m (4,512'). The geology is mapped as Amsden formation consisting of shale, siltstone and sandstone, interbedded with limestone and dolomite (KellerLynn 2011). The dominant vegetation cover is Utah juniper-curlleaf mountain mahogany woodland (Knight et al. 1987), although this area was mapped as juniper woodland by Myers et al. (1986).

In 2012, vegetation cover estimates were recorded from 50 sampling quadrats on June 5 and 6. Cheatgrass was the only non-native plant species documented during the 2012 season. Refer to map Figure 9 for quadrat and weed locations.

The frequency of target plant species and ground cover attributes for each Daubenmire cover class reported in 2012 are shown in Figure 10 and as proportions in Table 4.

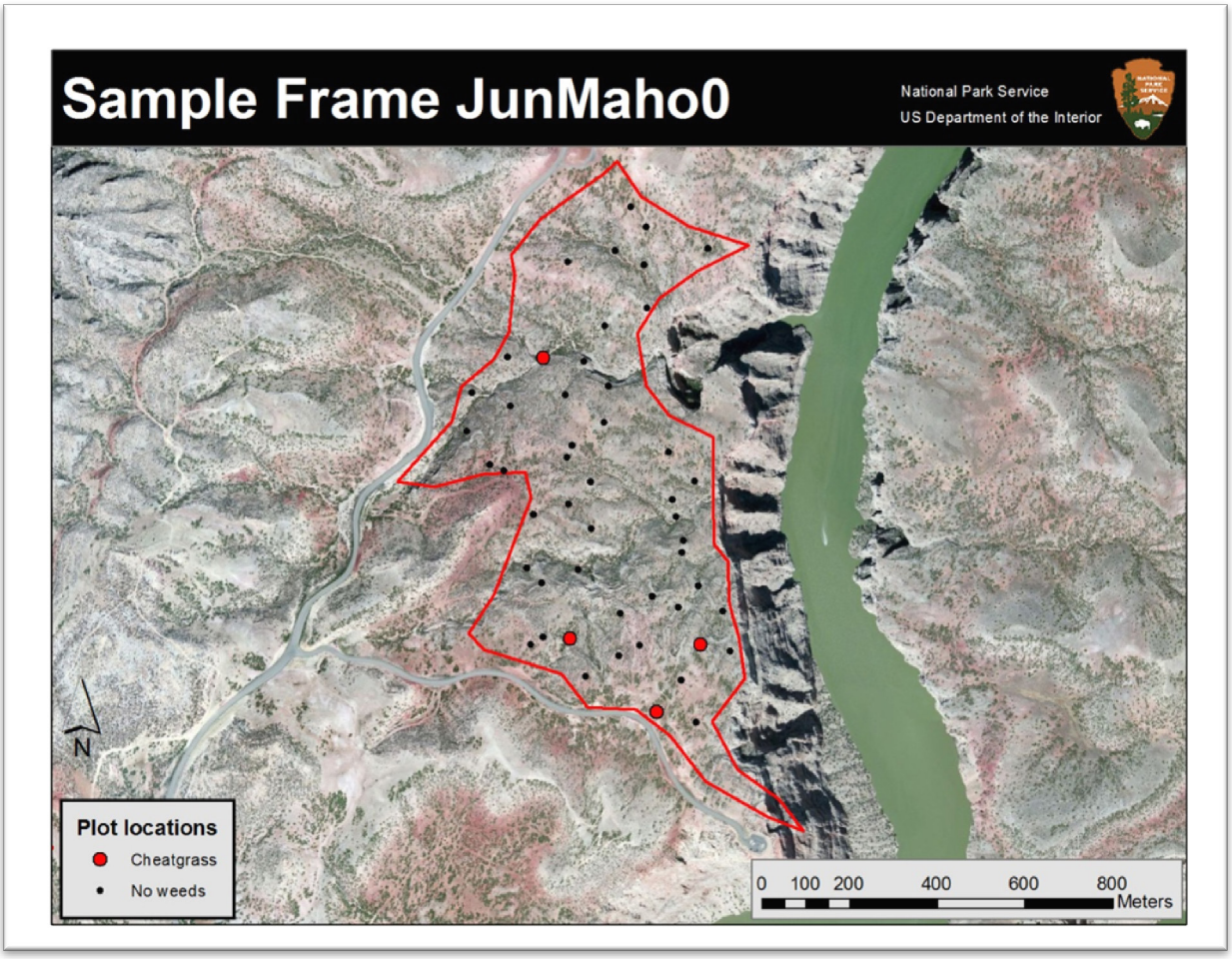

Figure 9. Map showing quadrats sampled in 2012 within sample frame JunMaho00. The red points are quadrats with cheatgrass present. The location of this sample frame is shown in Figure 1.

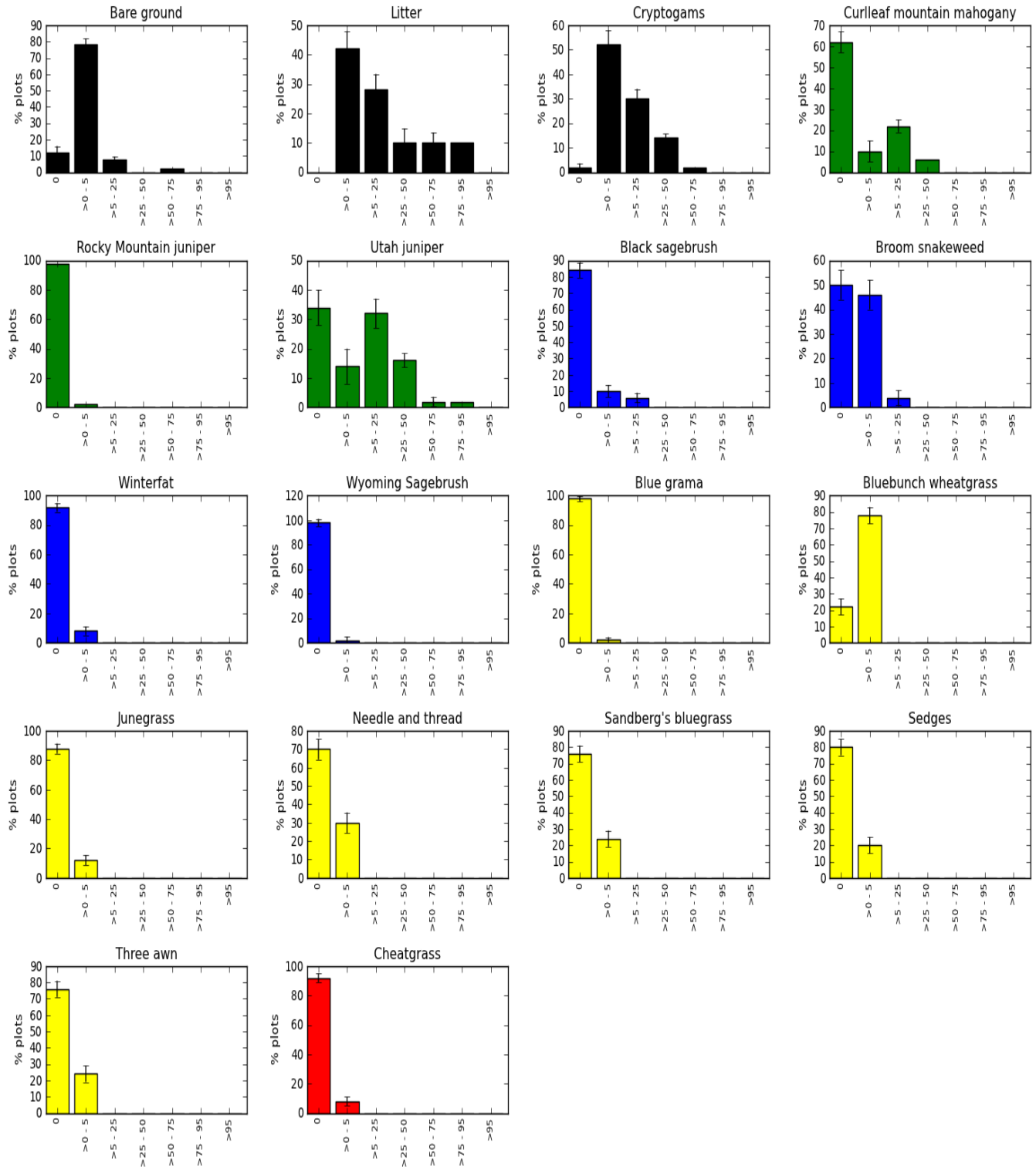

Figure 10. Percent frequency of quadrats (plots) by Daubenmire cover class for all target plant species reported in sample frame JunMaho00 in 2012. Chart colors show different strata: black=ground cover attributes, green=trees, blue=shrubs, yellow=grass and grass-like species, and red=non-native plants. Error bars show one standard error, calculated from the local variance estimator.

Table 4. Proportion of quadrats (n=50) in sample frame JunMaho00 within each cover class for ground cover and principal plant species organized by species guilds, Bighorn Canyon National Recreation Area, 2012.

Frame Name: JunMaho00 **Dominant cover type: Juniper-curlleaf mountain mahogany woodland**	**0%**[1]	**>0-5%**	**>5-25%**	**>25-50%**	**>50-75%**	**>75-95%**	**>95-100%**
Ground Cover							
Bare ground	0.12	0.78	0.08	0	0.02	0	0
Litter	0	0.42	0.28	0.1	0.1	0.1	0
Cryptogams	0.02	0.52	0.3	0.14	0.02	0	0
Trees							
Curlleaf mountain mahogany (*Cercocarpus ledifolius*)	0.62	0.1	0.22	0.06	0	0	0
Rocky Mountain juniper (*Juniperus scopulorum*)	0.98	0.02	0	0	0	0	0
Utah juniper (*Juniperus osteosperma*)	0.34	0.14	0.32	0.16	0.02	0.02	0
Shrubs							
Black sagebrush (*Artemisia nova*)	0.84	0.1	0.06	0	0	0	0
Broom snakeweed (*Gutierrezia sarothrae*)	0.5	0.46	0.04	0	0	0	0
Winterfat (*Krascheninnikovia lanata*)	0.92	0.08	0	0	0	0	0
Wyoming Sagebrush (*Artemisia tridentata*)	0.98	0.02	0	0	0	0	0
Grasses and grass-like							
Blue grama (*Bouteloua gracilis*)	0.98	0.02	0	0	0	0	0
Bluebunch wheatgrass (*Pseudoroegneria spicata*)	0.22	0.78	0	0	0	0	0
Junegrass (*Koeleria macrantha*)	0.88	0.12	0	0	0	0	0
Needle and thread (*Hesperostipa comata* var. *comata*)	0.7	0.3	0	0	0	0	0
Sandberg's bluegrass (*Poa secunda*)	0.76	0.24	0	0	0	0	0
Sedges (*Carex* spp.)	0.8	0.2	0	0	0	0	0
Three awn (*Aristida purpurea* var. *fendleriana*)	0.76	0.24	0	0	0	0	0
Non-native-present in park							
Cheatgrass (*Bromus tectorum*)	0.92	0.08	0	0	0	0	0

[1] Daubenmire Cover Class Categories

Sample Frame: JunMaho11

This sample frame is located south of the Wyoming state line in Pryor Mountain Wild Horse Range. The frame size is 210 ha (519 ac) and the elevation ranges between 1,242 m (4,075') and 1,314 m (4,313'). The geology is mapped as Tensleep sandstone and Madison Group undivided (KellerLynn 2011). The dominant cover is Utah juniper – curlleaf mountain mahogany woodland (Knight et al. 1987).

Habitat requirements for bighorn sheep include abundant forage and little or no visual obstruction that reduces security (Easterly and Jenkins 1991). Prescribed fire during the past decade has been used to reduce juniper cover to improve horizontal visibility for foraging animals and enhance wildlife habitat.

In 2012, vegetation cover estimates were recorded from 50 sampling quadrats on June 18 and 19. Refer to Figure 11 for quadrat and weed locations.

Three non-native plant species were documented during the 2012 season: cheatgrass, Russian thistle, and salt-lover. Post fire communities in juniper woodlands are typically dominated by annual vegetation that may persist for two or three years (Zlatnik 1999). During this time, species such as cheatgrass and Russian thistle are characteristic.

The frequency of target plant species and ground cover attributes for each Daubenmire cover class reported in 2012 are shown in Figure 12 and as proportions in Table 5.

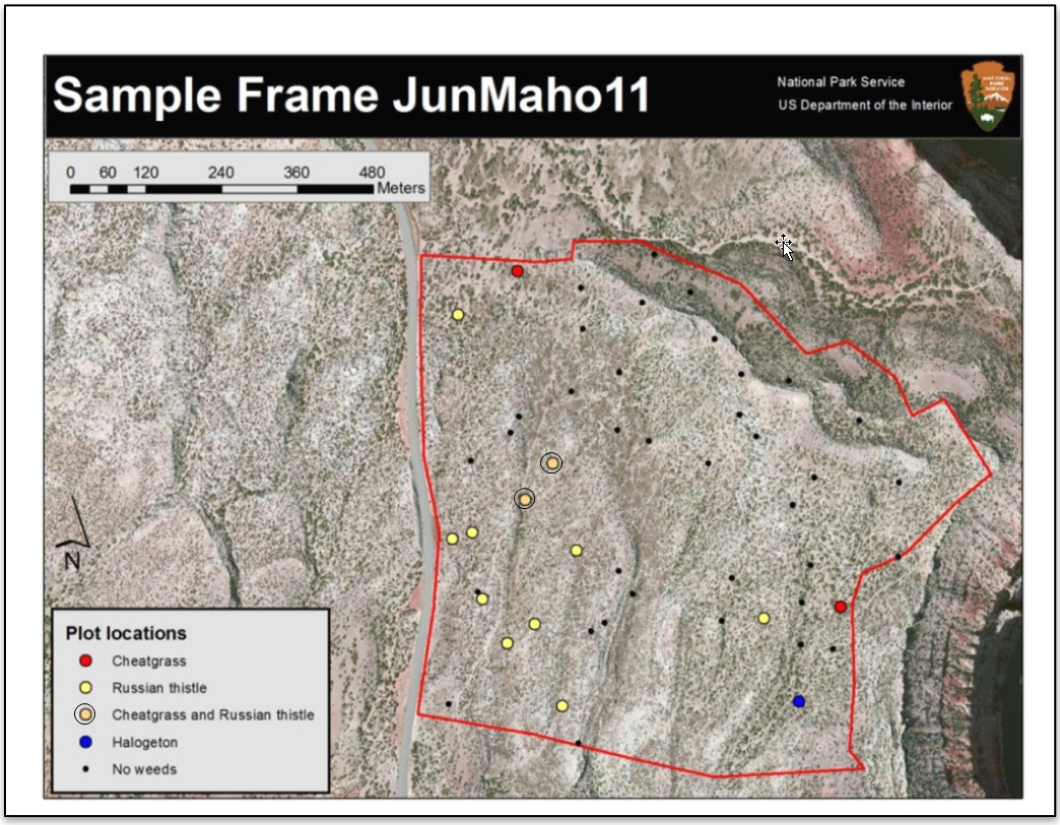

Figure 11. Map showing quadrats sampled in 2012 within sample frame JunMaho11. The colored points are quadrats with non-native plant species present. The location of this sample frame is shown in Figure 1.

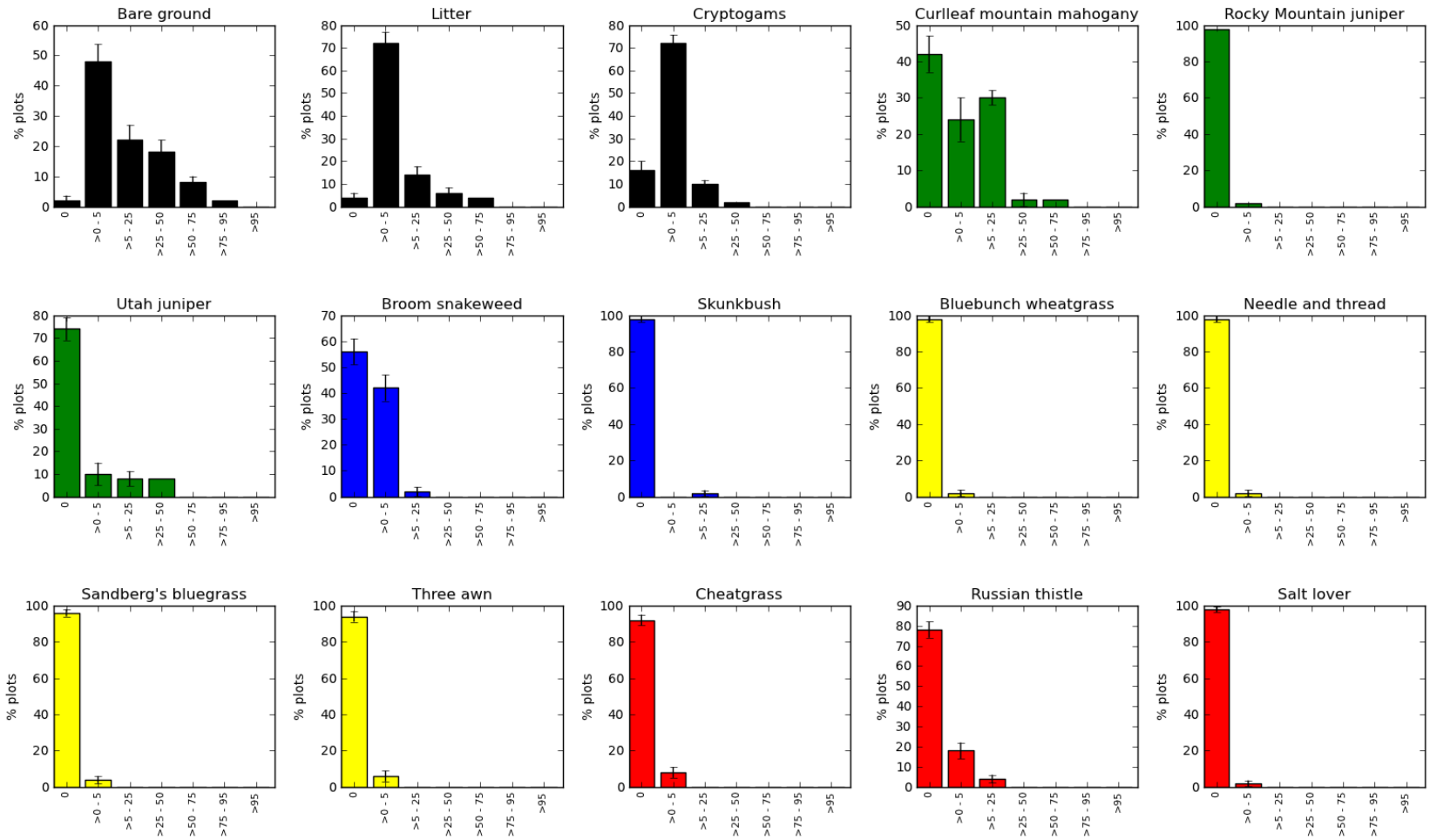

Figure 12. Percent frequency of quadrats (plots) by Daubenmire cover class for all target plant species reported in sample frame JunMaho11 in 2012. Chart colors show different strata: black=ground cover attributes, green=trees, blue=shrubs, yellow=grass and grass-like, and red=non-native plants. Error bars show one standard error, calculated from the local variance estimator.

Table 5. Proportion of quadrats (n=50) for sample frame JunMaho11 within each cover class for ground cover and principal plant species organized by species guilds, Bighorn Canyon National Recreation Area, 2012.

Frame Name: JunMaho11 **Dominant cover type: Juniper-curlleaf mountain mahogany woodland**	**0%**[1]	**>0-5%**	**>5-25%**	**>25-50%**	**>50-75%**	**>75-95%**	**>95-100%**
Ground Cover							
Bare ground	0.02	0.48	0.22	0.18	0.08	0.02	0
Litter	0.04	0.72	0.14	0.06	0.04	0	0
Cryptogams	0.16	0.72	0.1	0.02	0	0	0
Trees							
Curlleaf mountain mahogany (*Cercocarpus ledifolius*)	0.42	0.24	0.3	0.02	0.02	0	0
Rocky Mountain juniper (*Juniperus scopulorum*)	0.98	0.02	0	0	0	0	0
Utah juniper (*Juniperus osteosperma*)	0.74	0.1	0.08	0.08	0	0	0
Shrubs							
Broom snakeweed (*Gutierrezia sarothrae*)	0.56	0.42	0.02	0	0	0	0
Skunkbush (*Rhus aromatica* var. *trilobata*)	0.98	0	0.02	0	0	0	0
Grasses and grass-like							
Bluebunch wheatgrass (*Pseudoroegneria spicata*)	0.98	0.02	0	0	0	0	0
Needle and thread (*Hesperostipa comata* var. *comata*)	0.98	0.02	0	0	0	0	0
Sandberg's bluegrass (*Poa secunda*)	0.96	0.04	0	0	0	0	0
Three awn (*Aristida purpurea* var. *fendleriana*)	0.94	0.06	0	0	0	0	0
Non-native-present in park							
Cheatgrass (*Bromus tectorum*)	0.92	0.08	0	0	0	0	0
Salt-lover (*Halogeton glomeratus*)	0.98	0.02	0	0	0	0	0
Russian thistle (*Salsola tragus*)	0.78	0.18	0.04	0	0	0	0

[1] Daubenmire Cover Class Categories

Sample Frame: JunMaho02

This sample frame is located on the lower slopes of Sykes Ridge in the PMWHR. The frame size is 88 ha (217 ac) and the elevation ranges between 1,346 m (4,417') and 1,535 m (5,038'). The geology is mapped as Tensleep sandstone and Madison Group undivided (KellerLynn 2011). The dominant vegetation cover is Utah juniper-curl-leaf mountain mahogany woodland (Knight et al. 1987).

In 2012, vegetation cover estimates were recorded from 100 sampling quadrats on June 19 and 20. Cheatgrass was the only non-native plant species documented during the 2012 season. Refer to map Figure 13 for quadrat and non-native plant locations. Hairy prince's-plume *(Stanleya tomentosa* var. *tomentosa*) was observed flowering during the time of the survey in June. This is a plant of interest because of its heritage rank of G3/S3 (Heidel and Fertig 2000) which means that the plant is vulnerable at both the state and global scales, although not a species of concern in Montana (MTNHP 2012). The frequency of target plants and ground cover attributes for each Daubenmire cover class reported in 2012 are shown in Figure 14 and as proportions in Table 6.

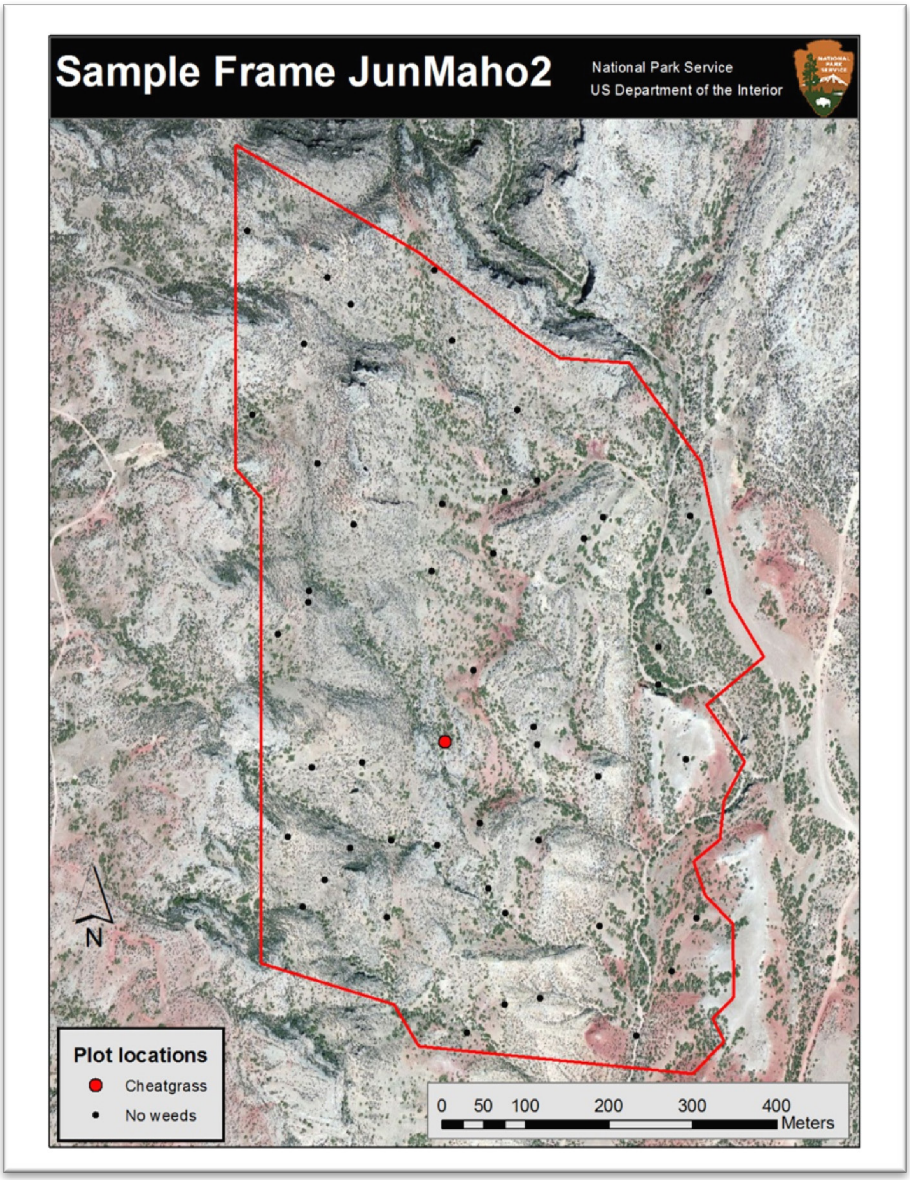

Figure 13. Map showing quadrats sampled in 2012 within sample frame JunMaho02. The colored points are quadrats with non-native plant species present. The location of this sample frame is shown in Figure 1.

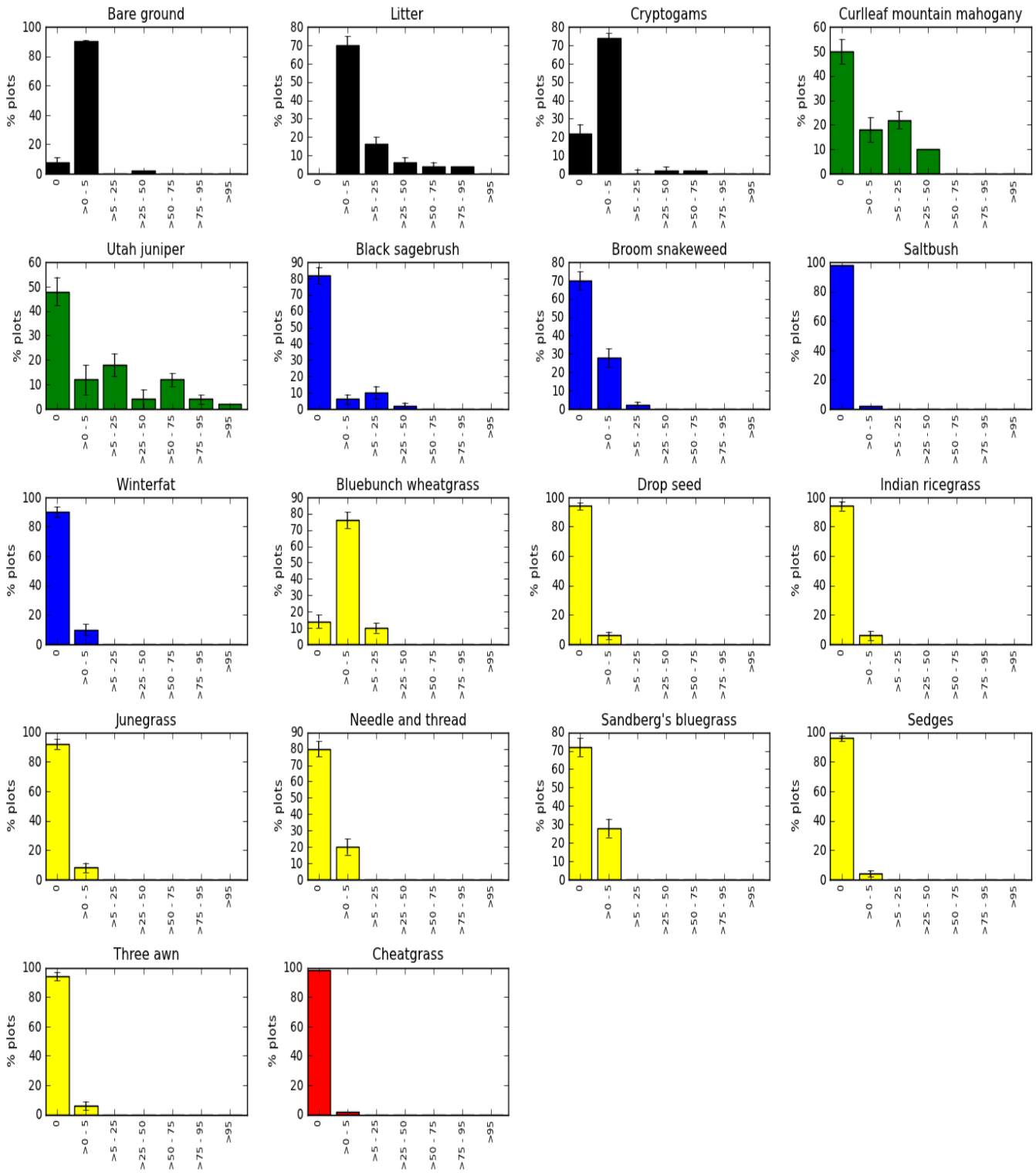

Figure 14. Percent frequency of quadrats (plots) by Daubenmire cover class for all target plant species reported in sample frame JunMaho02 in 2012. Chart colors show different strata: black=ground cover attributes, green=trees, blue=shrubs, yellow=grass and grass-like, and red=non-native plants. Error bars show one standard error, calculated from the local variance estimator.

Table 6. Proportion of quadrats (n=100) for sample frame JunMaho02 within each cover class for ground cover and principal plant species organized by species guilds, Bighorn Canyon National Recreation Area, 2012.

Frame Name: JunMaho02 **Dominant cover type: Juniper-curlleaf mountain mahogany woodland**	**0%**[1]	**>0-5%**	**>5-25%**	**>25-50%**	**>50-75%**	**>75-95%**	**>95-100%**
Ground Cover							
Bare ground	0.08	0.9	0	0.02	0	0	0
Litter	0	0.7	0.16	0.06	0.04	0.04	0
Cryptogams	0.22	0.74	0	0.02	0.02	0	0
Trees							
Curlleaf mountain mahogany (*Cercocarpus ledifolius*)	0.5	0.18	0.22	0.1	0	0	0
Utah juniper (*Juniperus osteosperma*)	0.48	0.12	0.18	0.04	0.12	0.04	0.02
Shrubs							
Black sagebrush (*Artemisia nova*)	0.82	0.06	0.1	0.02	0	0	0
Broom snakeweed (*Gutierrezia sarothrae*)	0.7	0.28	0.02	0	0	0	0
Saltbush (*Atriplex* spp.)	0.98	0.02	0	0	0	0	0
Winterfat (*Krascheninnikovia lanata*)	0.9	0.1	0	0	0	0	0
Grasses and grass-like							
Bluebunch wheatgrass (*Pseudoroegneria spicata*)	0.14	0.76	0.1	0	0	0	0
Drop seed (*Sporobolus* spp.)	0.94	0.06	0	0	0	0	0
Indian ricegrass (*Achnatherum hymenoides*)	0.94	0.06	0	0	0	0	0
Junegrass (*Koeleria macrantha*)	0.92	0.08	0	0	0	0	0
Needle and thread (*Hesperostipa comata* var. *comata*)	0.8	0.2	0	0	0	0	0
Sandberg's bluegrass (*Poa secunda*)	0.72	0.28	0	0	0	0	0
Sedges (*Carex* spp.)	0.96	0.04	0	0	0	0	0
Three awn (*Aristida purpurea* var. *fendleriana*)	0.94	0.06	0	0	0	0	0
Non-native-present in park							
Cheatgrass (*Bromus tectorum*)	0.98	0.02	0	0	0	0	0

[1] Daubenmire Cover Class Categories

Sample Frame: Juniper04

This sample frame is located at Mustang Flats along the northern boundary of the Pryor Mountain Wild Horse Range. The frame size is 260 ha (642 ac) and the elevation ranges between 1,330 m (4,309') and 1,552 m (5,092'). The geology is an alluvial fan deposit (KellerLynn 2011). The vegetation cover is sagebrush steppe and grassland intersected with Utah juniper woodlands (Knight et al. 1987) that are often associated with fractured bedrock (Wight and Fisser 1968 as cited in Knight et al. 1987). This area was mapped as juniper woodland by Myers et al. (1986).

In 2012, vegetation cover estimates were recorded from 100 sampling quadrats between June 9 and 11. Cheatgrass was the only non-native plant species documented during the 2012 season. Refer to map Figure 15 for quadrat and cheatgrass locations.

The frequency of target plants and ground cover attributes for each Daubenmire cover class reported in 2012 are shown in Figure 16 and as proportions in Table 7.

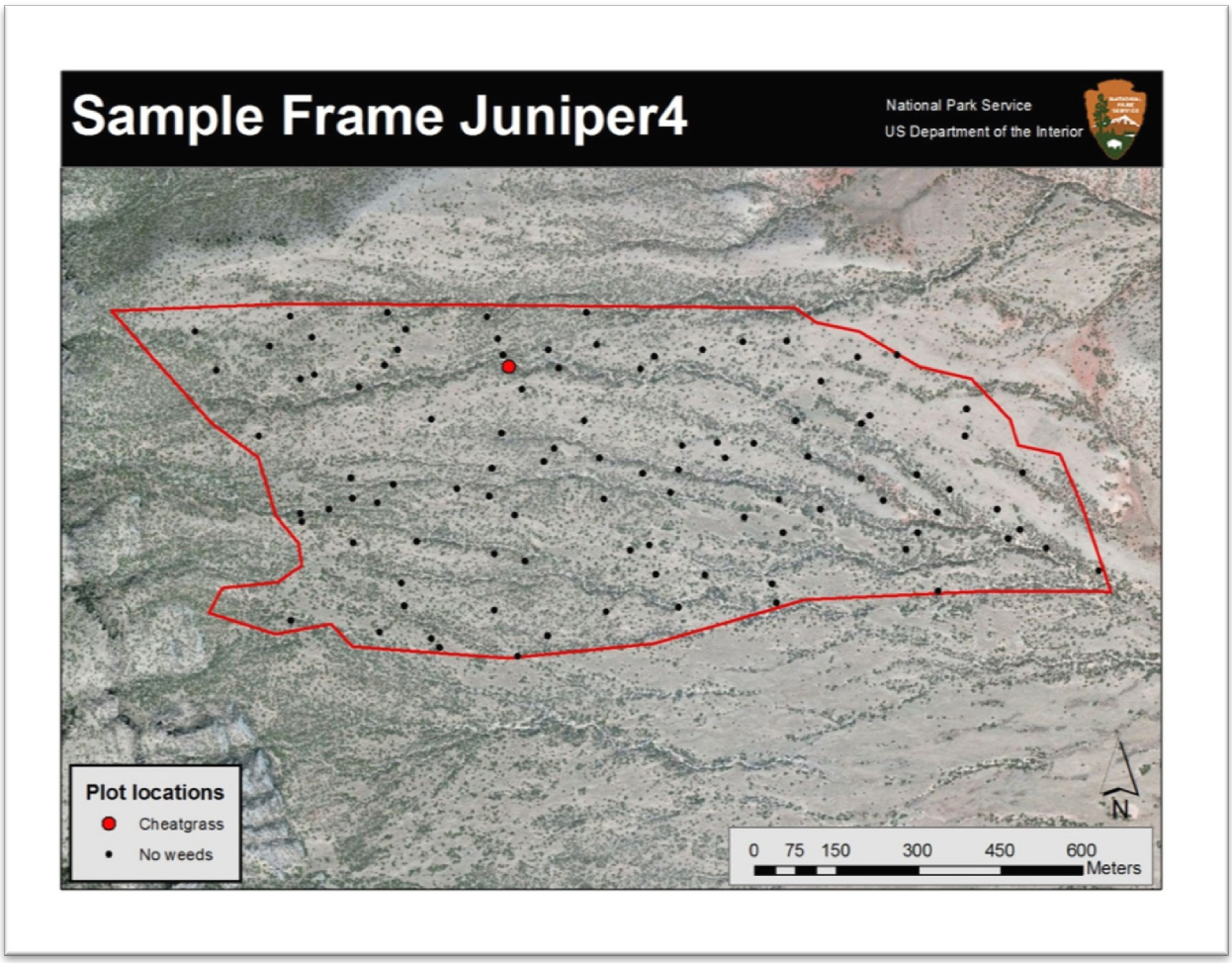

Figure 15. Map showing quadrats sampled in 2012 within sample frame Juniper04. The red points are quadrats with cheatgrass present. The location of this sample frame is shown in Figure 1.

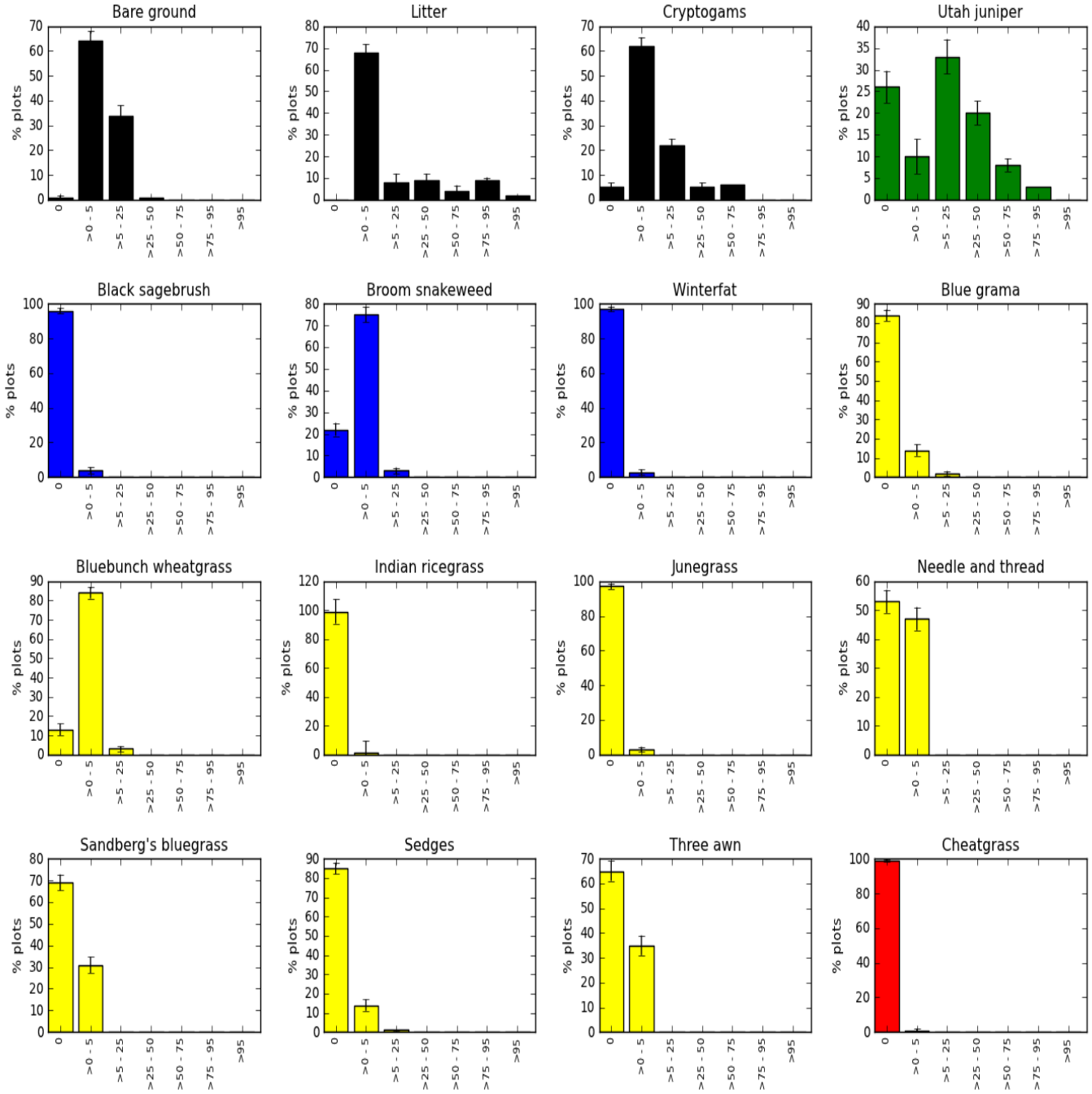

Figure 16. Percent frequency of quadrats (plots) by Daubenmire cover class for all target plant species reported in sample frame Juniper04 in 2012. Chart colors show different strata: black=ground cover attributes, green=trees, blue=shrubs, yellow=grass and grass-like, and red=non-native plants. Error bars show one standard error, calculated from the local variance estimator.

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Table 7. Proportion of quadrats (n=100) for sample frame Juniper04 within each cover class for ground cover and principal plant species organized by species guilds, Bighorn Canyon National Recreation Area, 2012.

Frame Name: Juniper04 **Dominant cover type: Juniper woodland**	**0%**[1]	**>0-5%**	**>5-25%**	**>25-50%**	**>50-75%**	**>75-95%**	**>95-100%**
Ground Cover							
Bare ground	0.01	0.64	0.34	0.01	0	0	0
Litter	0	0.68	0.08	0.09	0.04	0.09	0.02
Cryptogams	0.05	0.62	0.22	0.05	0.06	0	0
Trees							
Utah juniper (*Juniperus osteosperma*)	0.26	0.1	0.33	0.2	0.08	0.03	0
Shrubs							
Black sagebrush (*Artemisia nova*)	0.96	0.04	0	0	0	0	0
Broom snakeweed (*Gutierrezia sarothrae*)	0.22	0.75	0.03	0	0	0	0
Winterfat (*Krascheninnikovia lanata*)	0.97	0.03	0	0	0	0	0
Grasses and grass-like							
Blue grama (*Bouteloua gracilis*)	0.84	0.14	0.02	0	0	0	0
Bluebunch wheatgrass (*Pseudoroegneria spicata*)	0.13	0.84	0.03	0	0	0	0
Indian ricegrass (*Achnatherum hymenoides*)	0.99	0.01	0	0	0	0	0
Junegrass (*Koeleria macrantha*)	0.97	0.03	0	0	0	0	0
Needle and thread (*Hesperostipa comata* var. *comata*)	0.53	0.47	0	0	0	0	0
Sandberg's bluegrass (*Poa secunda*)	0.69	0.31	0	0	0	0	0
Sedges (*Carex* spp.)	0.85	0.14	0.01	0	0	0	0
Three awn (*Aristida purpurea* var. *fendleriana*)	0.65	0.35	0	0	0	0	0
Non-native-present in park							
Cheatgrass (*Bromus tectorum*)	0.99	0.01	0	0	0	0	0

[1]Daubenmire Cover Class Categories

Sample Frame: Juniper08

This sample frame is located near the South Fork of Trail Creek on the west side of Highway 37 outside the Pryor Mountain Wild Horse Range. The frame size is 77 ha (190 ac) and the elevation ranges between 1,229 m (4,034') and 1,306 m (4,286'). The geology is mapped as Tensleep Sandstone (KellerLynn 2011). The dominant vegetation cover is Utah juniper woodlands (Knight et al. 1987).

In 2012, vegetation cover estimates were recorded from 100 sampling quadrats between May 20 and 23. Cheatgrass was the only non-native plant species documented during the 2012 season. Refer to map Figure 17 for quadrat and cheatgrass locations.

In 2012 the Western Area Power Administration began rebuilding a power line running north/south through the National Recreation Area. As a result, Bighorn Canyon opened many access roads in 2012 and four of the five quadrats rejected were due to roadbed disturbance along the power line.

The frequency of target plants and ground cover attributes for each Daubenmire cover class reported in 2012 are shown in Figure 18 and as proportions in Table 7.

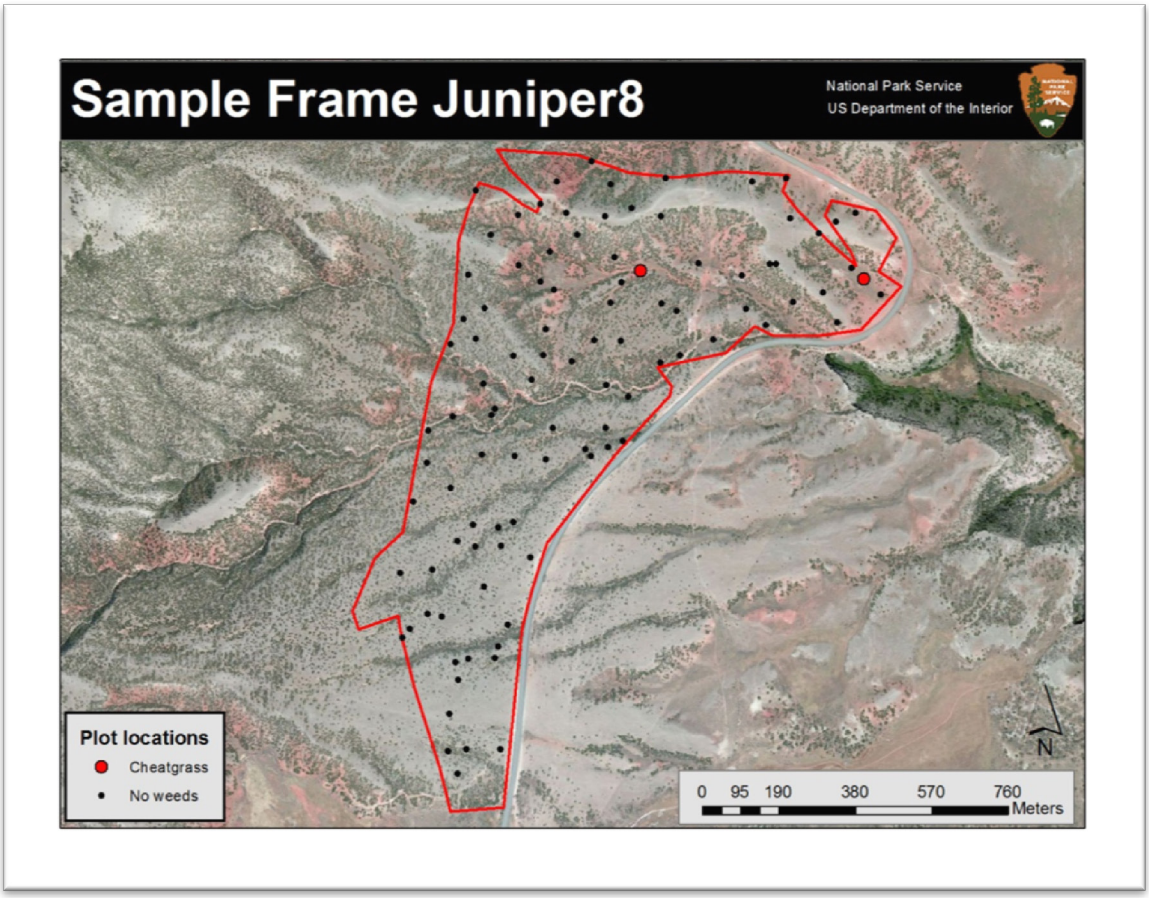


Figure 17. Map showing quadrats (plots) sampled in 2012 within sample frame Juniper08. The red points are quadrats with cheatgrass present. The location of this sample frame is shown in Figure 1.

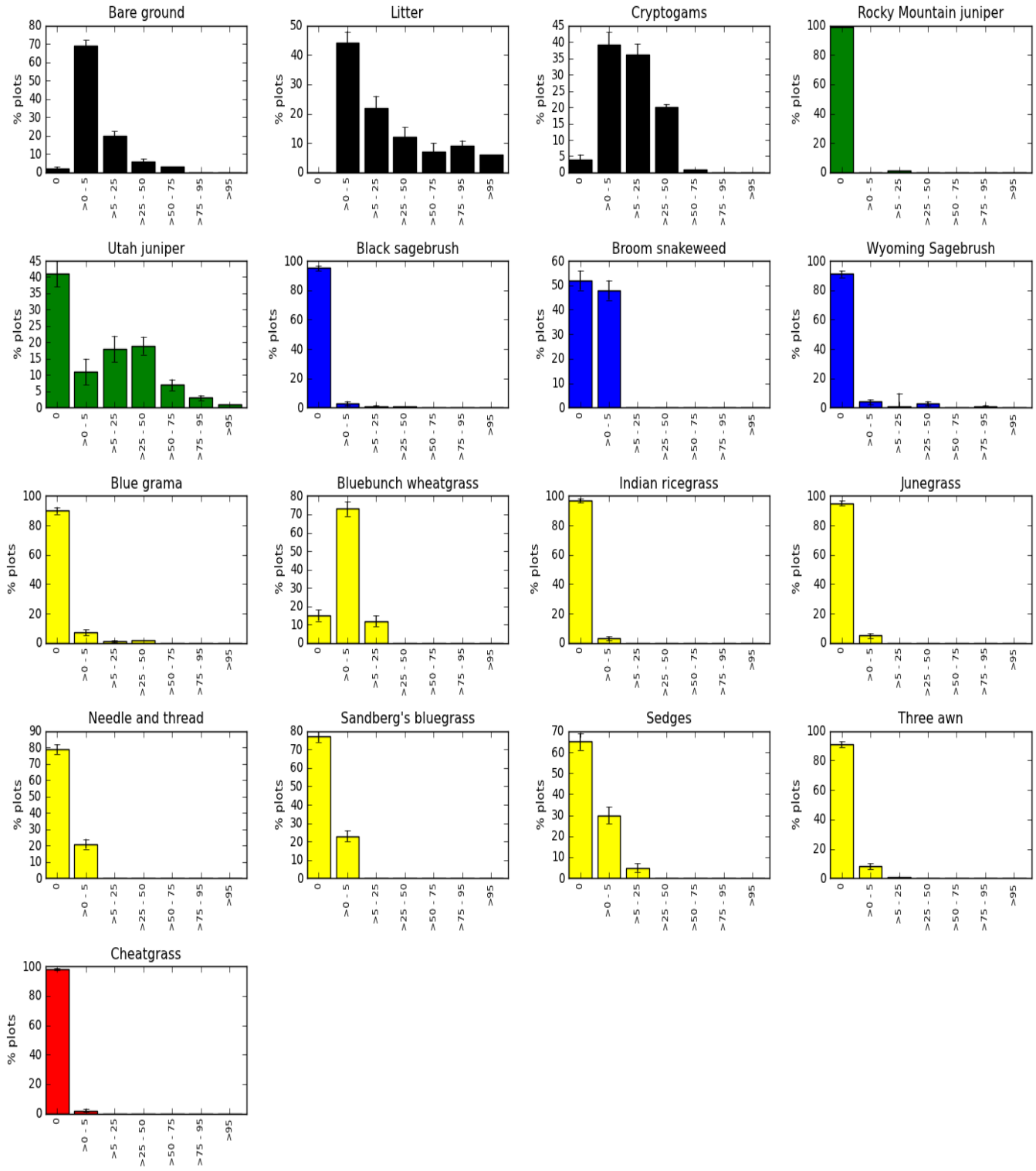


Figure 18. Percent frequency of quadrats (plots) by Daubenmire cover class for all target plant species reported in sample frame Juniper08 in 2012. Chart colors show different strata: black=ground cover attributes, green=trees, blue=shrubs, yellow=grass and grass-like, and red=non-native plants. Error bars show one standard error, calculated from the local variance estimator.

Table 8. Proportion of quadrats (n=100) for sample frame Juniper08 within each cover class for ground cover and principal plant species organized by species guilds, Bighorn Canyon National Recreation Area, 2012.

Frame Name: Juniper08 **Dominant cover type: Juniper woodland**	**0%**[1]	**>0-5%**	**>5-25%**	**>25-50%**	**>50-75%**	**>75-95%**	**>95-100%**
Ground Cover							
Bare ground	0.02	0.69	0.2	0.06	0.03	0	0
Litter	0	0.44	0.22	0.12	0.07	0.09	0.06
Cryptogams	0.04	0.39	0.36	0.2	0.01	0	0
Trees							
Rocky Mountain juniper (*Juniperus scopulorum*)	0.99	0	0.01	0	0	0	0
Utah juniper (*Juniperus osteosperma*)	0.41	0.11	0.18	0.19	0.07	0.03	0.01
Shrubs							
Black sagebrush (*Artemisia nova*)	0.95	0.03	0.01	0.01	0	0	0
Broom snakeweed (*Gutierrezia sarothrae*)	0.52	0.48	0	0	0	0	0
Wyoming Sagebrush (*Artemisia tridentata*)	0.91	0.04	0.01	0.03	0	0.01	0
Grasses and grass-like							
Blue grama (*Bouteloua gracilis*)	0.9	0.07	0.01	0.02	0	0	0
Bluebunch wheatgrass (*Pseudoroegneria spicata*)	0.15	0.73	0.12	0	0	0	0
Indian ricegrass (*Achnatherum hymenoides*)	0.97	0.03	0	0	0	0	0
Junegrass (*Koeleria macrantha*)	0.95	0.05	0	0	0	0	0
Needle and thread (*Hesperostipa comata* var. *comata*)	0.79	0.21	0	0	0	0	0
Sandberg's bluegrass (*Poa secunda*)	0.77	0.23	0	0	0	0	0
Sedges (*Carex* spp.)	0.65	0.3	0.05	0	0	0	0
Three awn (*Aristida purpurea* var. *fendleriana*)	0.91	0.08	0.01	0	0	0	0
Non-native-present in park							
Cheatgrass (*Bromus tectorum*)	0.98	0.02	0	0	0	0	0

[1] Daubenmire Cover Class Categories

Sample Frame: Lockhart Lane

This sample frame is located northwest of Lockhart Ranch in the upper reaches of Medicine Creek. The frame is split by the primary access road Highway 37, which is gravel at this point. The frame size is 57 ha (141 ac) and the elevation ranges between 1,278 m (4,195') and 1,365 m (4,481'). The geology is mapped primarily as the Chugwater formation which consists of fine grained sandstone, siltstone and mudstone (KellerLynn 2011). The dominant vegetation cover is juniper woodland (Knight et al. 1987). Medicine Creek is an important perennial water source in Bighorn Canyon and consequentially this area has a long history of human use.

In 2012, vegetation cover estimates were recorded from 100 sampling quadrats between June 20 and 23. Four different non-native plant species were reported during the 2012 survey; cheatgrass, Russian thistle, and potentially yellow and dalmation toadflax. If toadflax if confirmed, it would be the first report of these noxious weeds growing in Bighorn Canyon. Refer to map Figure 19 for quadrat and weed locations.

In 2012, the Western Area Power Administration began rebuilding the power line running north/south through the park. Consequently, the park opened many temporary access roads. Two of the five quadrats rejected during the survey were due to falling in roadbeds.

The frequency of target plants and ground cover attributes for each Daubenmire cover class reported in 2012 are shown in Figure 20 and as proportions in Table 9.

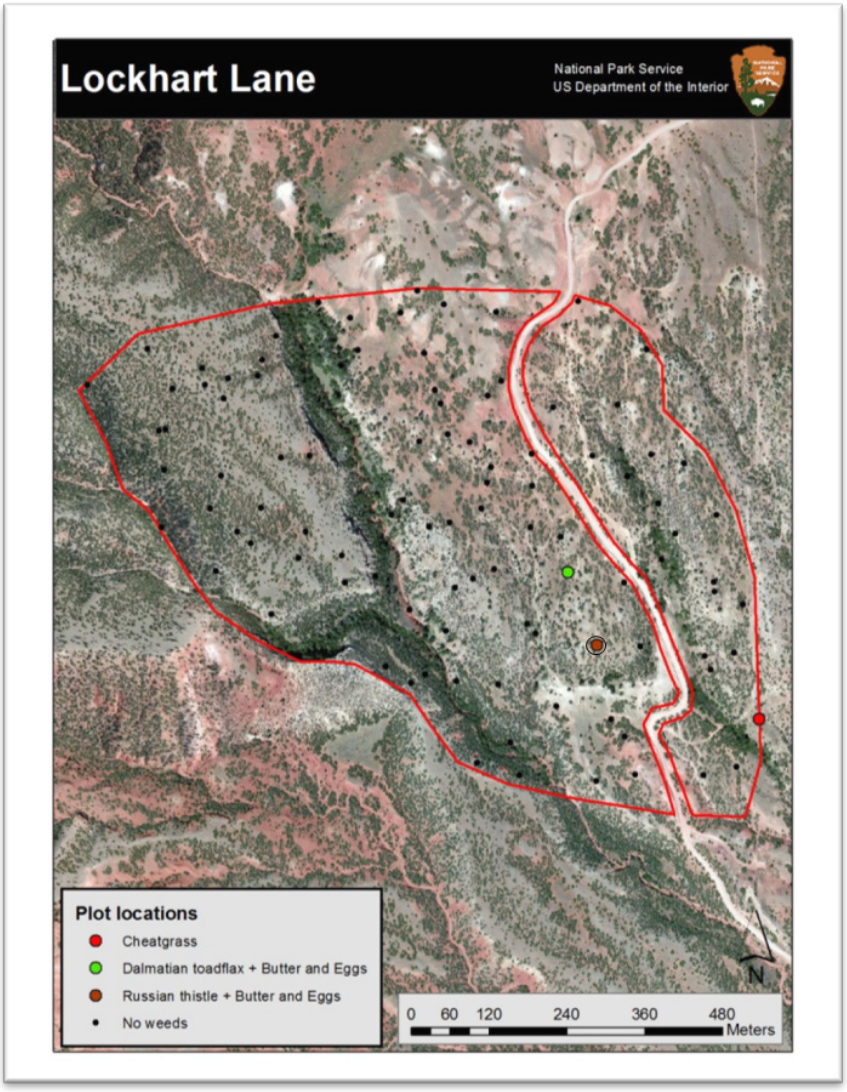


Figure 19. Map showing quadrats (plots) sampled in 2012 within sample frame Lockhart Lane. The colored points show locations where non-native plants were present. The location of this sample frame is shown in Figure 1.

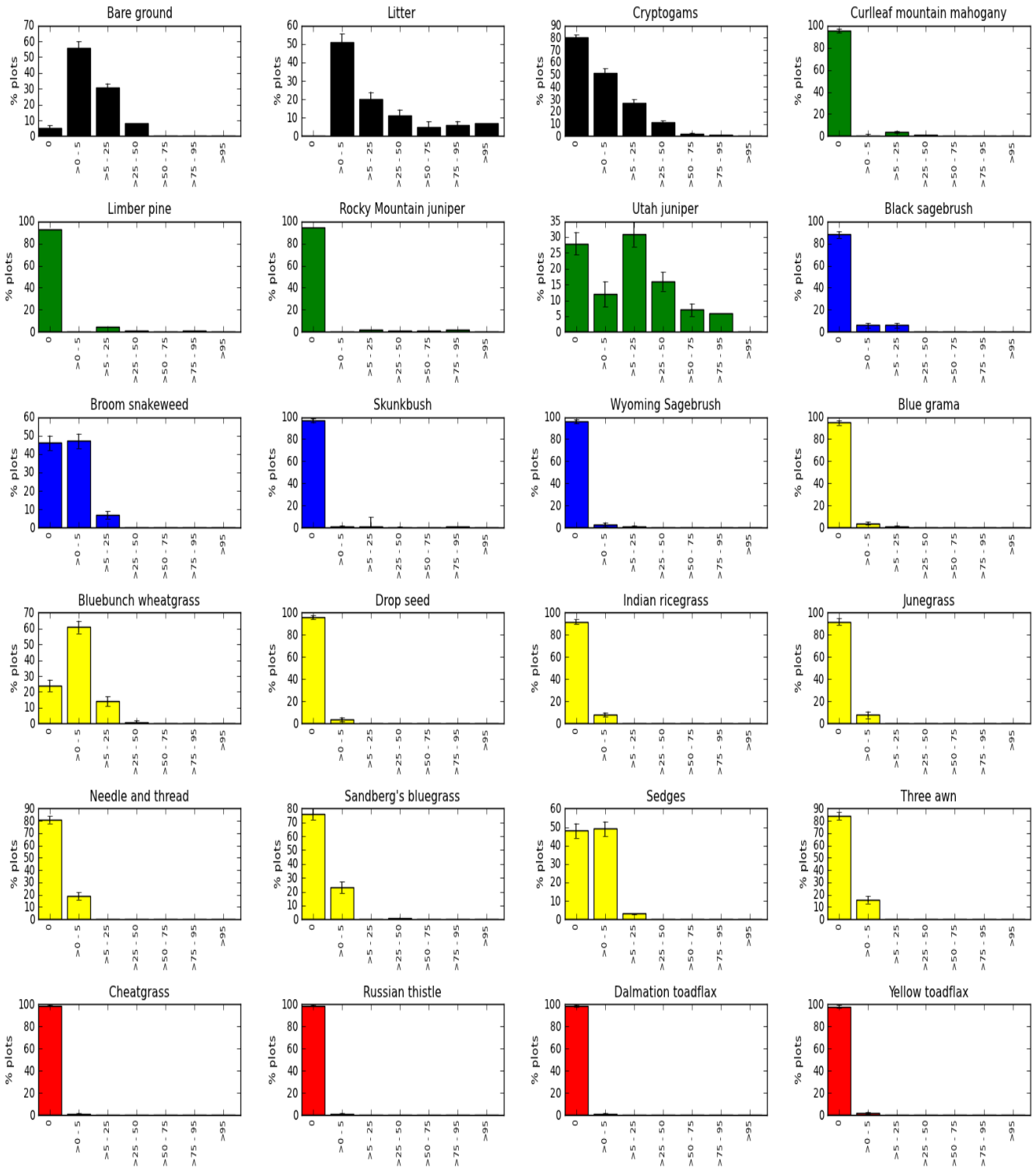


Figure 20 Percent frequency of quadrats (plots) by Daubenmire cover class for all target plant species reported in sample frame Lockhart Lane in 2012. Chart colors show different strata: black=ground cover attributes, green=trees, blue=shrubs, yellow=grass and grass-like, and red=non-native plants. Error bars show one standard error, calculated from the local variance estimator.

Table 9. Proportion of quadrats (n=100) for sample frame Lockhart Lane within each cover class for ground cover and principal plant species organized by species guilds, Bighorn Canyon National Recreation Area, 2012.

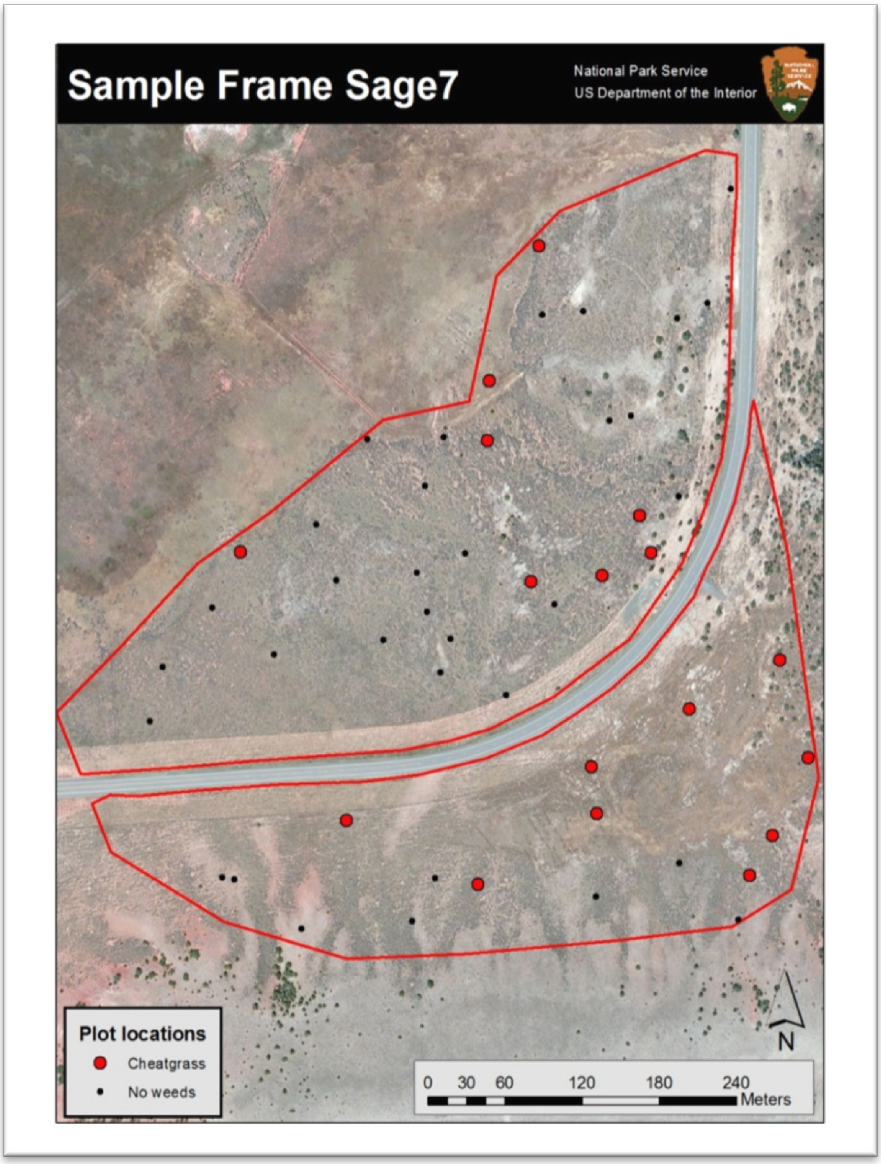
Frame Name: Lockhart Lane Dominant cover type: Juniper woodland	0%[1]	>0-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Ground Cover							
Bare ground	0.05	0.56	0.31	0.08	0	0	0
Litter	0	0.51	0.2	0.11	0.05	0.06	0.07
Cryptogams	0.8	0.51	0.27	0.11	0.02	0.01	0
Trees							
Curlleaf mountain mahogany (*Cercocarpus ledifolius*)	0.95	0	0.04	0.01	0	0	0
Limber pine (*Pinus flexilis*)	0.93	0	0.05	0.01	0	0.01	0
Rocky Mountain juniper (*Juniperus scopulorum*)	0.94	0	0.02	0.01	0.01	0.02	0
Utah juniper (*Juniperus osteosperma*)	0.28	0.12	0.31	0.16	0.07	0.06	0
Shrubs							
Black sagebrush (*Artemisia nova*)	0.88	0.06	0.06	0	0	0	0
Broom snakeweed (*Gutierrezia sarothrae*)	0.46	0.47	0.07	0	0	0	0
Skunkbush (*Rhus aromatica* var. *trilobata*)	0.97	0.01	0.01	0	0	0.01	0
Wyoming Sagebrush (*Artemisia tridentata*)	0.96	0.03	0.01	0	0	0	0
Grasses and grass-like							
Blue grama (*Bouteloua gracilis*)	0.95	0.04	0.01	0	0	0	0
Bluebunch wheatgrass (*Pseudoroegneria spicata*)	0.24	0.61	0.14	0.01	0	0	0
Drop seed (*Sporobolus* spp.)	0.96	0.04	0	0	0	0	0
Indian ricegrass (*Achnatherum hymenoides*)	0.92	0.08	0	0	0	0	0
Junegrass (*Koeleria macrantha*)	0.92	0.08	0	0	0	0	0
Needle and thread (*Hesperostipa comata* var. *comata*)	0.81	0.19	0	0	0	0	0
Sandberg's bluegrass (*Poa secunda*)	0.76	0.23	0	0.01	0	0	0
Sedges (*Carex* spp.)	0.48	0.49	0.03	0	0	0	0
Three awn (*Aristida purpurea* var. *fendleriana*)	0.84	0.16	0	0	0	0	0
Non-native-present in park							
Cheatgrass (*Bromus tectorum*)	0.99	0.01	0	0	0	0	0
Russian thistle (*Salsola tragus*)	0.99	0.01	0	0	0	0	0
Non-native-park watch list							
Dalmation toadflax (*Linaria dalmatica*)	0.99	0.01	0	0	0	0	0
Yellow toadflax (*Linaria vulgaris*)	0.98	0.02	0	0	0	0	0

[1] Daubenmire Cover Class Categories

Sample Frame: Sage07

This sample frame is located north of Layout Creek and immediately north of the PMWHR. The frame size is 44 ha (109 ac) and the elevation ranges between 1,275 m (4,186') and 1,297 m (4,255'). The geology is mapped as the Chugwater formation which consists of fine grained sandstone, siltstone and mudstone (KellerLynn 2011). The dominant vegetation cover is sagebrush steppe (Knight et al. 1987) and portions of the sample frame were mapped as agriculture land by Myers et al. (1986).

Layout Creek is an important perennial water source in Bighorn Canyon and consequentially this area has a long history of human use. The historic Ewing-Snell historic ranch site and the Common Corral, a corral still in use by local ranchers, are located nearby. Bighorn Canyon natural resource staff is actively restoring this area and bluebunch wheatgrass was seeded in the past decade. Evidence of the seed drilling operation (linear growth patterns) is still visible in 2012.



In 2012, vegetation cover estimates were recorded from 50 sampling quadrats on May 19 and 20. Six of eight quadrats rejected were due to falling within the road prism. Cheatgrass was the only non-native plant species documented during the 2012 season, however smooth brome (*Bromus inermis*) was noted as the dominant grass near the historic irrigation channel. Refer to map Figure 21 for quadrat and weed locations.

The frequency of target plants and ground cover attributes for each Daubenmire cover class reported in 2012 are shown in Figure 22 and as proportions in Table 10.

Figure 21. Map showing quadrats (plots) sampled in 2012 within sample frame Sage07. The red points are quadrats with cheatgrass present. The location of this sample frame is shown in Figure 1.

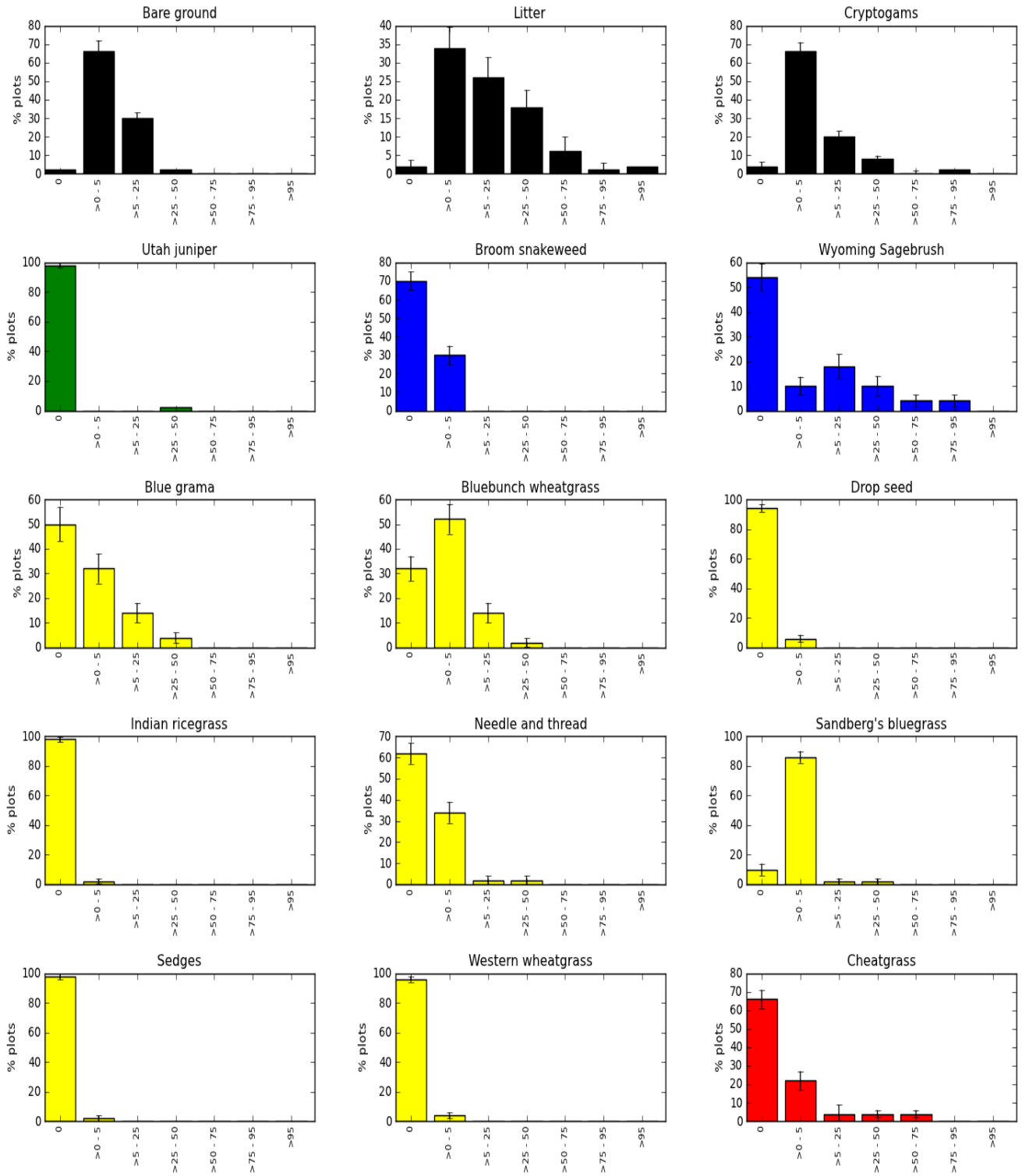


Figure 22. Percent frequency of quadrats (plots) by Daubenmire cover class for all target plant species reported in sample frame Sage07 in 2012. Chart colors show different strata: black=ground cover attributes, green=trees, blue=shrubs, yellow=grass and grass-like, and red=non-native plants. Error bars show one standard error, calculated from the local variance estimator.

Table 10. Proportion of quadrats (n=50) for sample frame Sage07 within each cover class for ground cover and principal plant species organized by species guilds, Bighorn Canyon National Recreation Area, 2012.

Frame Name: Sage07 **Dominant cover type: Sagebrush steppe**	**0%**[1]	**>0-5%**	**>5-25%**	**>25-50%**	**>50-75%**	**>75-95%**	**>95-100%**
Ground Cover							
Bare ground	0.02	0.66	0.3	0.02	0	0	0
Litter	0.02	0.34	0.26	0.18	0.06	0.012	0.02
Cryptogams	0.04	0.66	0.2	0.08	0	0.02	0
Trees							
Utah juniper (*Juniperus osteosperma*)	0.98	0	0	0.02	0	0	0
Shrubs							
Broom snakeweed (*Gutierrezia sarothrae*)	0.7	0.3	0	0	0	0	0
Wyoming Sagebrush (*Artemisia tridentata*)	0.54	0.1	0.18	0.1	0.04	0.04	0
Grasses and grass-like							
Blue grama (*Bouteloua gracilis*)	0.5	0.32	0.14	0.04	0	0	0
Bluebunch wheatgrass (*Pseudoroegneria spicata*)	0.32	0.52	0.14	0.02	0	0	0
Drop seed (*Sporobolus* spp.)	0.94	0.06	0	0	0	0	0
Indian ricegrass (*Achnatherum hymenoides*)	0.98	0.02	0	0	0	0	0
Needle and thread (*Hesperostipa comata* var. *comata*)	0.62	0.34	0.02	0.02	0	0	0
Sandberg's bluegrass (*Poa secunda*)	0.1	0.86	0.02	0.02	0	0	0
Sedges (*Carex* spp.)	0.98	0.02	0	0	0	0	0
Western wheatgrass (*Pascopyrum smithii*)	0.96	0.04	0	0	0	0	0
Non-native-present in park							
Cheatgrass (*Bromus tectorum*)	0.66	0.22	0.04	0.04	0.04	0	0

[1] Daubenmire Cover Class Categories

Sample Frame: Sage05

This sample frame is located near the rim of Bighorn Canyon on a bench north of the Trail Creek campground. This area is outside the PMWHR and is an important area for bighorn sheep. The frame size is 103 ha (255 ac) and the elevation ranges between 1,193 m (3,916') and 1,216 m (3,990'). The geology is mapped as Tensleep Sandstone (KellerLynn 2011). The dominant vegetation cover is sagebrush steppe (Knight et al. 1987).

In 2012, vegetation cover estimates were recorded from 50 sampling quadrats on June 7 and 8; an additional two quadrats were completed on June 20. Two non-native plant species, cheatgrass and Russian thistle, were documented during the 2012 season. Refer to map Figure 23 for quadrat and weed locations.

The frequency of target plants and ground cover attributes for each Daubenmire cover class reported in 2012 are shown in Figure 24 and as proportions in Table 11.

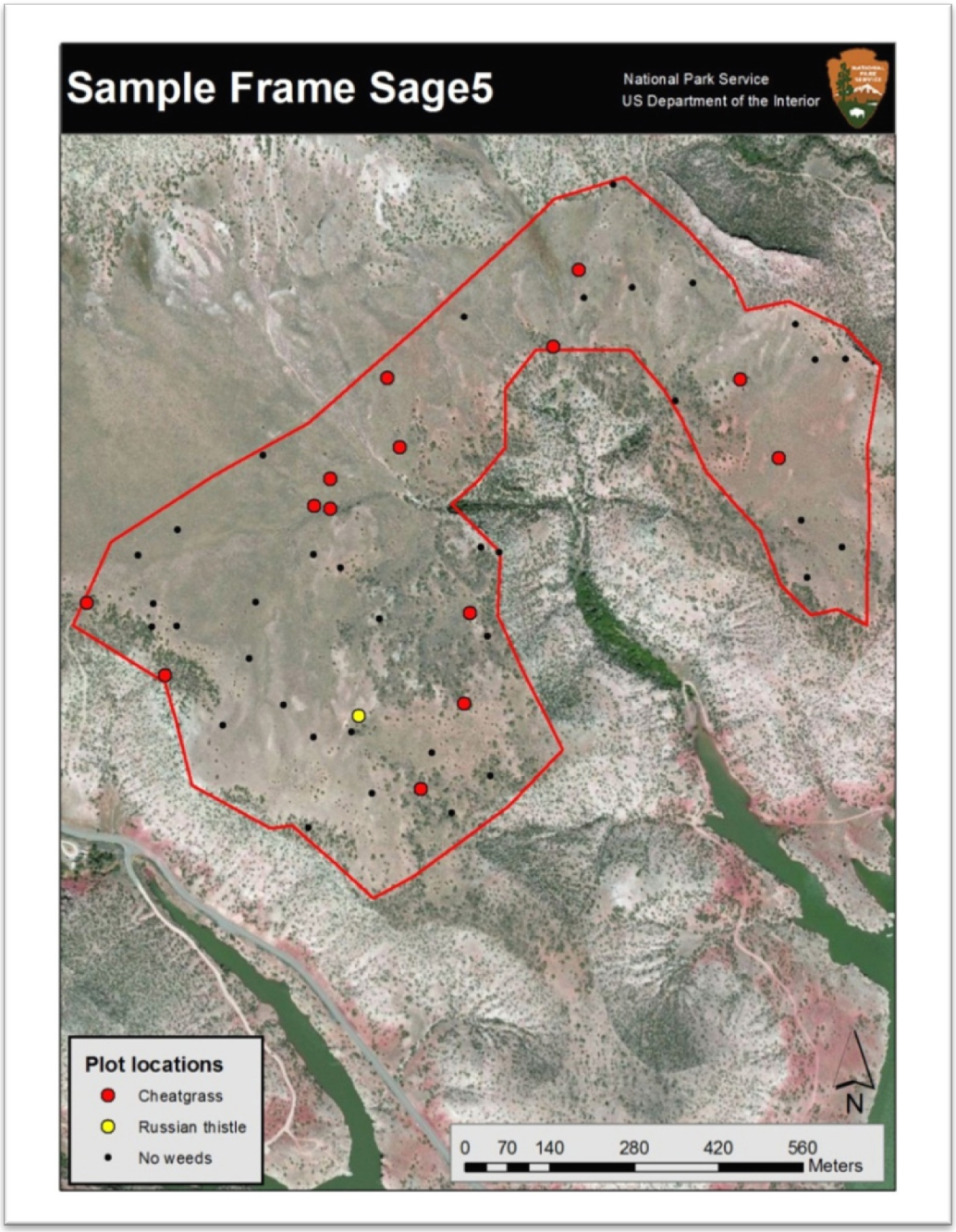


Figure 23. Map showing quadrats sampled in 2012 within sample frame Sage05. The red points are quadrats with cheatgrass present; the yellow points have Russian thistle present. The location of this sample frame is shown in Figure 1.

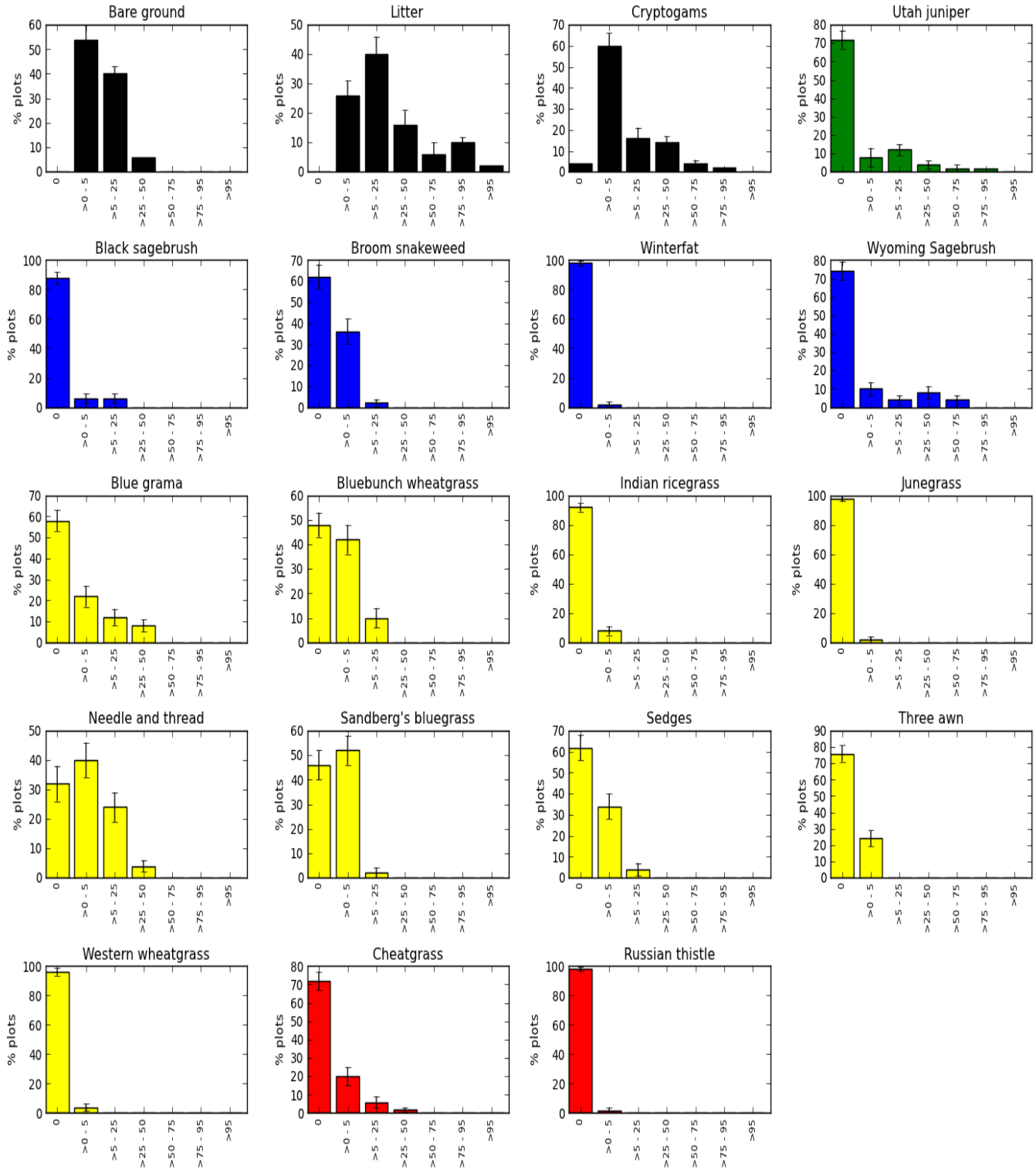


Figure 24. Percent frequency of quadrats (plots) by Daubenmire cover class for all target plant species reported in sample frame Sage05 in 2012. Chart colors show different strata: black=ground cover attributes, green=trees, blue=shrubs, yellow=grass and grass-like, and red=non-native plants. Error bars show one standard error, calculated from the local variance estimator.

Table 11. Proportion of quadrats (n=50) for sample frame Sage05 within each cover class for ground cover and principal plant species organized by species guilds, Bighorn Canyon National Recreation Area, 2012.

Frame Name: Sage05 Dominant cover type: Sagebrush steppe	0%[1]	>0-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Ground Cover							
Bare ground	0	0.54	0.4	0.06	0	0	0
Litter	0	0.26	0.4	0.16	0.06	0.1	0.02
Cryptogams	0.04	0.6	0.16	0.14	0.04	0.02	0
Trees							
Utah juniper (*Juniperus osteosperma*)	0.72	0.08	0.12	0.04	0.02	0.02	0
Shrubs							
Black sagebrush (*Artemisia nova*)	0.88	0.06	0.06	0	0	0	0
Broom snakeweed (*Gutierrezia sarothrae*)	0.62	0.36	0.02	0	0	0	0
Winterfat (*Krascheninnikovia lanata*)	0.98	0.02	0	0	0	0	0
Wyoming Sagebrush (*Artemisia tridentata*)	0.74	0.1	0.04	0.08	0.04	0	0
Grasses and grass-like							
Blue grama (*Bouteloua gracilis*)	0.58	0.22	0.12	0.08	0	0	0
Bluebunch wheatgrass (*Pseudoroegneria spicata*)	0.48	0.42	0.1	0	0	0	0
Indian ricegrass (*Achnatherum hymenoides*)	0.92	0.08	0	0	0	0	0
Junegrass (*Koeleria macrantha*)	0.98	0.02	0	0	0	0	0
Needle and thread (*Hesperostipa comata* var. *comata*)	0.32	0.4	0.24	0.04	0	0	0
Sandberg's bluegrass (*Poa secunda*)	0.46	0.52	0.02	0	0	0	0
Sedges (*Carex* spp.)	0.62	0.34	0.04	0	0	0	0
Three awn (*Aristida purpurea* var. *fendleriana*)	0.76	0.24	0	0	0	0	0
Western wheatgrass (*Pascopyrum smithii*)	0.96	0.04	0	0	0	0	0
Non-native-present in park							
Cheatgrass (*Bromus tectorum*)	0.72	0.2	0.06	0.02	0	0	0
Russian thistle (*Salsola tragus*)	0.98	0.02	0	0	0	0	0

[1] Daubenmire Cover Class Categories

Sample Frame: Sage08

This sample frame is located near the rim of Bighorn Canyon between Layout and Trail creeks outside the PMWHR. The frame size is 49 ha (121 ac) and the elevation ranges between 1,185 m (3,891') and 1,210 m (3,970'). The geology is mapped as Tensleep Sandstone (KellerLynn 2011). The dominant vegetation cover is sagebrush steppe (Knight et al. 1987).

In 2012, vegetation cover estimates were recorded from 50 sampling quadrats on June 23 and 24. Two non-native plant species, cheatgrass and Russian thistle were documented during the 2012 season. Refer to map Figure 25 for quadrat and non-native plant locations.

The frequency of target plants and ground cover attributes for each Daubenmire cover class reported in 2012 are shown in Figure 26 and as proportions in Table 12.

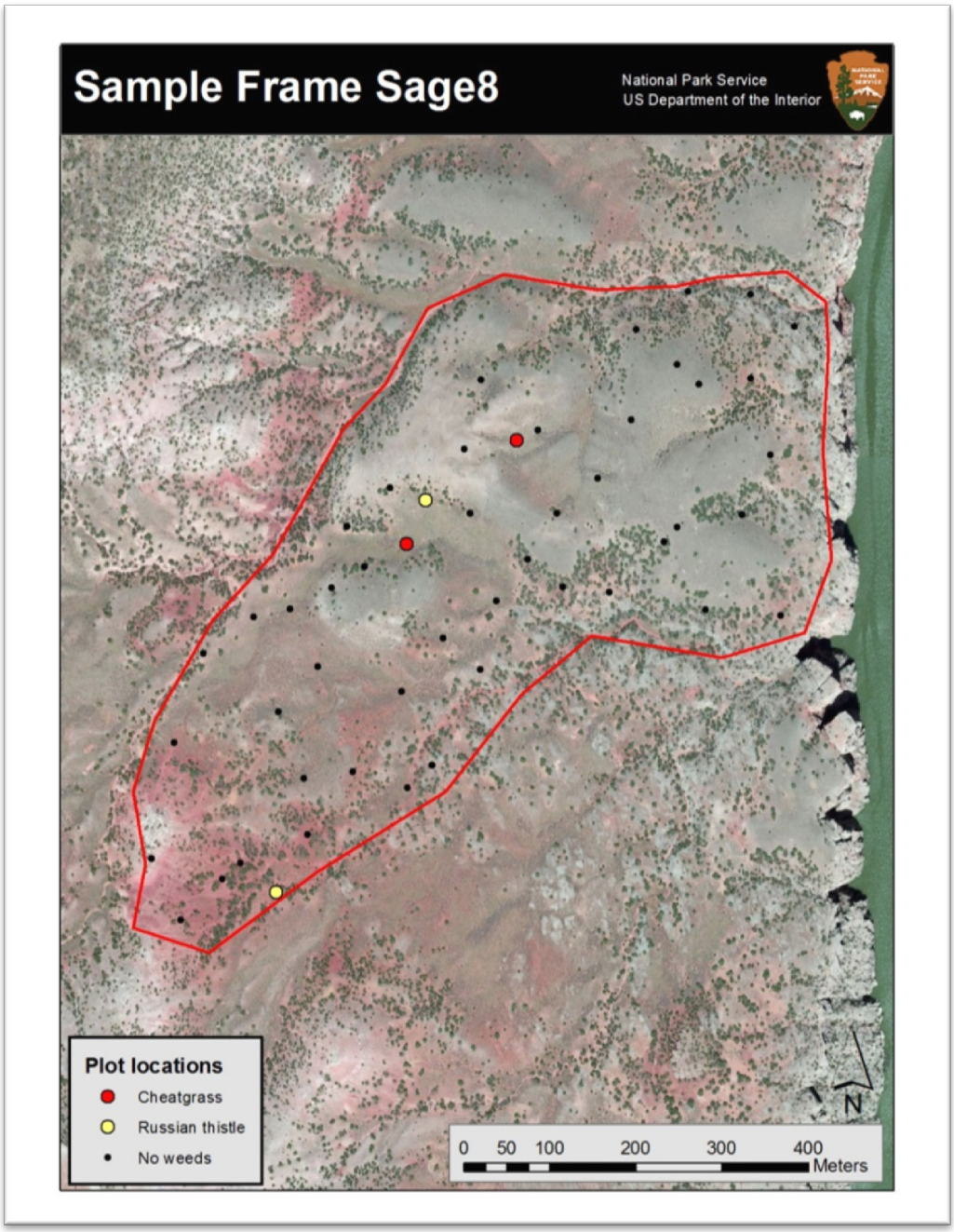


Figure 25. Map showing quadrats sampled in 2012 within sample frame Sage08. The red points are quadrats with cheatgrass present; the yellow points have Russian thistle. The location of this sample frame is shown in Figure 1.

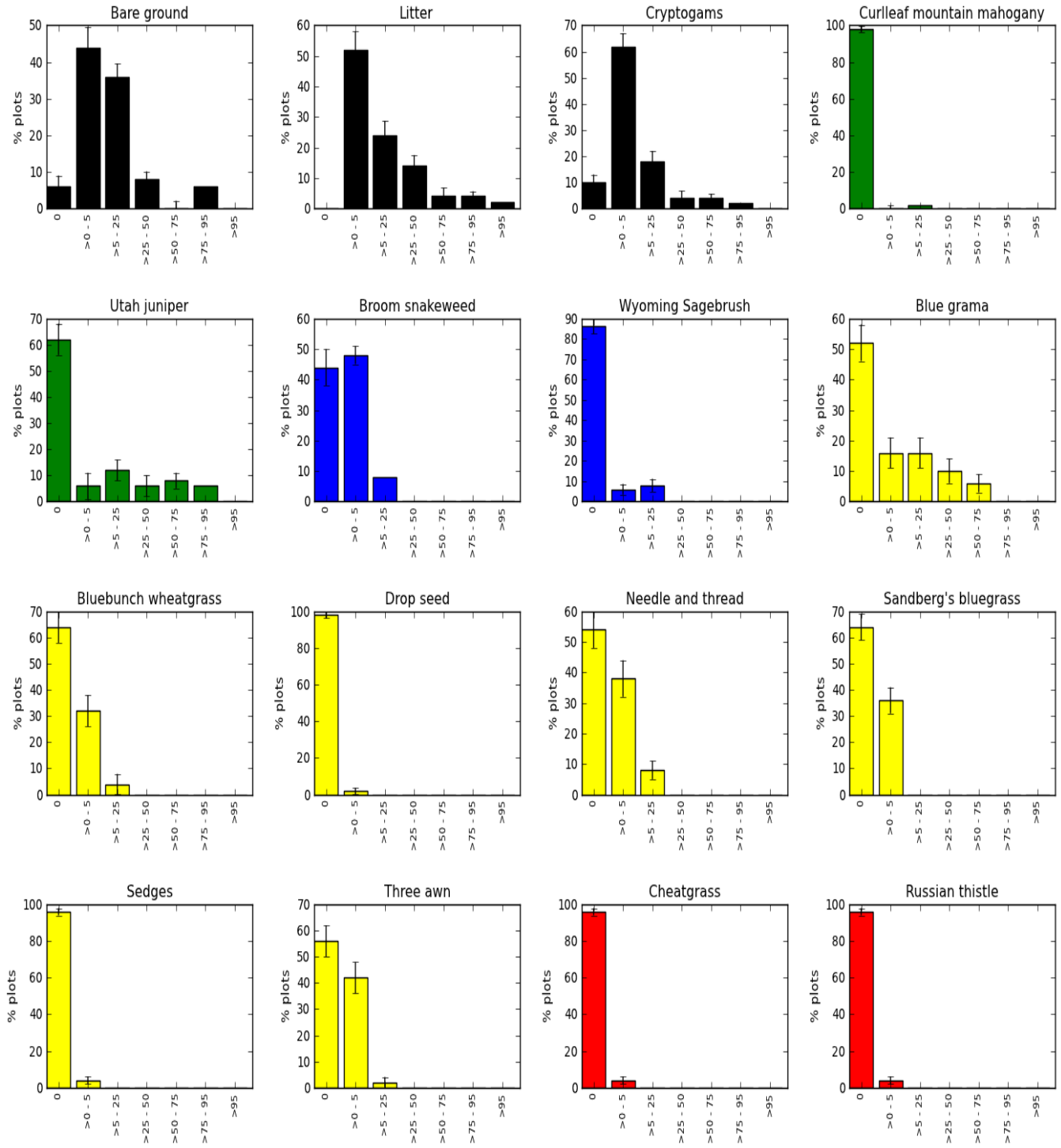


Figure 26. Percent frequency of quadrats (plots) by Daubenmire cover class for all target plant species reported in sample frame Sage08 in 2012. Chart colors show different strata: black=ground cover attributes, green=trees, blue=shrubs, yellow=grass and grass-like, and red=non-native plants. Error bars show one standard error, calculated from the local variance estimator.

Table 12. Proportion of quadrats (n=50) for sample frame Sage08within each cover class for ground cover and principal plant species organized by species guilds, Bighorn Canyon National Recreation Area, 2012.

Frame name: Sage08 Dominant cover type: Sagebrush steppe	0%[1]	>0-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Ground Cover							
Bare ground	0.06	0.44	0.36	0.08	0	0.06	0
Litter	0	0.52	0.24	0.14	0.04	0.04	0.02
Cryptogams	0.1	0.62	0.18	0.04	0.04	0.02	0
Trees							
Curlleaf mountain mahogany (*Cercocarpus ledifolius*)	0.98	0	0.02	0	0	0	0
Utah juniper (*Juniperus osteosperma*)	0.62	0.06	0.12	0.06	0.08	0.06	0
Shrubs							
Broom snakeweed (*Gutierrezia sarothrae*)	0.44	0.48	0.08	0	0	0	0
Wyoming Sagebrush (*Artemisia tridentata*)	0.86	0.06	0.08	0	0	0	0
Grasses and grass-like							
Blue grama (*Bouteloua gracilis*)	0.52	0.16	0.16	0.1	0.06	0	0
Bluebunch wheatgrass (*Pseudoroegneria spicata*)	0.64	0.32	0.04	0	0	0	0
Drop seed (*Sporobolus* spp.)	0.98	0.02	0	0	0	0	0
Needle and thread (*Hesperostipa comata* var. *comata*)	0.54	0.38	0.08	0	0	0	0
Sandberg's bluegrass (*Poa secunda*)	0.64	0.36	0	0	0	0	0
Sedges (*Carex* spp.)	0.96	0.04	0	0	0	0	0
Three awn (*Aristida purpurea* var. *fendleriana*)	0.56	0.42	0.02	0	0	0	0
Non-native-present in park							
Cheatgrass (*Bromus tectorum*)	0.96	0.04	0	0	0	0	0

[1] Daubenmire Cover Class Categories

Noteworthy Protocol Changes

In late 2012, the GRYN Upland Vegetation Monitoring Protocol (Tercek et al. 2013) and standard operating procedures (Jean et al. 2013) underwent internal and formal peer review. The relevant changes are highlighted here to explain how data collected in 2012 will differ from the long term data-set collected using the approved and published monitoring protocol.

The boundary of each sampling frame was evaluated, and four of the nine frames sampled in 2012 were realigned to better fit the target vegetation and to reduce the heterogeneous vegetation composition. Although the sample frame location is generally unchanged, adjustments to the perimeter and areal extent of the following frames are significant enough that no direct comparisons should be made between data from 2012 and future years: Lockhart Lane (now BICA_LTM_Veg40), Juniper8 (now BICA_LTM_Veg60), Sage5 (now BICA_LTM_Veg70) and Sage8 (now BICA_LTM_Veg90).

As shown in the list above, each sample frame is now identified by a standardized code in place of the "vegetation community type" identifiers used in 2012. The new coding scheme uses the park's alpha code (BICA), the acronym "LTM" for "Long Term Monitoring," "Veg" to signify the type of monitoring, and a two-digit number incremented by tens to distinguish between sample frames.

Starting in 2013 estimates of litter cover will be determined only within the spaces between plant canopies. This differs from 2012 estimates that also included litter beneath the canopy of plants. This change was made in order to better evaluate how litter, in the form of detached dead stems, leaves, and other woody debris in contact with the ground, protects soil between plants.

Also starting in 2013, recruitment data for each trees species present will be recorded as a count of single-stemmed and multi-stemmed live trees less than 10 cm in height within the 3.16 m^2 sampling quadrat. The range of juniper communities in general has expanded significantly since settlement of the western U.S. Overgrazing, fire exclusion, dispersion of seed by humans or cattle, or a combination of these and other factors have contributed to juniper expansion. Collecting data on tree recruitment will improve the ability to assess and predict the density of juniper in the sample frames and will complement anecdotal evidence suggesting that densities of juniper within the park are increasing (NPS 2009).

Smooth brome (*Bromus inermis*) and prickly pear (*Opuntia polyacantha*) were added to the target plant list in 2012. Smooth brome was introduced decades ago as a pasture grass and for reclamation purposes and is a now a persistent non-native plant species that can invade disturbed sites. Smooth brome was reported by crew members in frame Sage07 in 2012. Prickly pear is useful to monitor because it can also invade degraded sites.

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Appendix A. Plant Species and Ground Cover Attributes

Table A-1. Vascular plants and ground cover attributes targeted for monitoring in the Upland Vegetation Monitoring Protocol in 2012 (Tercek et al. 2013).

Scientific Name	Common Name
Ground Cover	
Bare ground	*Bare ground*
Cryptobiotic soil crust	*Cryptobiotic soil crust*
Litter	*Litter*
Grass or grass-like	
Achnatherum hymenoides	Indian ricegrass
Aristida purpurea var. *fendleriana*	Three awn
Bouteloua gracilis	Blue grama
Carex spp.	Sedges
Festuca idahoensis	Idaho fescue
Hesperostipa comata var. *comata*	Needle and thread
Koeleria macrantha	Junegrass
Pascopyrum smithii	Western wheatgrass
Poa secunda	Sandberg's bluegrass
Pseudoroegneria spicata	Bluebunch wheatgrass
Sporobolus spp.	Drop seed
Shrubs	
Artemisia nova	Black sagebrush
Artemisia tridentata	Wyoming Sagebrush
Atriplex spp.	Saltbush
Gutierrezia sarothrae	Broom snakeweed
Krascheninnikovia lanata	Winter fat
Rhus aromatica var. *trilobata*	Skunkbush
Trees	
Cercocarpus ledifolius	Curlleaf mountain mahogany
Juniperus osteosperma	Utah juniper
Juniperus scopulorum	Rocky Mountain juniper
Pinus flexilis	Limber pine
Non-native-present in park	
Agropyron cristatum	Crested wheatgrass
Arctium minus	Common burdock
Bassia sieversiana	Kochia
Bromus japonicus	Japanese brome
Bromus tectorum	Cheatgrass
Cardaria chalapensis	White top
Cardaria pubescens	Hoary cress
Centaurea diffusa	Diffuse knapweed
Centaurea maculosa	Spotted knapweed
Centaurea repens	Russian knapweed
Cirsium arvense	Canada thistle
Cirsium vulgare	Bull thistle

Table A-1. Vascular plants and ground cover attributes targeted for monitoring in the Upland Vegetation Monitoring Protocol in 2012 (continued).

Scientific Name	Common Name
Non-native-present in park (cont.)	
Conium maculatum	Poison hemlock
Convolvulus arvensis	Field bindweed
Cynoglossum officinale	Houndstounge
Dactylis glomerata	Orchard grass
Elaeagnus angustifolia	Russian olive
Elymus repens	Quackgrass
Halogeton glomeratus	Salt-lover
Melilotus spp.	Sweet-clover
Salsola tragus	Russian thistle
Tamarix chinensis	Salt cedar
Tanacetum vulgare	Common tansy
Tribulus terrestris	Puncture vine
Non-native-watch list	
Carduus acanthoides	Plumeless thistle
Cardaria draba	Hoary cress
Carduus nutans	Musk thistle
Chondrilla juncea	Rush skeletonweed
Chrysanthemum leucanthemum	Ox-eye daisy
Euphorbia esula	Leafy spurge
Hypericum perforatum	St. John's wort
Isatis tinctoria	Dyer's woad
Lepidium latifolium	Perennial pepperweed
Linaria dalmatica	Dalmatian toadflax
Linaria vulgaris	Yellow toadflax
Lythrum salicaria	Purple loosestrife
Onopordum acanthium	Scotch thistle
Sonchus arvensis	Perennial sowthistle