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Sagebrush Steppe Vegetation Monitoring in Craters of the Moon National Monument and Preserve, Hagerman Fossil Beds National Monument, John Day Fossil Beds National Monument, and Lake Roosevelt National Recreation Area

2009 Annual Report

Natural Resource Technical Report NPS/UCBN/NRTR—2010/302

ON THE COVER
Sagebrush-steppe vegetation, Lake Roosevelt National Recreation Area, Washington
Photograph courtesy of the Upper Columbia Basin Network

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Abstract

As part of the Upper Columbia Basin Network's (UCBN) effort to conduct vital signs monitoring in 2009, key indicators of sagebrush steppe vegetation biotic integrity, soil stability, and hydrologic function were measured in Craters of the Moon National Monument and Preserve (CRMO), Hagerman Fossil Beds National Monument (HAFO), John Day Fossil Beds National Monument (JODA), and Lake Roosevelt National Recreation Area (LARO). Sagebrush steppe is one of the most threatened ecosystems in the intermountain west, and land use practices both within and adjacent to UCBN park steppe communities have resulted in fragmented and altered park ecosystems. Predicted climate change for the region may exacerbate these changes. This annual report summarizes key indicators of rangeland health obtained from the first pilot season of monitoring in CRMO and LARO, and the second pilot season of monitoring in HAFO and JODA. Methods followed a draft protocol that had been peer-reviewed and was in revision at the time of data collection. A final, peer-reviewed and approved protocol was produced following the 2009 field season, which will be implemented in 2010. Changes between the draft and final protocol were inconsequential to methods and analyses conducted for this report and the data used for this report will be included in subsequent trend analyses. Cover of principal native and non-native plant species and bare ground was estimated in 1244 plots distributed across the 4 parks in multiple discrete sampling "frames". Sample plot locations were drawn using a spatially-balanced random sampling design, the Generalized Random Tessellation Stratified (GRTS) design, which ensures a good representative random sample with good dispersion within each sampling frame.

Analyses of 2009 data included here describe baseline conditions of sagebrush steppe community composition and structure against which future change will be measured. In general, the results from 2009 provide consistent and biologically interpretable descriptions of existing conditions (status) of park frames. Areas in good condition have higher amounts of native vegetation and fewer non-native species, as expected. However, a wide range of conditions were encountered among and within parks. The proportion of plots containing cheatgrass (*Bromus tectorum*), a ubiquitous invasive annual grass introduced from Eurasia during the 19th century, ranged from 4% in one CRMO frame, to 100% in several frames in HAFO, JODA, and LARO. The proportion of plots with cheatgrass cover >25% ranged among frames from 2%-89%. Bluebunch wheatgrass (*Pseudoroegneria spicata*), a fundamental native perennial bunchgrass species included in potential natural vegetation descriptions for all 4 parks, was not encountered in any sample plot in HAFO. The proportion of plots in the other parks in which this species occurred with > 5% cover ranged from 2%-73%. The proportion of plots containing >5% cover of big sagebrush (*Artemisia tridentata*) ranged from 0% in one frame in LARO to 70% in CRMO. Noxious weeds were encountered rarely within plots ($\leq$4%), and only in areas with highest historic disturbance and that were also covered with large amounts of cheatgrass and other non-native species. Tumbling mustard (*Sisymbrium altissimum*), a Eurasian annual forb indicative of rangeland degradation, occurred with >5% cover in 4-15% of plots in HAFO. Each of these parks occurs in very different environmental settings. Elevations, soil types, and land use histories differ widely among the 4 parks and differences in status are not readily comparable. Rather, each park needs to be considered within its own unique biophysical context, and, accordingly, this report presents results by park in a graphical format.

Introduction

Prior to European colonization, sagebrush steppe covered approximately 44 million ha of the Intermountain West (West and Young 2000). Since then the sagebrush steppe ecosystem has experienced extensive changes (USDA Forest Service 1996, West and Young 2000, Bureau of Land Management 2002, Reid et al. 2002). Substantial portions of the region have been converted to agriculture and development (West and Young 2000, Bunting et al. 2002). Much of the remaining sagebrush steppe has been degraded through overgrazing by livestock, altered fire regimes, and invasion of introduced plants (Reid et al. 2002). These changes have had significant impacts on the ecological condition of the sagebrush steppe, including a decline in native flora and fauna, decreased soil stability, and reduced hydrologic function (Mack and D'Antonio 1998, Wisdom et al. 2000, Keane et al. 2002, Knick et al. 2003, Dobkin and Sauder 2004). Sagebrush steppe today is one of the most threatened ecosystems in the Intermountain West (Noss et al. 1995). Biological invasions, altered fire regimes, and other stressors continue to cause major, possibly irreversible, changes to steppe ecosystem structure and function (e.g., Knick et al. 2003, 2005, Brooks et al. 2004, Dobkin and Sauder 2004).

The degradation of sagebrush steppe so widespread throughout the Intermountain West has also occurred within UCBN parks. Sagebrush steppe is the most extensive ecosystem type in the Upper Columbia Basin Network (UCBN), occupying over 50% of land cover in City of Rocks National Reserve, Hagerman Fossil Beds National Monument (HAFO), and the John Day Fossil Beds National Monument (JODA). At Craters of the Moon National Monument and Preserve (CRMO), where bare lava rock comprises 81% of the total land cover, sagebrush steppe represents over 90% of the vegetation cover. At Lake Roosevelt National Recreation Area (LARO), sagebrush steppe is present and extensive in the southern half of the Park. Historic and current land use practices both within and adjacent to UCBN parks continue to fragment and alter steppe ecosystems (e.g., Knick and Rotenberry 1997, Hanser and Huntly 2006). Predicted climate change scenarios for the region will likely exacerbate these changes with potential outcomes including increased frequency of drought and wildfire, increased ability of non-native species to invade sagebrush steppe, and altered plant phenology (Smith et al. 2000, Wagner et al. 2003, Karl et al. 2009). Long-term vegetation trends at the Idaho National Laboratory (INL) near CRMO provide substantial evidence of the importance of climate patterns on sagebrush steppe vegetation dynamics (Anderson and Inouye 2001). A half century of monitoring at INL has shown a multi-decadal plant community response to prolonged drought during the mid-20th century that has important implications for management within the context of varying and changing climate.

The UCBN has identified the ecological condition of sagebrush steppe vegetation as a high priority vital sign and monitoring of steppe condition will be a central element to the UCBN monitoring program (Garrett et al. 2007). Community response to fire and drought, vulnerability to invasion, and the potential for restoration and recovery can differ significantly among sagebrush steppe communities (Reid et al. 2002, Bureau of Land Management 2002). The heterogeneity of sagebrush community types (e.g., alliances and associations defined by *Artemisia* subtaxa) in the UCBN, the complexity of ecological threats to sagebrush steppe ecosystems, and the substantial variability of vegetation change that has been reported among

years and decades emphasizes the uncertainty that managers face. Understanding the complexity of change at the park level is critical for effective management strategies to be developed. These challenges underscore the need for a long-term monitoring program that provides for routine evaluation of the status of UCBN steppe communities, and for identification of trends over time within parks and across the network. This information will provide the feedback required for effective adaptive management. In this report I present the results of pilot monitoring in CRMO, HAFO, JODA, and LARO. In 2009 a final draft protocol was implemented. The protocol was in review during field work, and was revised following the 2009 field season. A final peer-reviewed and approved protocol is now available (http://science.nature.nps.gov/im/units/ucbn/reports/index.cfm#Sage_Mon) and will be implemented in 2010. Changes to the methods and recommended analytical procedures between draft and final protocol versions were inconsequential to this report, and 2009 data will be stored in the project database described by Yeo et al. (2009) and included in subsequent trend analyses. In 2009, information on the cover and frequency of principal indicator species of rangeland health, including both native and non-native species, as well as the cover of exposed bare soil, were obtained. These data are some of the first available to quantify the composition and abundance of sagebrush steppe vegetation in these parks. This report describes fundamental baseline conditions for the following key indicators: cover of exposed bare soil, steppe bluegrass (*Poa secunda*), bluebunch wheatgrass (*Pseudoeregneria spicata*), cheatgrass (*Bromus tectorum*), native perennial forbs (as a physiognomic group), tumbling mustard (*Sisymbrium altissimum*), and big sagebrush (*Artemisia tridentata*). Cover estimates of other principal species are also available upon request from the UCBN. The presentation of results in this report is primarily graphical, providing quick and easy snapshots of condition in each park sampling frame, and facilitating quick referencing by park managers and easy visual comparisons among frames within parks.

Objectives

The monitoring objectives for this vital sign monitoring program are:

- 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 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 rangeland health indicator status estimates obtained for sagebrush steppe communities from CRMO, HAFO, JODA, and LARO in 2009. In 2009 the UCBN sampled 1244 plots in multiple discrete park sampling frames in a pilot effort to test the UCBN draft protocol and to establish baseline conditions for park managers to consider.

Methods

The UCBN used a generalized random tessellation stratified (GRTS) spatially-balanced sampling design (Stevens and Olsen 2004) within each of multiple park sampling frames in CRMO, HAFO, JODA, and LARO in 2009 (Figures 1-5) following methods outlined by Yeo et al. (2009). The GRTS design ensures that each frame is sampled with good representativeness and dispersion. Frame areas were adjusted following the 2009 field season and Figures 1-5 shows boundaries that are similar but do not exactly match final frame boundaries described by Yeo et al. (2009). The total number of sample plots was 1244, distributed across frames following sample size determination described by Yeo et al. (2009). A minimum of 50 plots were sampled in any one frame, and maximum of 100 plots were sampled, according to the area of each frame. Table 1 summarizes the realized samples sizes in each park frame. Several frames had to be adjusted or had plots fall outside of designated inclusion criteria, and some sample sizes differed slightly from desired sample sizes. Sampling methods followed those detailed by Yeo et al. (2009). The approach utilized 1 m^2 quadrats, anchored at each GRTS sample point on the lower right-hand corner of the frame. Cover was visually estimated following Daubenmire's (1959) 6-point cover class system (Table 2). Cover was estimated separately for principal native and non-native plant species as well as for exposed bare soil. The lists of principal species are listed by Yeo et al. (2009). For this report, bar graphs were utilized to present status categorical point estimates for each sampling frame, and include 90% confidence intervals obtained by calculating the more efficient "local" variance estimator developed for GRTS samples by Stevens and Olsen (2003). The height of each bar represents the proportion of plots within each sample frame that were estimated to contain the corresponding amount of cover. Graphs are color coded to facilitate readability but also to provide a qualitative measure of the level of concern associated with 2009 estimates. For example, cheatgrass cover is clearly of great concern to the integrity of park sagebrush steppe ecosystems. Accordingly, I have graded the colors of bars in graphs from green to red for increasing cheatgrass cover. Conversely, a reverse ordering is used for native species indicators where elevated cover is positive. Also, I have refrained from using strong colors where value judgments of good versus bad are less certain, or where judgments need to be made in a more nuanced manner within the context of other factors, such as ecological site or site history. The colors should be not be interpreted rigidly, but rather are meant to draw attention quickly to differences among frames, and where additional management attention may wish to focus. Environmental attributes unique to each frame, such as the age of lava and subsequent soil development in CRMO, influences characteristics such as bare ground, and so change over time within frames will be more meaningful than comparisons among frames. This report focuses on only 6 key indicators: exposed bare soil cover, steppe bluegrass cover, bluebunch wheatgrass cover, cheatgrass cover, native perennial forb cover, and big sagebrush cover. For HAFO, I substituted tumbling mustard for bluebunch wheatgrass, since no plants of that species were encountered in plots in 2009. Not all species for which data have been collected (see Yeo et al. 2009 for a list of species) are addressed in this report. Additional information on the larger suite of indicator species collected during 2009 sampling will be included in subsequent trend reports, and will be made available upon request from the UCBN during the interim.

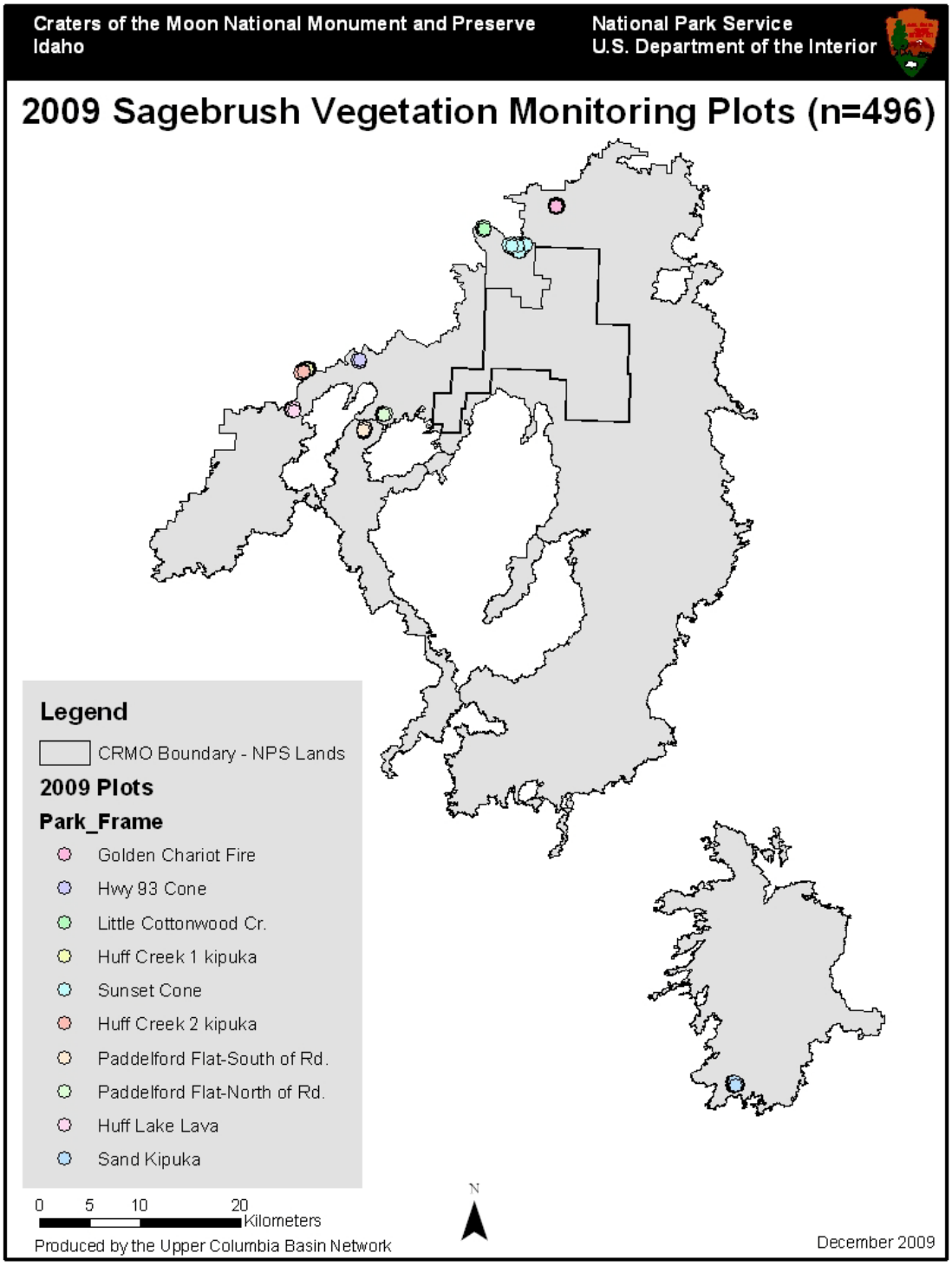

Figure 1. Sagebrush steppe vegetation monitoring sampling locations for 2009 pilot monitoring in Craters of the Moon National Monument and Preserve. Because the park is so large, detail maps of plots in frames are not provided, but are available upon request from the UCBN. Details of sampling frame development are available in the UCBN sagebrush steppe vegetation draft monitoring protocol (Yeo et al. 2009).

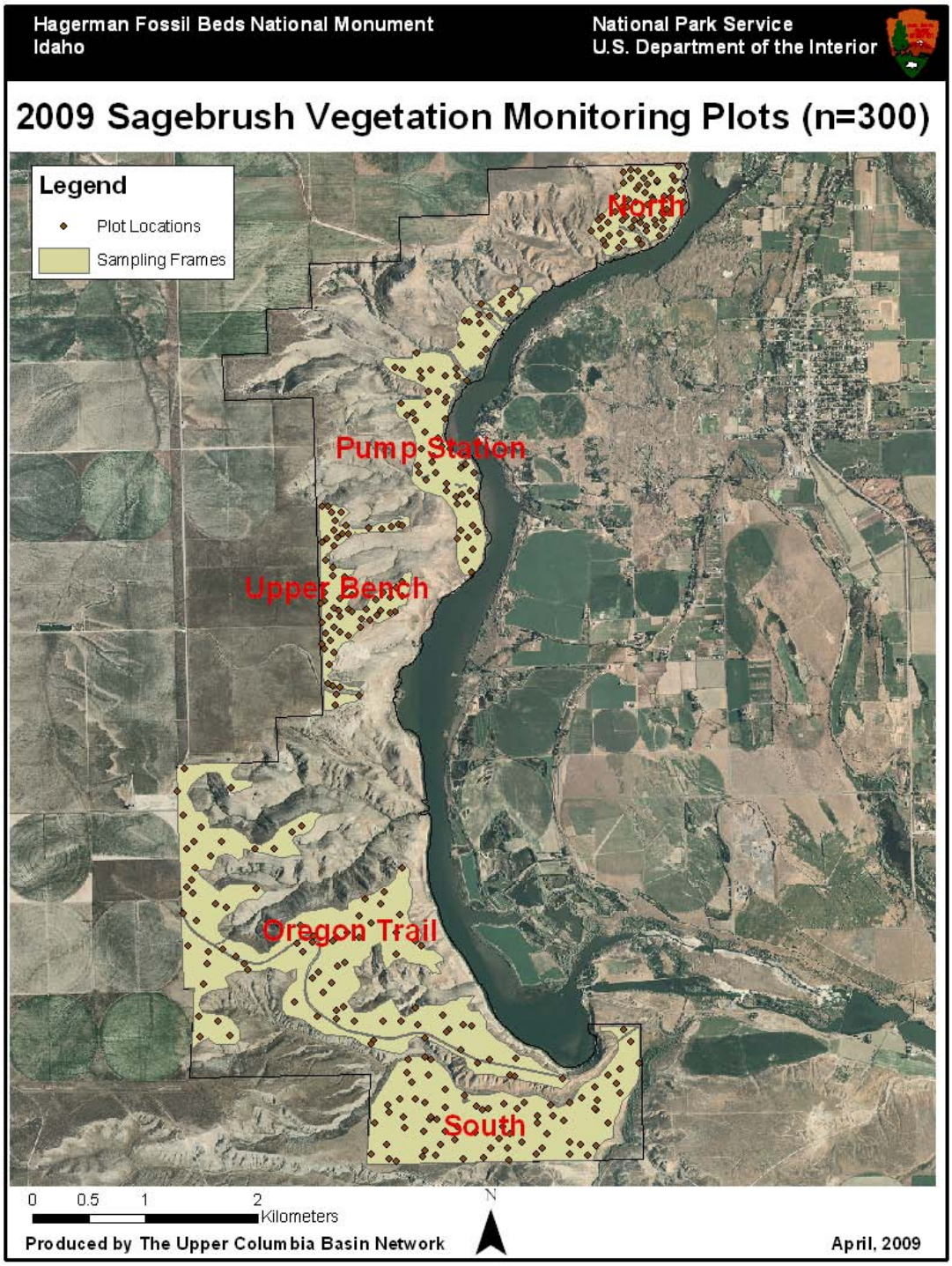

Figure 2. Sagebrush steppe vegetation monitoring sampling frames and spatially-balanced random sample points (GRTS sample points) for 2009 pilot monitoring in Hagerman Fossil Beds National Monument. Steep slopes and land cover outside the target population were excluded from the sampling frames. Details of sampling frame development are available in the UCBN sagebrush steppe vegetation draft monitoring protocol (Yeo et al. 2009).

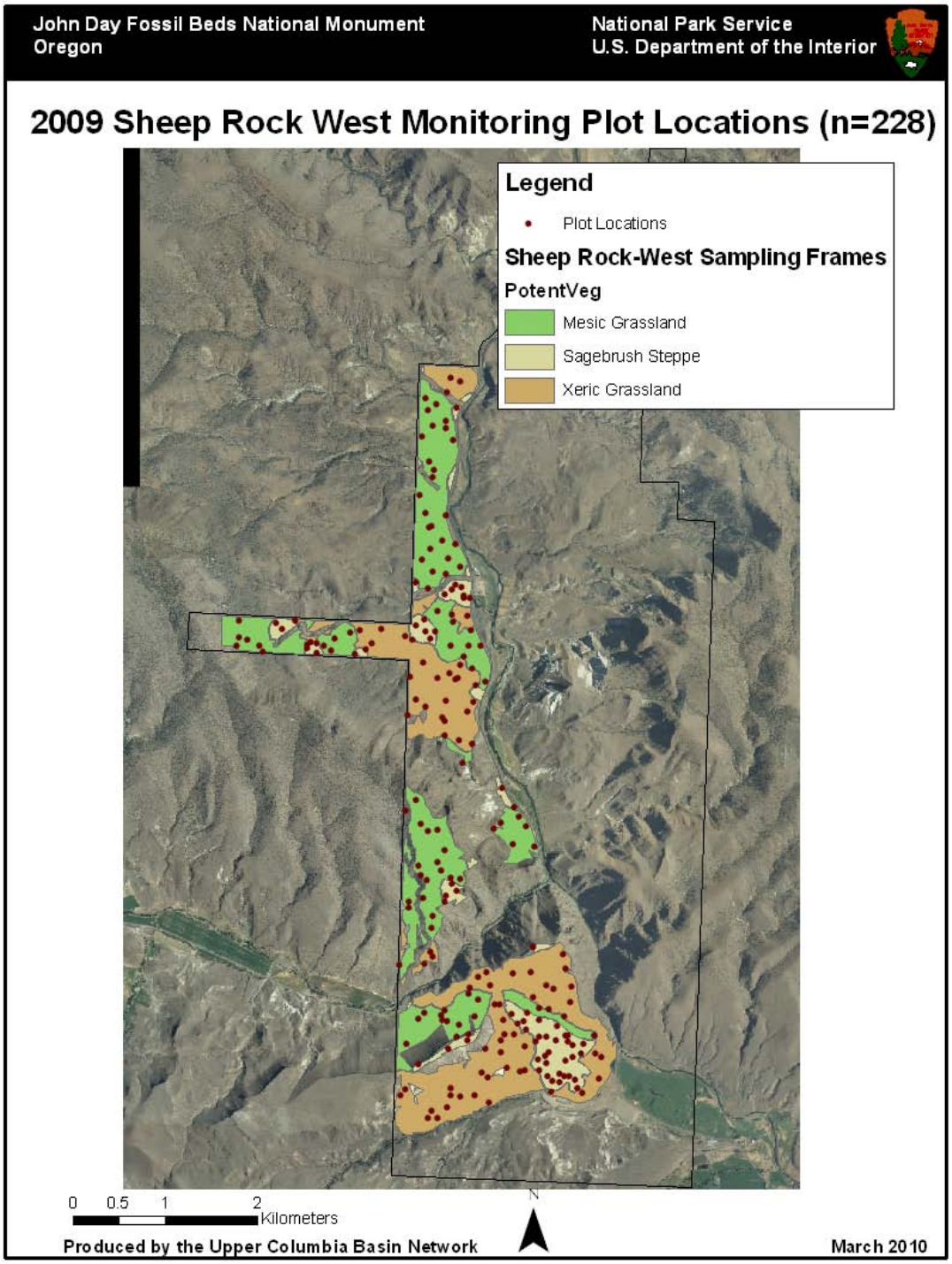

Figure 3. Sagebrush steppe vegetation monitoring sampling frames and spatially-balanced random sample points (GRTS sample points) for 2009 pilot monitoring in the Sheep Rock Unit of the John Day Fossil Beds National Monument. Steep slopes, and land cover outside the target population were excluded from the sampling frames. Details of sampling frame development are available in the UCBN sagebrush steppe vegetation draft monitoring protocol (Yeo et al. 2009).

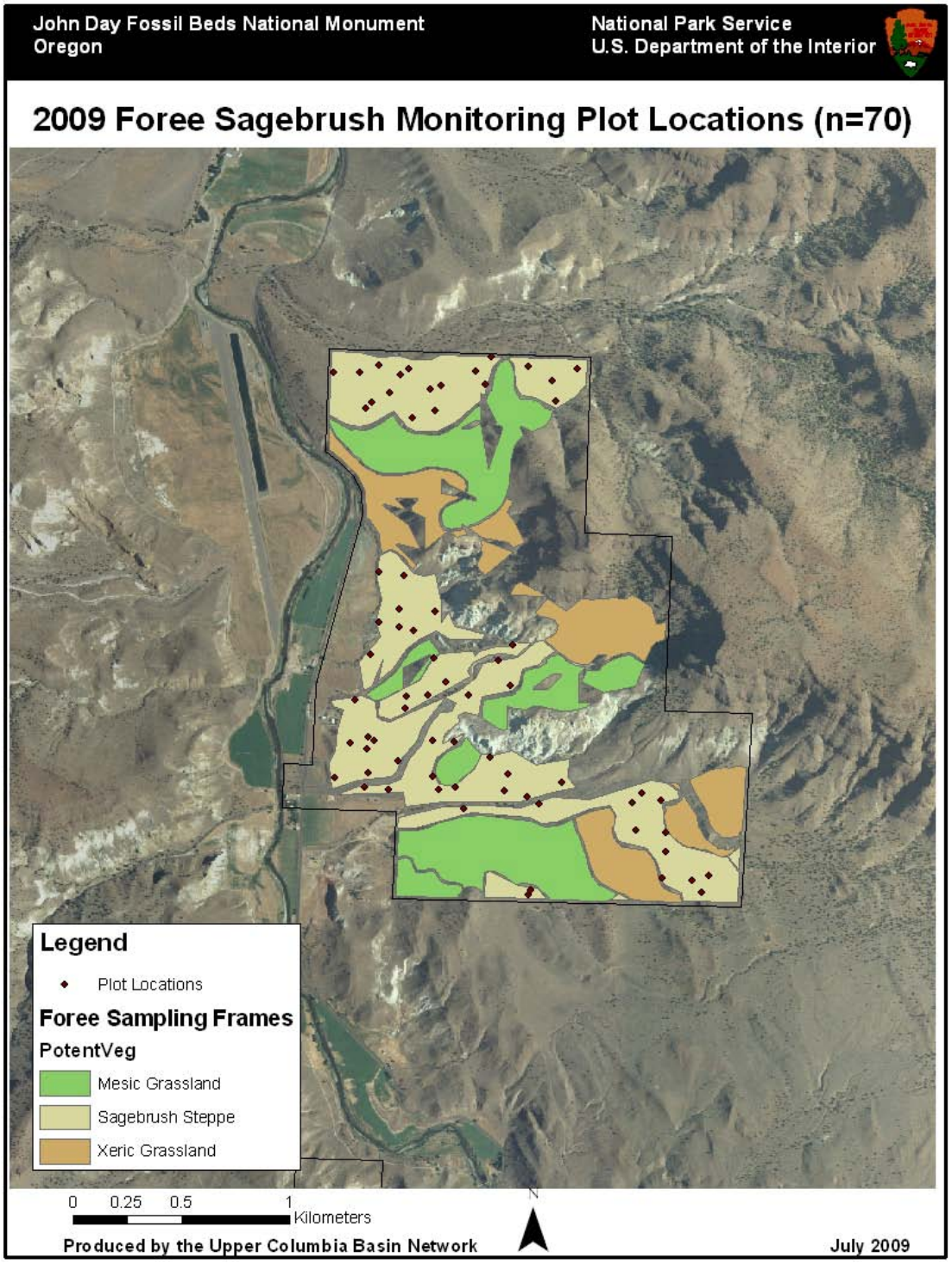

Figure 4. Sagebrush steppe vegetation monitoring sampling frames and spatially-balanced random sample points (GRTS sample points) for 2009 pilot monitoring in the Foree Unit of the John Day Fossil Beds National Monument. Steep slopes, and land cover outside the target population were excluded from the sampling frames. Details of sampling frame development are available in the UCBN sagebrush steppe vegetation draft monitoring protocol (Yeo et al. 2009).

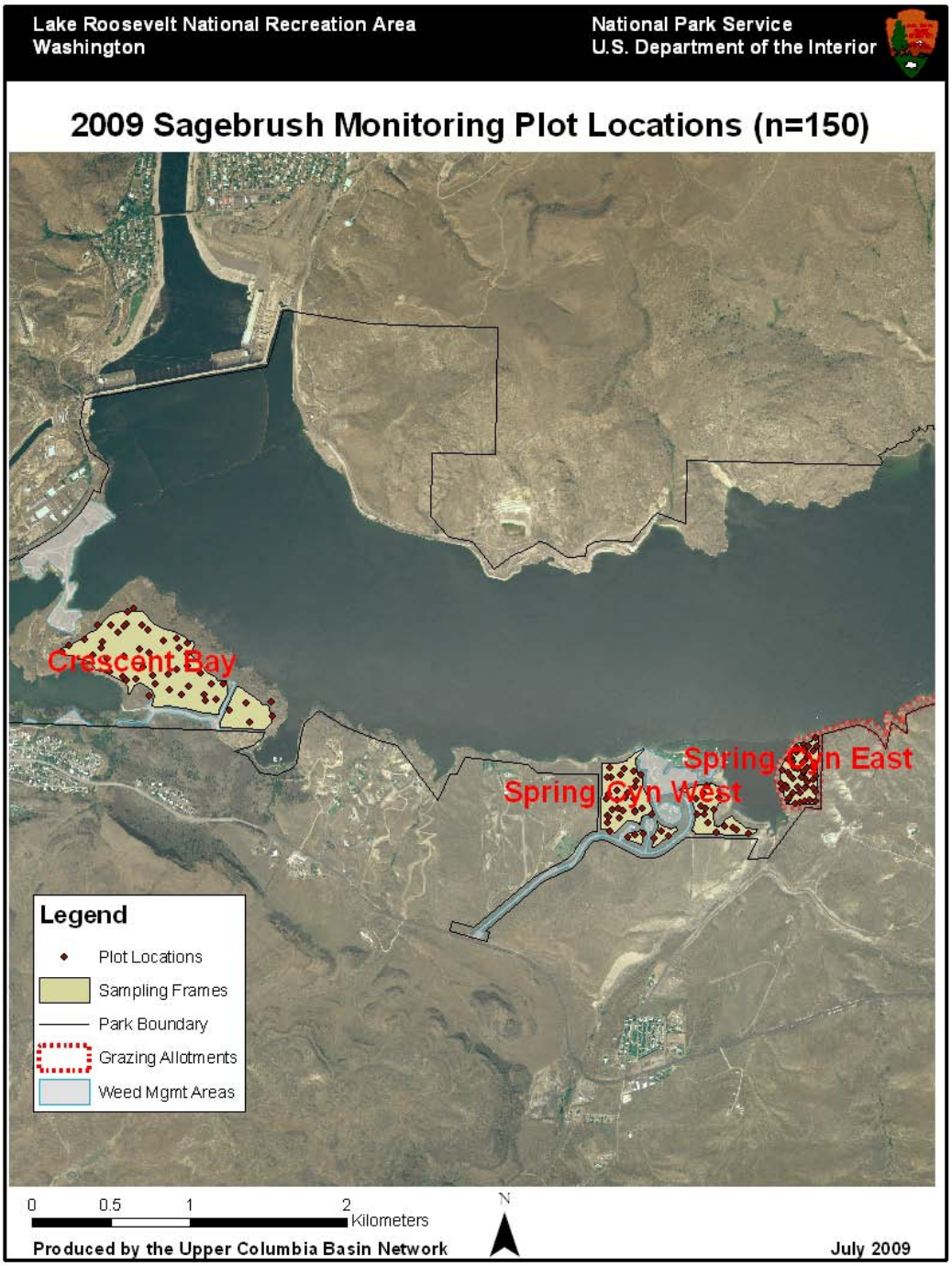

Figure 5. Sagebrush steppe vegetation monitoring sampling frames and spatially-balanced random sample points (GRTS sample points) for 2009 pilot monitoring in Lake Roosevelt National Recreation Area. Steep slopes, and land cover outside the target population were excluded from the sampling frames. Details of sampling frame development are available in the UCBN sagebrush steppe vegetation draft monitoring protocol (Yeo et al. 2009).

Table 1. Sample sizes obtained during 2009 pilot monitoring in Craters of the Moon National Monument and Preserve, Hagerman Fossil Beds National Monument, John Day Fossil Beds National Monument, and Lake Roosevelt National Recreation Area. Multiple discrete sampling frames were established in each park. Details of frame development and desired sample sizes are provided in Yeo et al. (2009).

Park	Sampling Frame	Sample Size
CRMO	Golden Chariot Fire	50
CRMO	Hwy 93 Cone	50
CRMO	Little Cottonwood Cr.	49
CRMO	Huff Cr. 1 kipuka	50
CRMO	Sunset Cone	50
CRMO	Huff Cr. 2 kipuka	50
CRMO	Paddelford Flat-South of Rd.	50
CRMO	Paddelford Flat-North of Rd.	50
CRMO	Huff Lake Lava	47
CRMO	Sand Kipuka	50
HAFO	North	50
HAFO	Oregon Trail	75
HAFO	Pump Station	55
HAFO	South	65
HAFO	Upper Bench	55
JODA	Foree Sage	70
JODA	Sheep Rock West Sage	65
JODA	Sheep Rock West Mesic	85
JODA	Sheep Rock West Xeric	78
LARO	LARO Crescent Bay	49
LARO	LARO Spring Cyn East	51
LARO	LARO Spring Cyn West	50
Total		1244

Table 2. Daubenmire's cover classes used for visually estimating vegetation cover in 1 m^2 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%

Results

Craters of the Moon National Monument and Preserve

A total of 496 plots were measured in 10 sampling frames in 2009 (Figure 1). Most frames visited were along the northern tier of the park, but one, Sand Kipuka, was located on the Wapi Flow in the extreme southern portion of the park. The Golden Chariot Fire frame is in an area that burned in 2000. Little Cottonwood Creek and Sunset Cone frames are the two highest elevation frames (approximately 2000 m), whereas Sand Kipuka is at approximately 1350 m. Sunset Cone, Little Cottonwood Creek, Hwy 93 Cone, the 2 Huff Creek kipukas, and Paddelford Flat North frames were all in areas recently mapped as *Artemisia tridentata vaseyana* (mountain big sagebrush) shrubland complexes (Bell et al. 2009). The Golden Chariot Fire frame was mapped as a mixed weedy herbaceous complex, but formerly would have supported a mountain big sagebrush community. Huff Lake Lava and Sand Kipuka occurred in areas mapped as *Artemisia tridentata wyomingensis* (Wyoming big sagebrush) complexes. The Paddelford Flat South frame occurred on sparsely vegetated pahoehoe lava dominated by *Chrysothamnus viscidiflorus* and *Ericameria nauseosus* (rabbitbrush) alliances.

Exposed Bare Soil

Figure A-1 in Appendix A shows the proportion of plots in each frame estimated to have exposed bare soil (bare ground) in each of the 6 Daubenmire cover classes (Table 1). Few frames had plots with bare ground estimates >25% (≤6% of plots in Sunset Cone and Huff Creek 2 kipuka). Paddelford Flat South had the highest bare ground cover, as expected because of its position on sparsely vegetated pahoehoe lava. Frames on older soils that had relatively high amounts of bare ground were those mountain big sagebrush frames with well developed sagebrush canopies.

Principal Native Species

Figures A-2, A-3, A-5 and A-6 in Appendix A show the proportion of plots containing steppe bluegrass, bluebunch wheatgrass, native perennial forbs, and big sagebrush among the sampling frames that were sampled in 2009. Sunset Cone stands out as having very high amounts of native vegetation. Perennial forb cover was moderately high among all frames. Huff Lake Lava had the lowest amount of forb cover. In general, frames that supported large amounts of bluebunch wheatgrass had less steppe bluegrass.

Principal Non-Native Species

The mean frequency of cheatgrass occurrence in frames ranged from 4% in Sunset Cone to 98% in the Golden Chariot Fire. Figure A-4 in Appendix A shows the proportion of plots containing cheatgrass in each of the 6 Daubenmire cover classes. Again, Sunset Cone stands out as having very little cheatgrass cover, whereas the Golden Chariot Fire, recently burned, and Sand Kipuka in the southern, lowest portion of the park had highest amounts of cheatgrass cover. Little Cottonwood Creek, the highest frame in the park, had surprisingly high amounts of cheatgrass cover. Few noxious weeds were encountered in plots in CRMO in 2009. Spotted knapweed (*Centaurea maculosa*) was found in 2% of plots in Huff Creek 2 kipuka.

Hagerman Fossil Beds National Monument

A total of 300 plots were measured in 5 sampling frames in 2009 (Figure 2). The frames encompass essentially all existing or potential sagebrush steppe vegetation in accessible areas of the park (Yeo et al. 2009). Most of the sampling frames have been mapped as *Artemisia tridentata wyomingensis* (Wyoming big sagebrush) complexes, but substantial areas within the sampling frames are *Bromus tectorum*/*Sisymbrium altissimum* herbaceous vegetation or other similar types of disturbed land degraded by heavy invasion of non-native vegetation (Erixson and Cogan 2009). There is a short elevational gradient in HAFO, and the entire park falls within 800-1000 m elevation.

Exposed Bare Soil

Figure B-1 in Appendix B shows the proportion of plots in each frame estimated to have exposed bare soil (bare ground) in each of the 6 Daubenmire cover classes (Table 1). All frames had plots with bare ground estimates >25%, and one frame, the Upper Bench, had 10% of plots with exposed bare ground >25% cover.

Principal Native Species

Figures B-2, B-4, and B-6 in Appendix B show the proportion of plots containing steppe bluegrass, native perennial forbs, and big sagebrush among the sampling frames that were sampled in 2009. The North and Pump Station frames had highest cover of big sagebrush (26% and 21% of plots >25% cover, respectively). Conversely, those frames had no plots with steppe bluegrass cover >25%, a striking pattern given that no bluebunch wheatgrass occurred in those frames, or in any of the other three frames. Steppe bluegrass cover was highest in Upper Bench (25% of plots >25% cover). Other native bunchgrasses that occurred in HAFO in low amounts were bottlebrush squirreltail (*Sitanion hystrix*) and indian ricegrass (*Oryzopsis hymenoides*).

Principal Non-Native Species

Figures B-3 and B-5 in Appendix B show the proportion of plots in each frame estimated to contain cheatgrass and tumbling mustard in each of the 6 Daubenmire cover classes. Cheatgrass occurred with > 93% frequency in all frames and with > 25% cover in > 70% of plots in all frames. The North and Pump Station frames had highest overall cheatgrass cover. Tumbling mustard occurred with >5% cover in 4-15% of plots in all frames. The Oregon Trail and South frames had highest amounts of tumbling mustard. The noxious weed Canada thistle (*Cirsium arvense*) was found in 2% of plots in the Oregon Trail frame, and in 1% of plots in Pump and Upper Bench frames. Scotch thistle (*Onopordum acanthium*) was found in 4% of Oregon Trail plots, in 2% of Upper Bench plots, and in 1.5% of South frame plots.

John Day Fossil Beds National Monument

A total of 298 plots were measured in all 3 sampling frames in the western portion of the Sheep Rock Unit and in the Sage (only 1 of 3 frames) frame in the Foree Unit of the park in 2009 (Figures 3-4). The frames in Sheep Rock West encompass essentially all existing or potential sagebrush steppe vegetation, as well as bunchgrass-dominated vegetation in accessible areas of the park and are delineated according to ecological site descriptions developed for the park by the Natural Resources Conservation Service (Yeo et al. 2009). Plant associations in Sage frames were those that included *Artemisia tridentata tridentata*. Mesic frames included associations with *Festuca idahoensis* (Idaho fescue) and *Pseudoeregneria spicata*, and Xeric frames included associations with *Achnatherum thurberiana* (Thurber's needlegrass) or *Sporobolus cryptandrus* (sand dropseed). Elevations in Sheep Rock West and Foree range from approximately 700-1000 m. Only the Sage frame was sampled in Foree in 2009 due to logistical constraints. JODA has an active prescribed fire program, and most of the Foree Unit was burned in 2005 and 2007. In 2004, much of the western portion of Sheep Rock was burned.

Exposed Bare Soil

Figure C-1 in Appendix C shows the proportion of plots in each frame estimated to have exposed bare soil (bareground) in each of the 6 Daubenmire cover classes (Table 1). All frames had plots with bare soil estimates >25% (range 8-10% of plots).

Principal Native Species

Figures C-2, C-3, C-5, and C-6 in Appendix C show the proportion of plots containing steppe bluegrass, bluebunch wheatgrass, native perennial forbs, and big sagebrush among the sampling frames that were sampled in 2009. Native perennial bunchgrasses are a substantial component of upland plant communities in the park. All frames had plots with >5% steppe bluegrass cover (range 2-30%) and many plots with >25% cover of bluebunch wheatgrass (range 15-27%). The Mesic frame in Sheep Rock West had the highest amounts of bluebunch wheatgrass, and as its name implies, captures higher, more mesic (typically north facing slopes) areas of the park. Perennial forb cover occurred with >25% cover in 2-5% of plots in all frames except the Sheep Rock West Xeric frame. Sagebrush cover occurred in 2-25% of plots with >25% cover. Sagebrush cover was highest (25% of plots >25% cover) in the Sheep Rock West Sage Frame, and lowest (2% of plots >25% cover) in the Foree Sage frame, presumably due to recent fires there.

Principal Non-Native Species

Figure C-4 in Appendix C shows the proportion of plots in each frame estimated to contain cheatgrass in each of the 6 Daubenmire cover classes. Cheatgrass occurred with >87% frequency in all frames and with >25% cover in 66-77% of plots in all frames. The Sheep Rock West Mesic frame had the lowest cheatgrass frequencies and plot cover estimates. Medusahead (*Elymus caput-medusae*), a species of great concern to JODA natural resource management, occurred in all frames with plot frequencies ranging from 1.2 to 3.7%. The highest frequency was in the Sage frame of Sheep Rock West. Only 1 noxious weed, Dalmation toadflax (*Linaria dalmatica*), was found with 4.3% plot frequency in the Foree Sage Frame. No other noxious weeds were encountered in plots.

Lake Roosevelt National Recreation Area

A total of 150 plots were measured in 3 sampling frames in LARO in 2009 (Figure 5). The land area in LARO is narrowly confined to the lake shore, and only the southwestern portion of the park is covered in existing or potential sagebrush steppe vegetation. Our frames included three of the largest areas of contiguous steppe vegetation. 2 frames were constructed to interface with park weed management areas (Figure 5). A 3rd frame, Spring Cyn East, includes a substantial portion of an active grazing allotment (Figure 5). When full, Lake Roosevelt is approximately 300 m elevation, and uplands included in sampling frames are 100-200 m above that level. Existing and potential vegetation within these 3 frames is dominated by *A. t. tridentata* but includes some bitterbrush (*Purshia tridentata*).

Exposed Bare Soil

Figure D-1 in Appendix C shows the proportion of plots in each frame estimated to have exposed bare soil (bareground) in each of the 6 Daubenmire cover classes (Table 1). The proportion of plots with bare ground estimates >25% ranged from 0-17%. The lowest bare ground cover was in Spring Cyn West and the highest, by a substantial amount, was in Spring Cyn East, which is actively grazed by cattle.

Principal Native Species

Figures D-2, D-3, D-5, and D-6 in Appendix D show the proportion of plots containing steppe bluegrass, bluebunch wheatgrass, native perennial forbs, and big sagebrush among the sampling frames that were sampled in 2009. All frames had plots with >5% steppe bluegrass cover (range 12-16%) and plots with >25% cover of bluebunch wheatgrass (range 0-8%). Spring Cyn East, a heavily grazed area, had no plots with >25% bluebunch wheatgrass cover and only 2% of plots with >5% bluebunch wheatgrass cover. Crescent Bay had the highest amounts of perennial bunchgrasses, and includes a substantial north-facing slope with mesic growing conditions, similar to north-facing slopes in JODA. Perennial forb cover occurred with >25% cover in 0-14% of plots with the highest amount in Crescent Bay and the lowest amount in Spring Cyn East. Sagebrush cover occurred in 0-32% of plots with >25% cover, and again Crescent Bay had the highest amounts. No big sagebrush plants were encountered in Spring Cyn West, and shrubs in that frame were dominated by bitterbrush (*Purshia tridentata*; encountered in 26% of plots) and rabbitbrush.

Principal Non-Native Species

Figure D-4 in Appendix D shows the proportion of plots in each frame estimated to contain cheatgrass in each of the 6 Daubenmire cover classes. Cheatgrass occurred with >79% frequency in all frames and with >25% cover in 43-48% of plots in all frames. Crescent Bay had the lowest cheatgrass frequencies but some of the highest cheatgrass cover estimates. Russian knapweed (*Acroptilon repens*) occurred with 4% plot frequency in Crescent Bay, primarily in an area of high disturbance near the south access point. Dalmation toadflax occurred with 2% frequency in that frame and with 10% frequency in Spring Cyn West. No other noxious weeds were encountered in plots.

Discussion

The UCBN sagebrush steppe monitoring program initiated monitoring in CRMO, the Sheep Rock Unit of JODA, and in LARO in 2009. A 2nd season of pilot monitoring was conducted in HAFO and in a portion of the Foree Unit of JODA as well (reported by Rodhouse [2009]). Methods followed a draft protocol developed by the UCBN which has subsequently been completed, peer-reviewed and approved (Yeo et al. 2009). The preliminary analyses provided in this report are some of the first quantitative descriptions of sagebrush steppe plant communities in these parks. Sample sizes ranged from 47 to 85 and were extensive enough to support inferences from rangeland health indicator estimates to each of the respective park areas (sampling frames). These estimates provide descriptions of initial baseline conditions of park steppe ecosystems and will contribute to the foundation of the UCBN steppe monitoring program in these parks. These ecosystems are highly variable, however, and several years of subsequent sampling in each of these parks will be required before a clear picture of sagebrush steppe condition status will emerge. Of particular importance is a recognition that environmental conditions (e.g., elevation, soil types, and land use histories) in each of the frames are so varied and influential that comparison among parks, and even among frames within parks, may not be warranted, other than perhaps as a very general way to provide some context for interpreting current conditions, or to look at regional patterns. For example, it is clear that the lowest elevation parks have much higher amounts of cheatgrass invasion, a pattern which has been noted generally (e.g., Chambers et al. 2007). Change over time within frames, measured relatively, will provide the best measure of ecological condition and changes in those conditions for park resource managers to consider in their decision making.

Craters of the Moon National Monument

Patterns of cover observed in CRMO frames in 2009 tended to co-occur in ways that suggest areas of high ecological condition (e.g., Sunset Cone) and low ecological condition (e.g., Sand Kipuka). The estimates of cover in Sunset Cone plots were particularly striking for their consistency, and describe an area of the park that appears to be resistant to cheatgrass invasion and other attributes of degradation. Native perennial forb cover was substantial there. Native perennial forb cover has been attributed to ecological resistance and resiliance in western sagebrush rangelands, generally (Germino et al. 2004). Based on 2009 observations, this area should receive high priority for resource management and protection from disturbance, including fire. The Golden Chariot Fire is very close to Sunset Cone, of similar elevation, and illustrates the changes that could occur in Sunset Cone in response to fire. The high amount of cheatgrass observed in the Golden Chariot Fire frame was striking. Native perennial forb cover remained relatively high, however, and provides evidence that the area may be able to recover. Of particular interest for the Golden Chariot Fire frame is the large numbers of sage grouse that use the area for lekking and brood rearing (M. Munts, CRMO, personal communication). Monitoring data that provides a measure of change in that frame will be important for park management. Sand Kipuka, in the lowest portion of CRMO, was also observed with high amounts of cheatgrass cover, and low amounts of native vegetation. Low native bunchgrass cover is of concern, but as with the Golden Chariot Fire, relatively high amounts of native perennial forb cover suggests some potential for resilience and recovery. In general, however, low elevation portions of the park are less likely to exhibit resilience, particularly if climate change predictions

for the region, which include increased aridity, are realized (Chambers et al. 2007, Karl et al. 2009). Finally, management attention should be given to the Little Cottonwood Creek frame, which presented somewhat incongruous results. The relatively high cheatgrass cover in that frame was somewhat surprising, given the elevation of the frame, and its relative isolation. The frame was estimated to have high cover of native vegetation, except steppe bluegrass. Little Cottonwood Creek frame is in an area proposed for National Natural Landmark designation and is located near Sunset Cone. Site disturbance history may explain the localized cheatgrass invasion. Sheep grazing and mining activities have occurred in the drainage in the past (J. Apel, CRMO, personal communication). Trends in cheatgrass cover in this frame should be watched carefully.

Hagerman Fossil Beds National Monument

The high frequency and cover of cheatgrass and the complete absence of bluebunch wheatgrass in the park was striking and of concern. This pattern was also observed in 2008 (Rodhouse 2009) and reinforces current status estimates. The Natural Resource Conservation Service (NRCS) ecological site descriptions for HAFO suggest that big sagebrush/bluebunch wheatgrass communities should dominate the area. The North and Pump Station frames both exhibited a pattern of high sagebrush cover, high cheatgrass and tumbling mustard cover, and low steppe bluegrass cover. These areas are in the lowest ecological condition in the park, and are at great risk for accelerated degradation in the event of fire. Removal of sagebrush cover would likely exacerbate the transition of those areas away from native sagebrush steppe to invasive annual grassland, which has widely and (apparently) permanently degraded much of Idaho's Snake River Plain (Knick and Rotenberry 1997, Bunting et al. 2002).

John Day Fossil Beds National Monument

In general, JODA supports substantial native perennial bunchgrass communities, a pattern that was also noted in 2008 (Rodhouse 2009). The mesic, higher and north-facing aspects of Sheep Rock West were particularly striking for the large amounts of bunchgrass cover observed. The cover of native bunchgrasses were higher, and the cover of invasive cheatgrass was lower than in the Clarno and Painted Hills Units observed in 2008 (Rodhouse 2009). However, the presence of medusahead in Sheep Rock West and Foree was concerning and presents a threat to the integrity of bunchgrass steppe plant communities in the park. This aggressive annual grass has invaded a substantial portion of the Clarno Unit (Rodhouse 2009), which is lower and has experienced more frequent wildfires. Establishing whether medusahead is increasing over the next few years in higher areas of the park in better ecological condition will be important for effective resource protection. Prescribed fires set in these areas may have enabled this species to gain a foothold in otherwise resistant plant communities. Monitoring results over the next few years may shed additional light on this complex resource management question.

Lake Roosevelt National Recreation Area

Several noteworthy patterns emerged from 2009 sampling in LARO. First, portions of Crescent Bay appear to be in good ecological condition, as suggested by the frame's high cover of native vegetation. The combination of relatively low cheatgrass frequency but high cheatgrass cover points to the spatial complexity of condition in this frame, however. Substantial portions of the frame contain mesic, north-facing slopes that are isolated from human activity, and accordingly

are in best condition. But near the southern boundary of the frame, where road access occurs (Figure 5), the site has experienced degrading land use. It is in this southern portion where cheatgrass and noxious weeds were encountered. This presents a management challenge for the park, particularly given the relatively small amounts of intact native shrubsteppe vegetation contained in the park. Natural resource management attention should be directed to the Crescent Bay area, particularly given its proximity to human settlement and proposed plans for recreational developments in the vicinity (J. Weaver, LARO, personal communication).

Second, discussion of results from LARO sagebrush steppe vegetation monitoring differs from those of the other parks included in this report because of the influence of the active grazing program in the Spring Cyn East frame. Comparisons among frames are complicated because livestock had actively removed canopy cover of grasses and forbs prior to 2009 sampling. However, it is reasonable to conclude that heavy grazing pressure has contributed to the low amounts of bunchgrass cover encountered in Spring Cyn East, relative to the other two frames. Of particular relevance to grazing is the high amount of exposed bare soil in Spring Cyn East. This is also a result of heavy livestock use, and management attention should be directed to this issue. Finally, while Spring Cyn West appears to be in relatively good condition, the high frequency of dalmation toadflax is worrisome. Vegetation in the frame provides a good example of native shrub steppe, and provides opportunities for visitors to experience this type of plant community, particularly in the western portion of the frame where the hiking trail has been placed. However, the frame is bisected by a road, parking lot, and boat landing, all vectors for weed invasion, and creates another resource management challenge. Trends in all of these issues will be very relevant for management decision-making in the future.

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Appendix A. Bar graphs for Craters of the Moon National Monument and Preserve

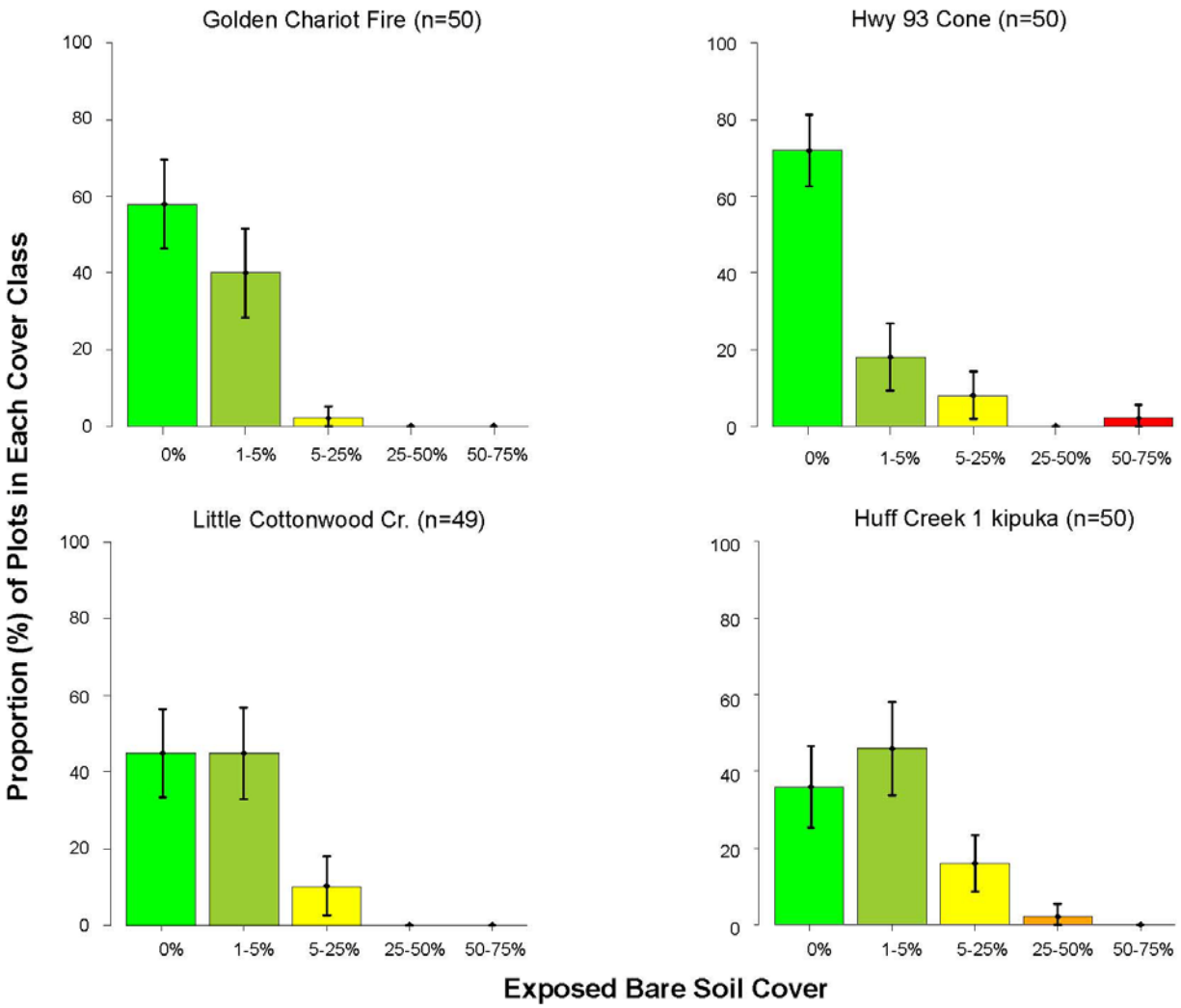


Figure A-1. Exposed bare soil cover.

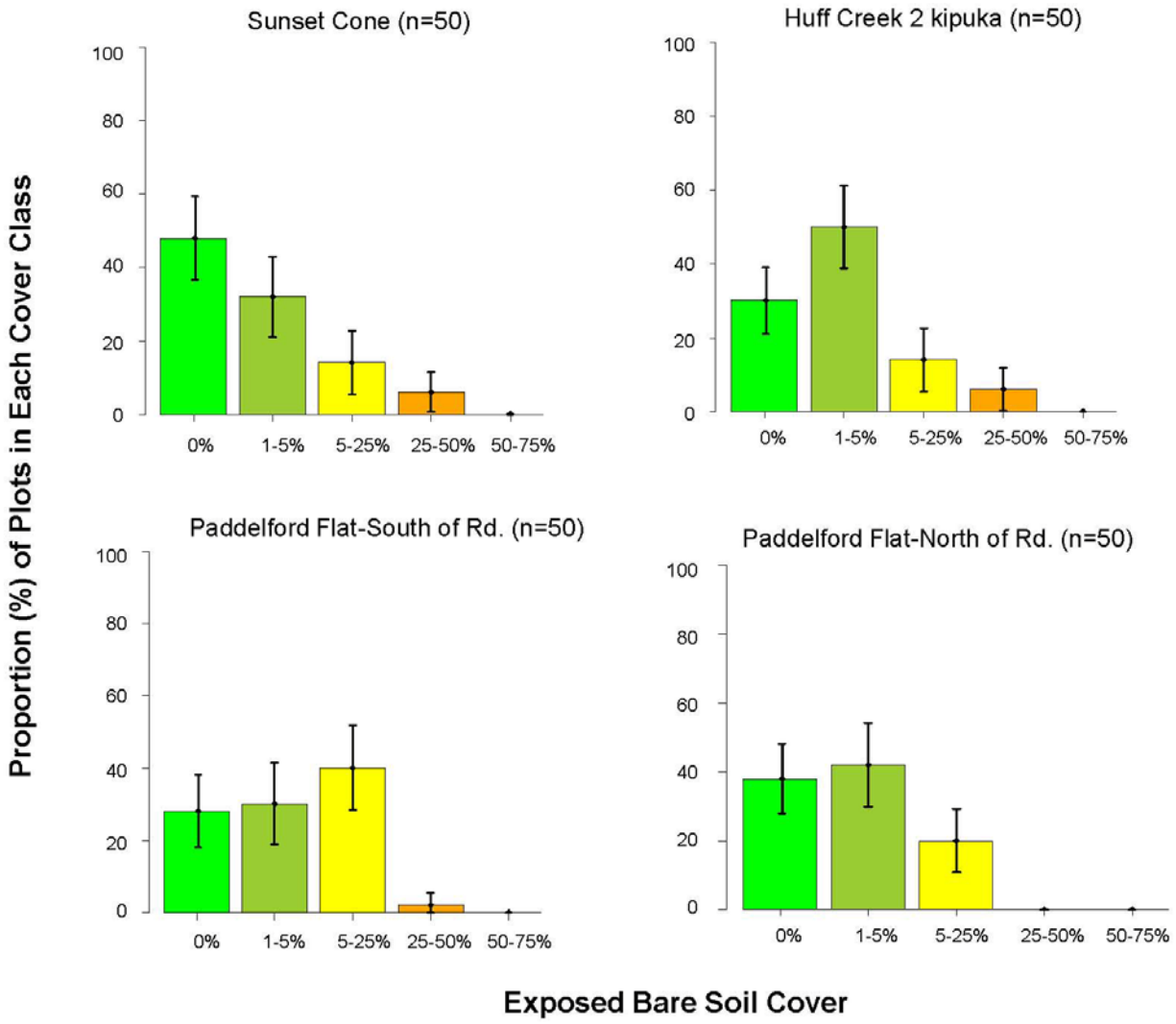


Figure A-1. Exposed bare soil cover (continued).

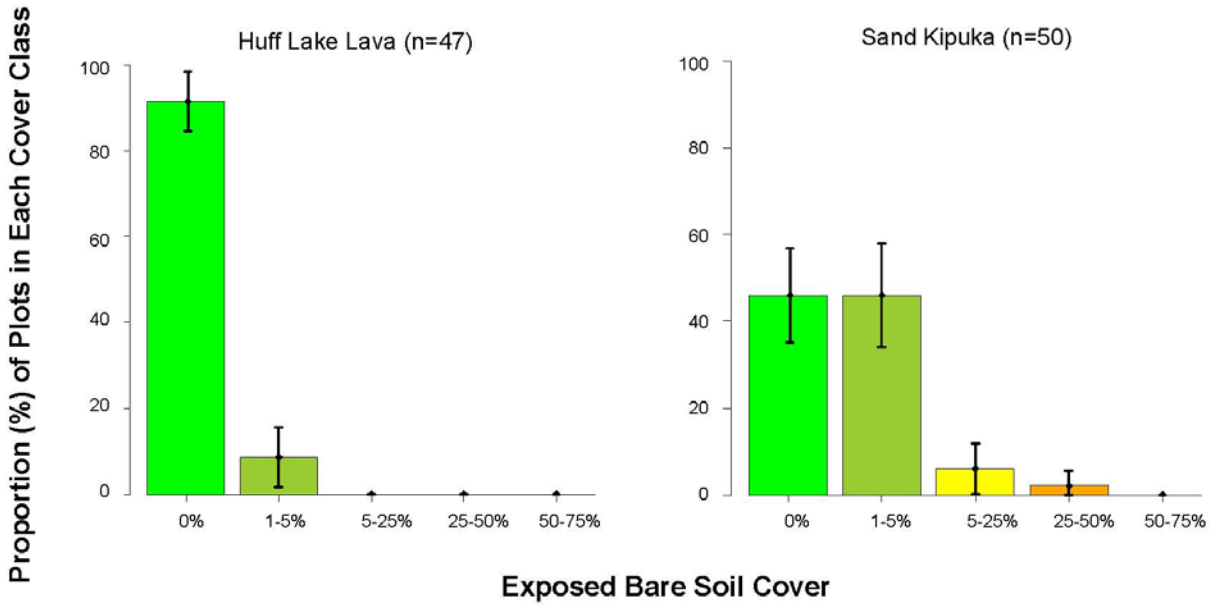


Figure A-1. Exposed bare soil cover (continued).

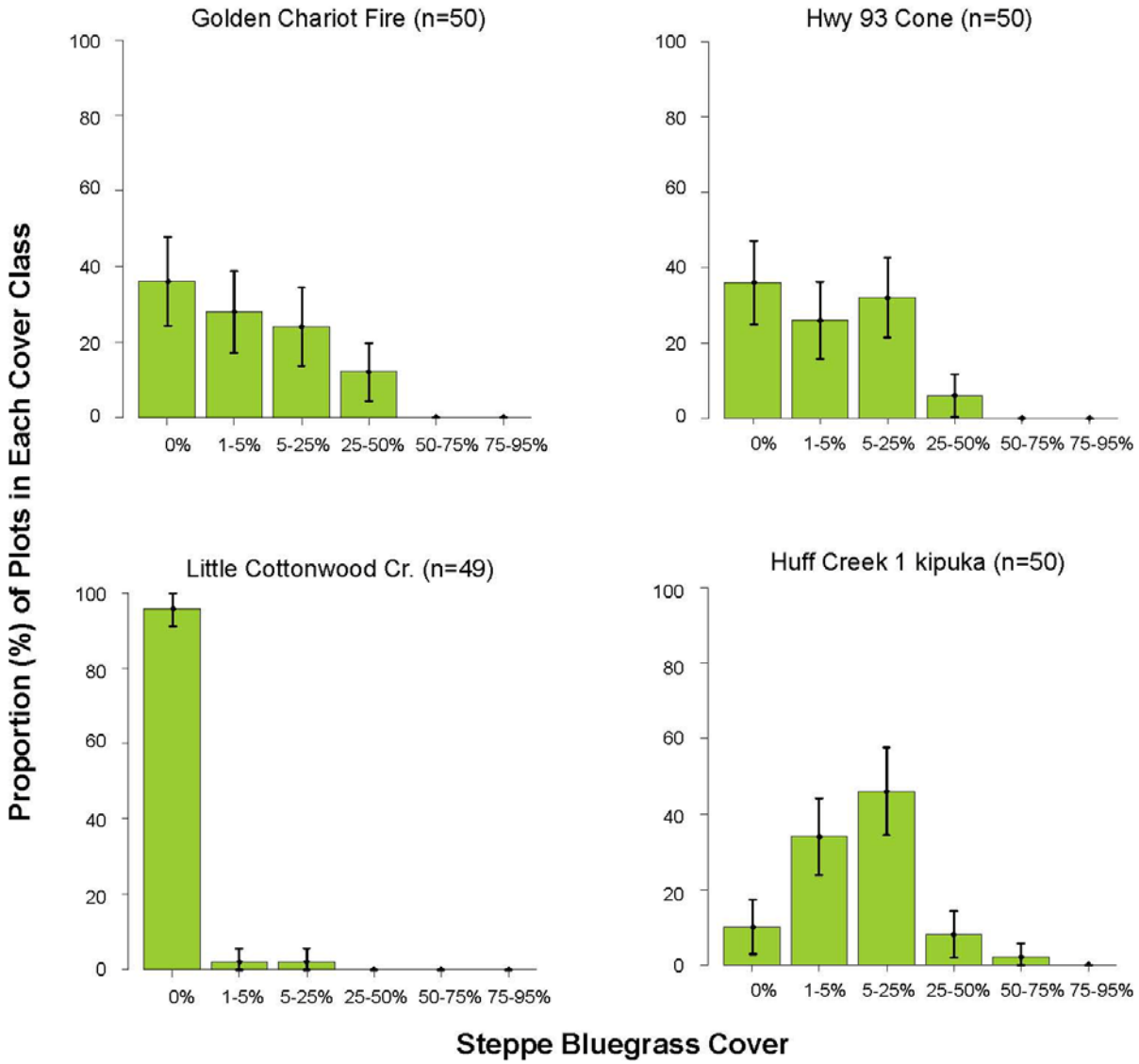


Figure A-2. Steppe bluegrass cover.

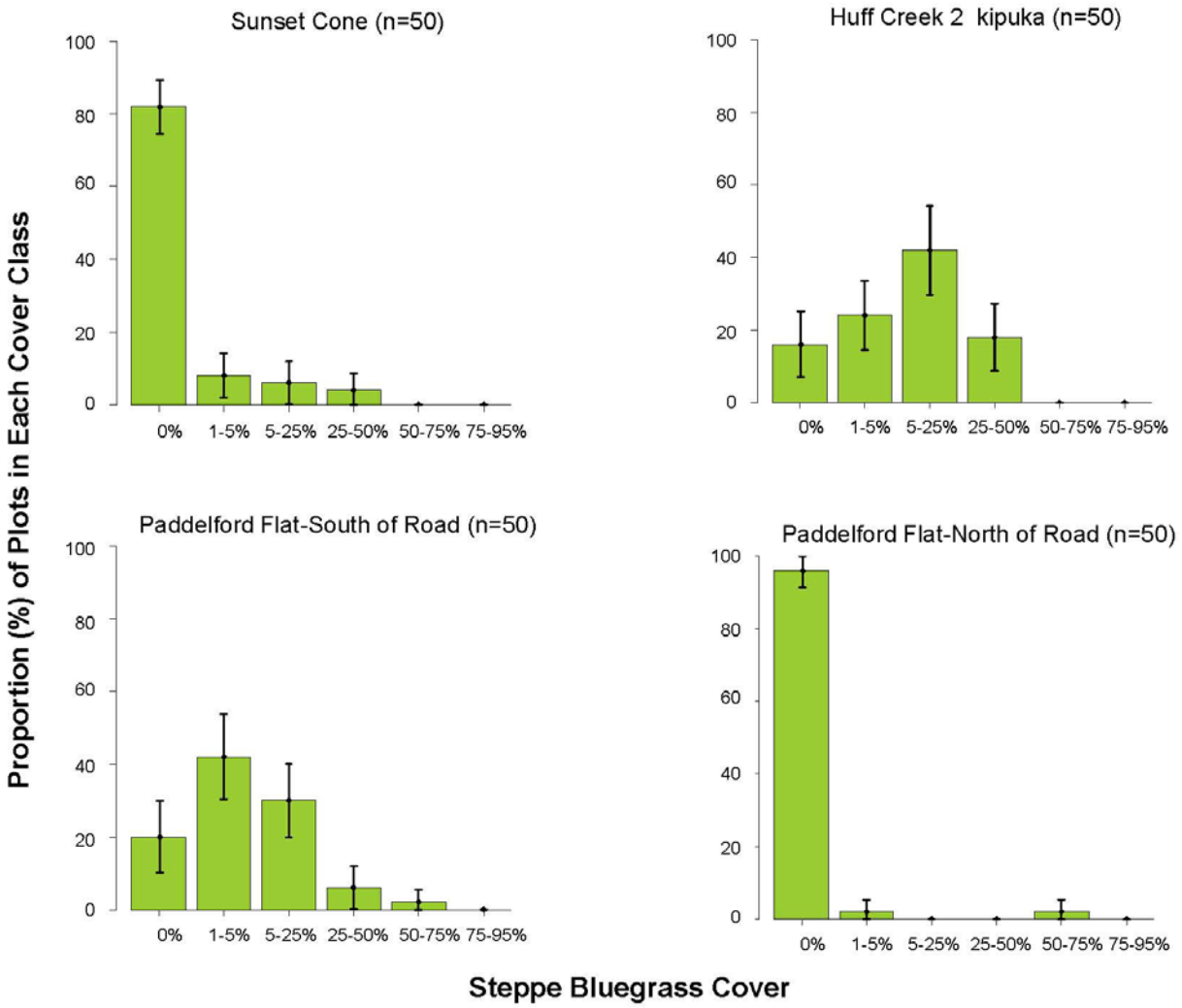


Figure A-2. Steppe bluegrass cover (continued).

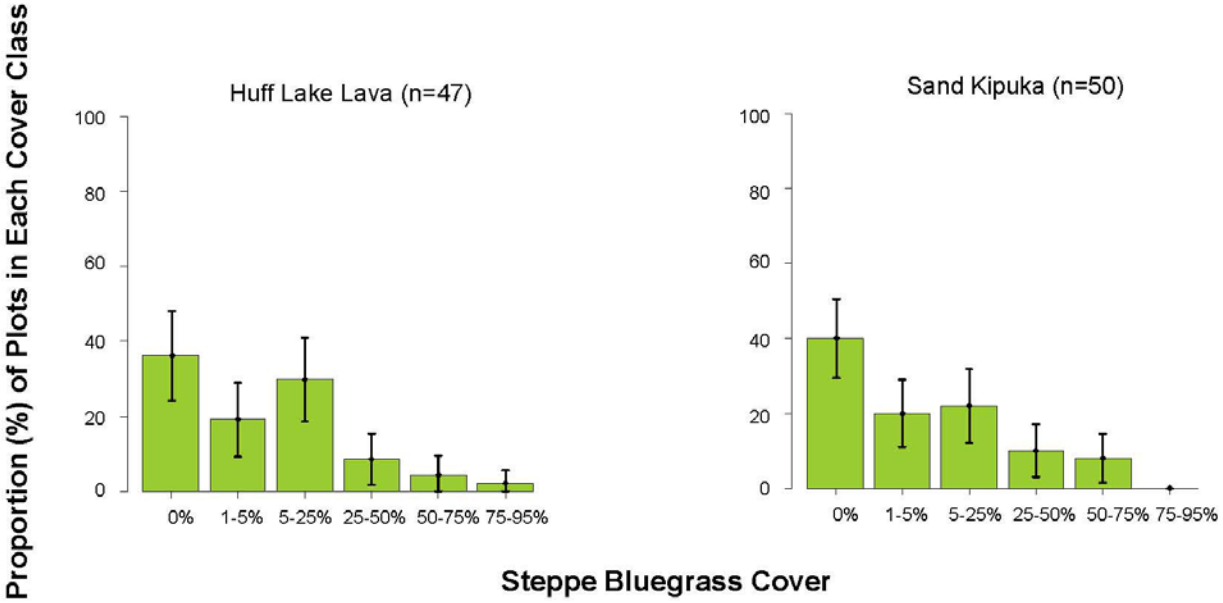


Figure A-2. Steppe bluegrass cover (continued).

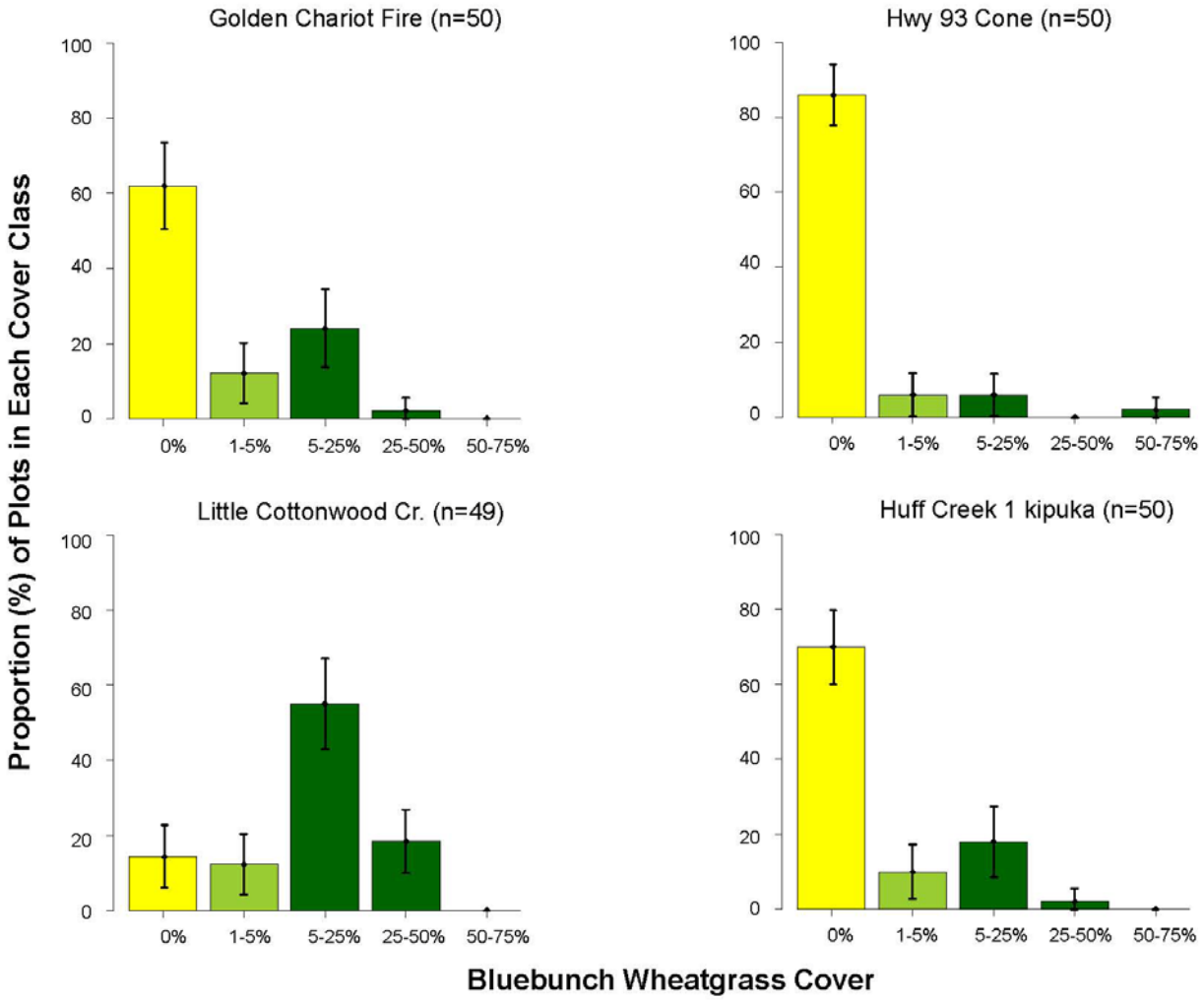
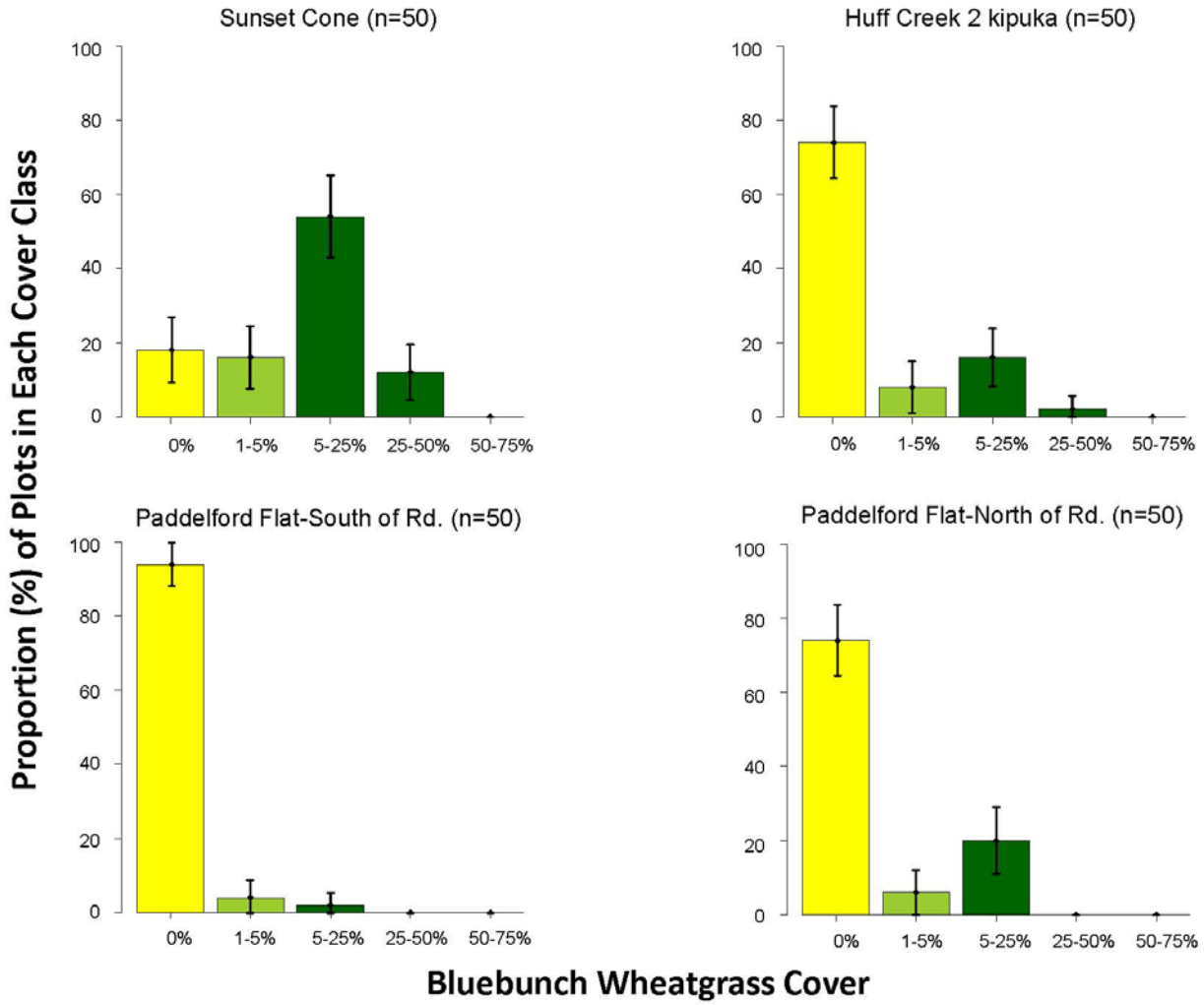


Figure A-3. Bluebunch wheatgrass cover.



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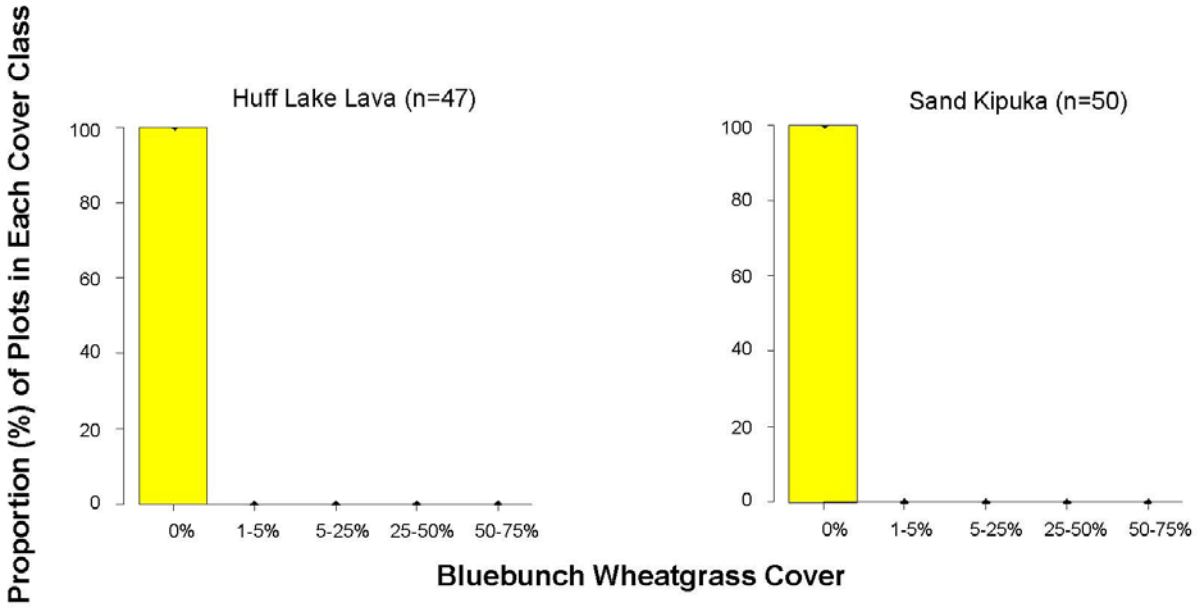


Figure A-3. Bluebunch wheatgrass cover (continued).

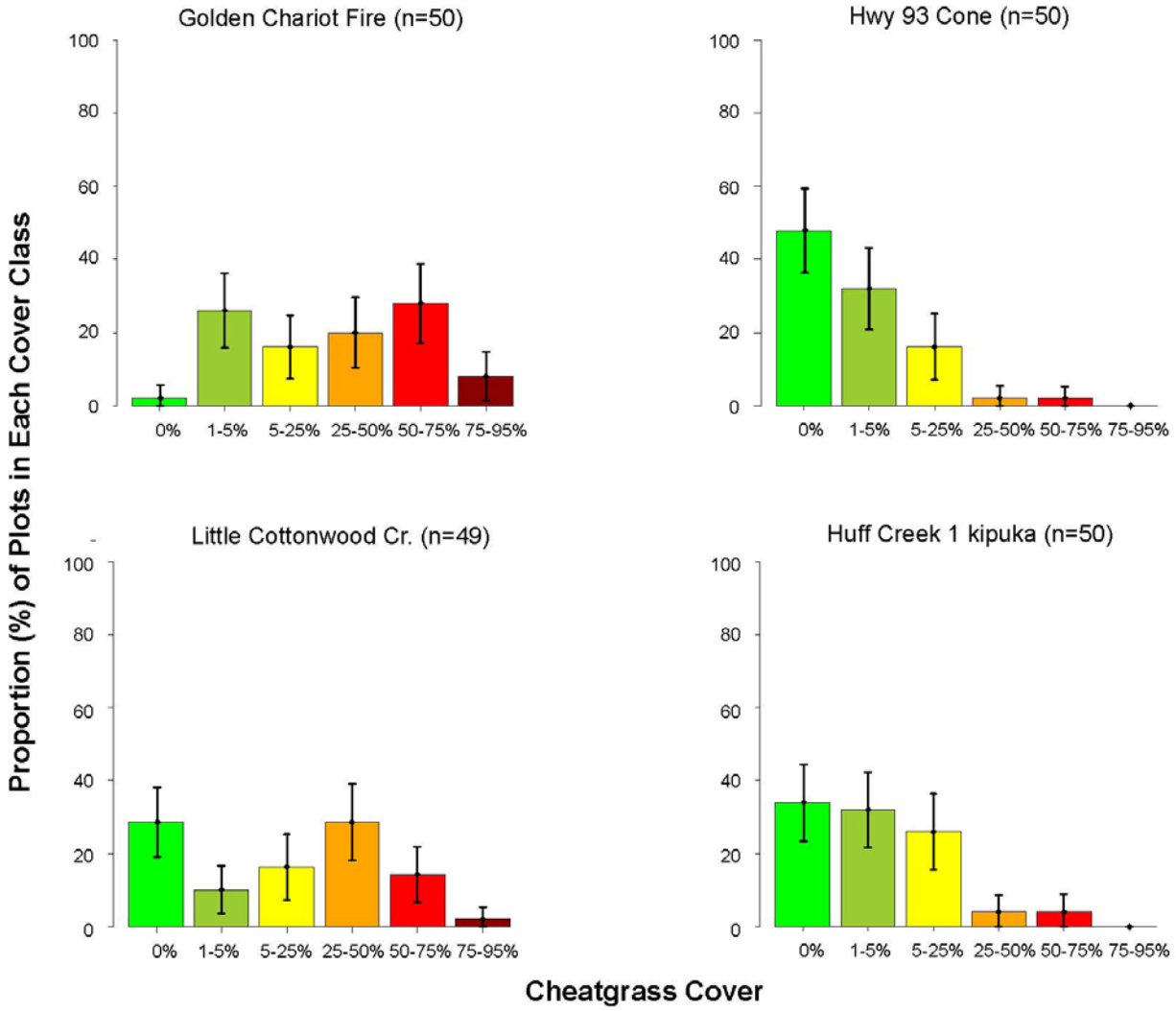
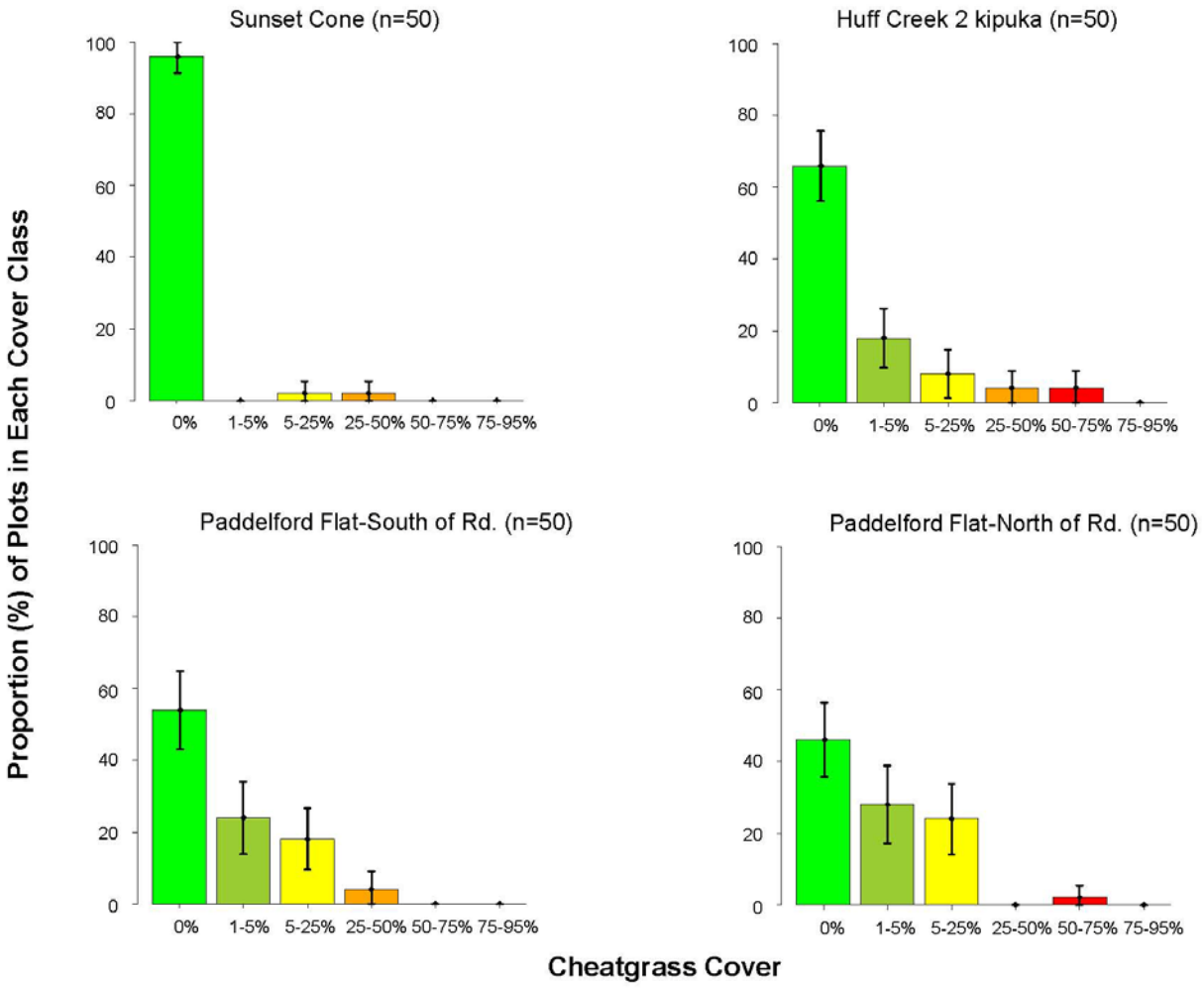


Figure A-4. Cheatgrass cover.



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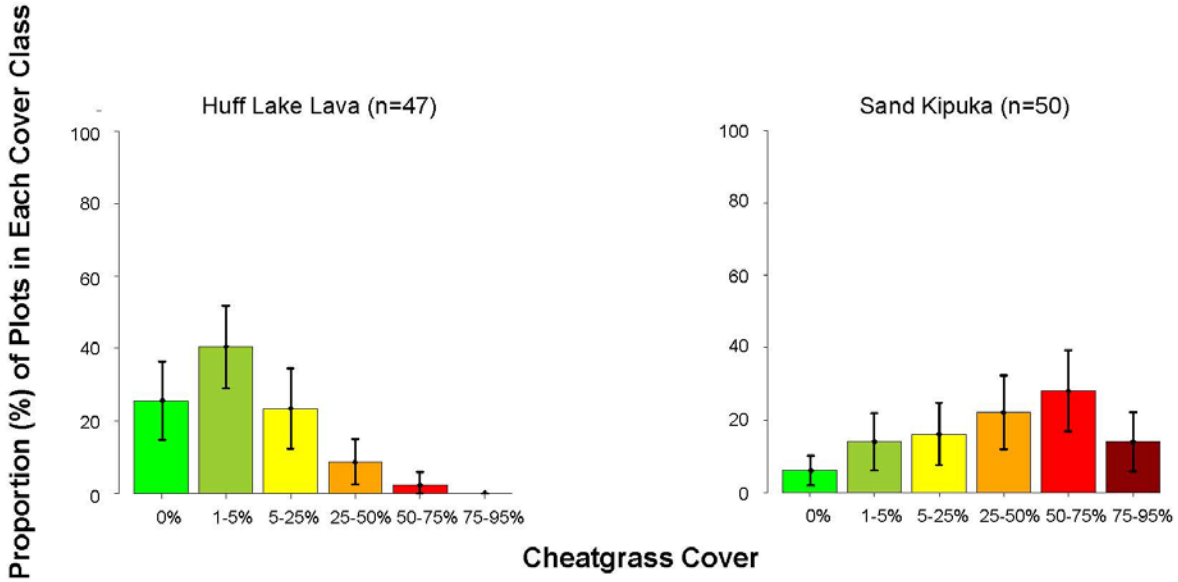


Figure A-4. Cheatgrass cover (continued).

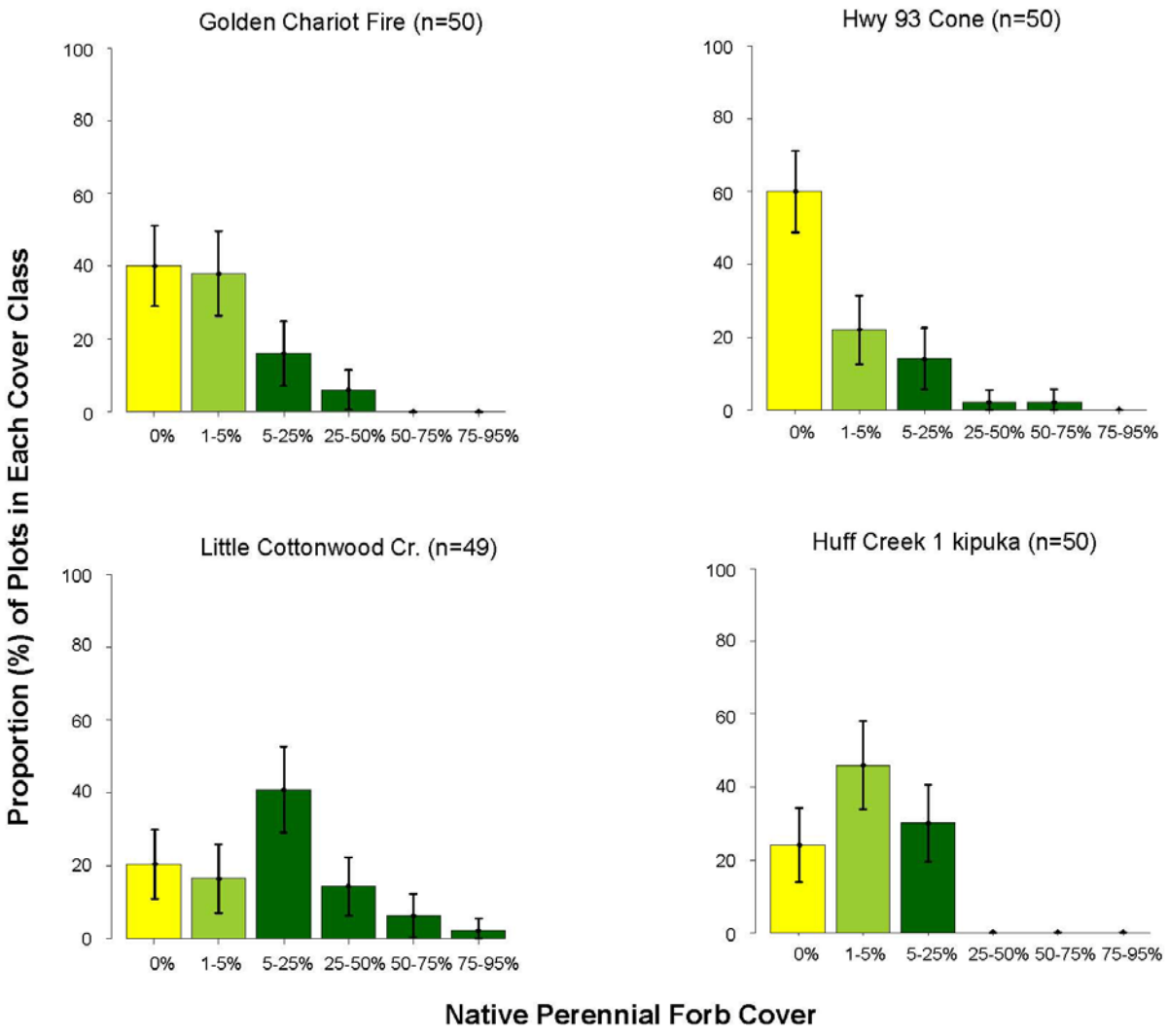


Figure A-5. Native perennial forb cover.

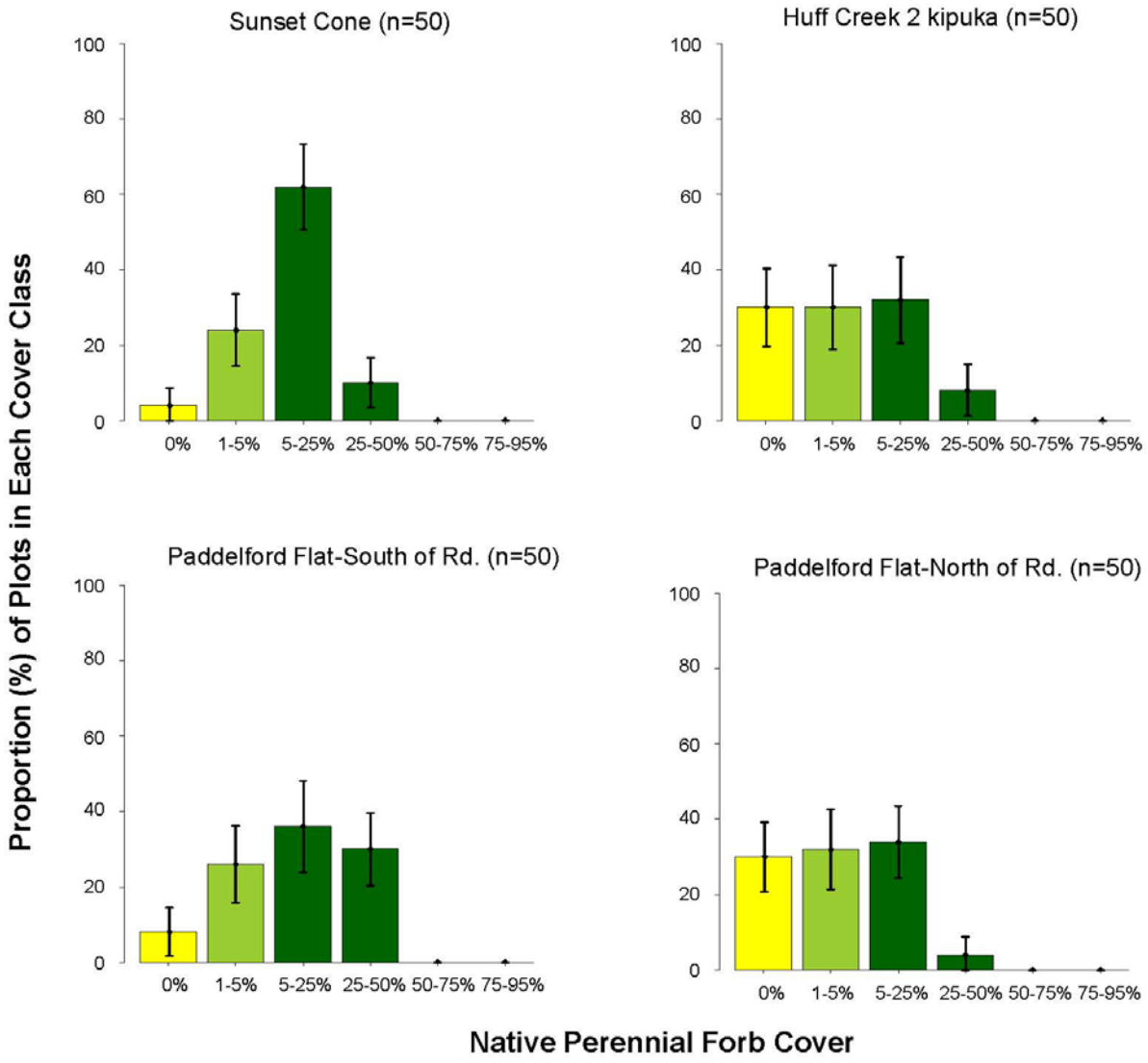
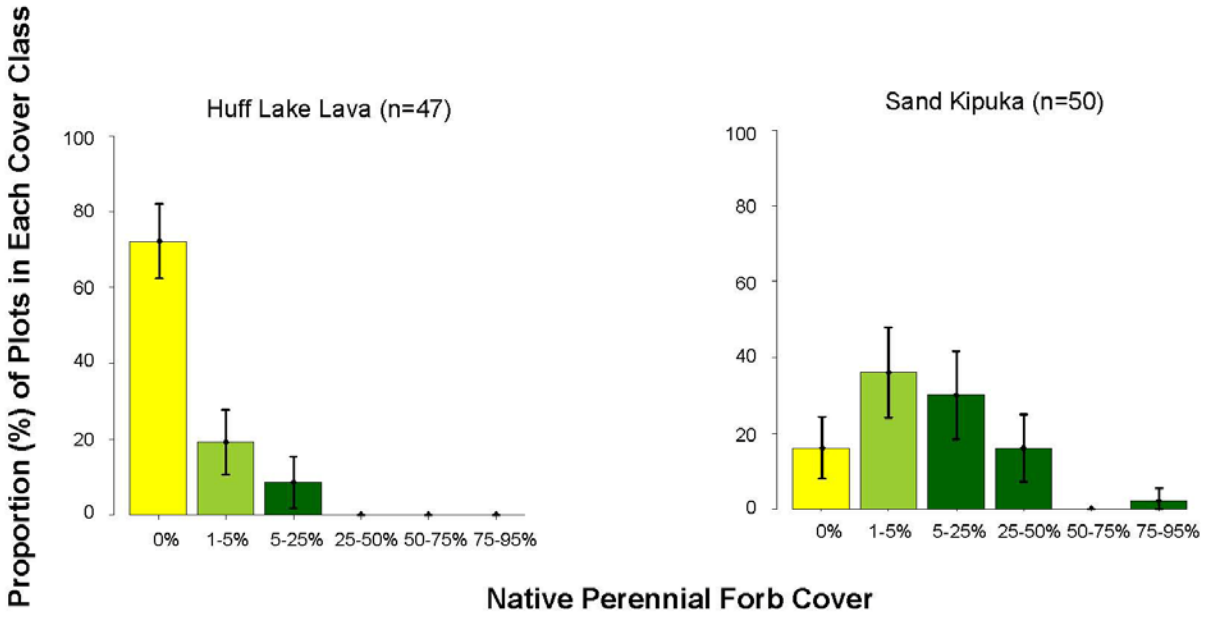


Figure A-5. Native perennial forb cover (continued).



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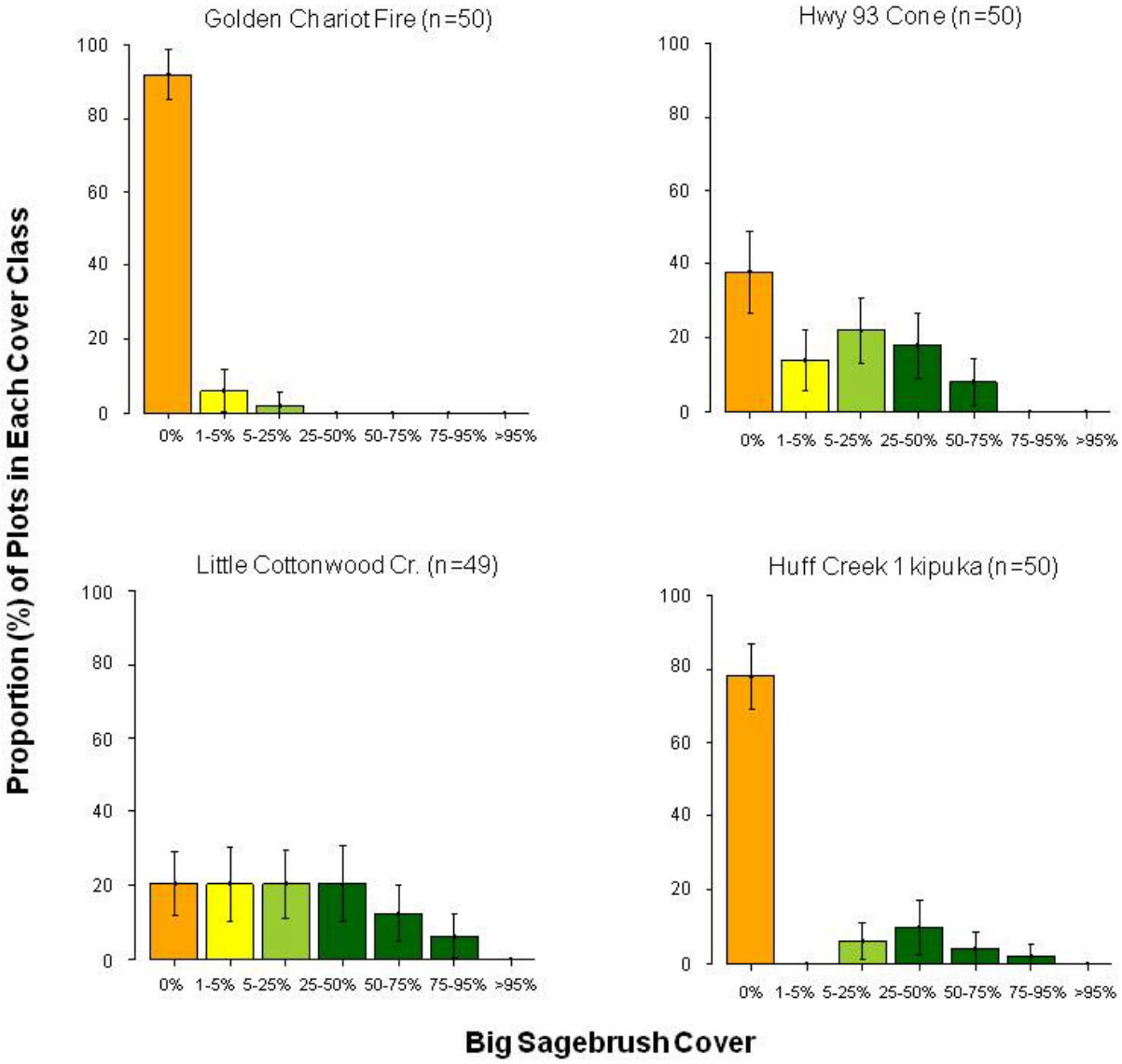

Figure A-6. Big sagebrush cover.

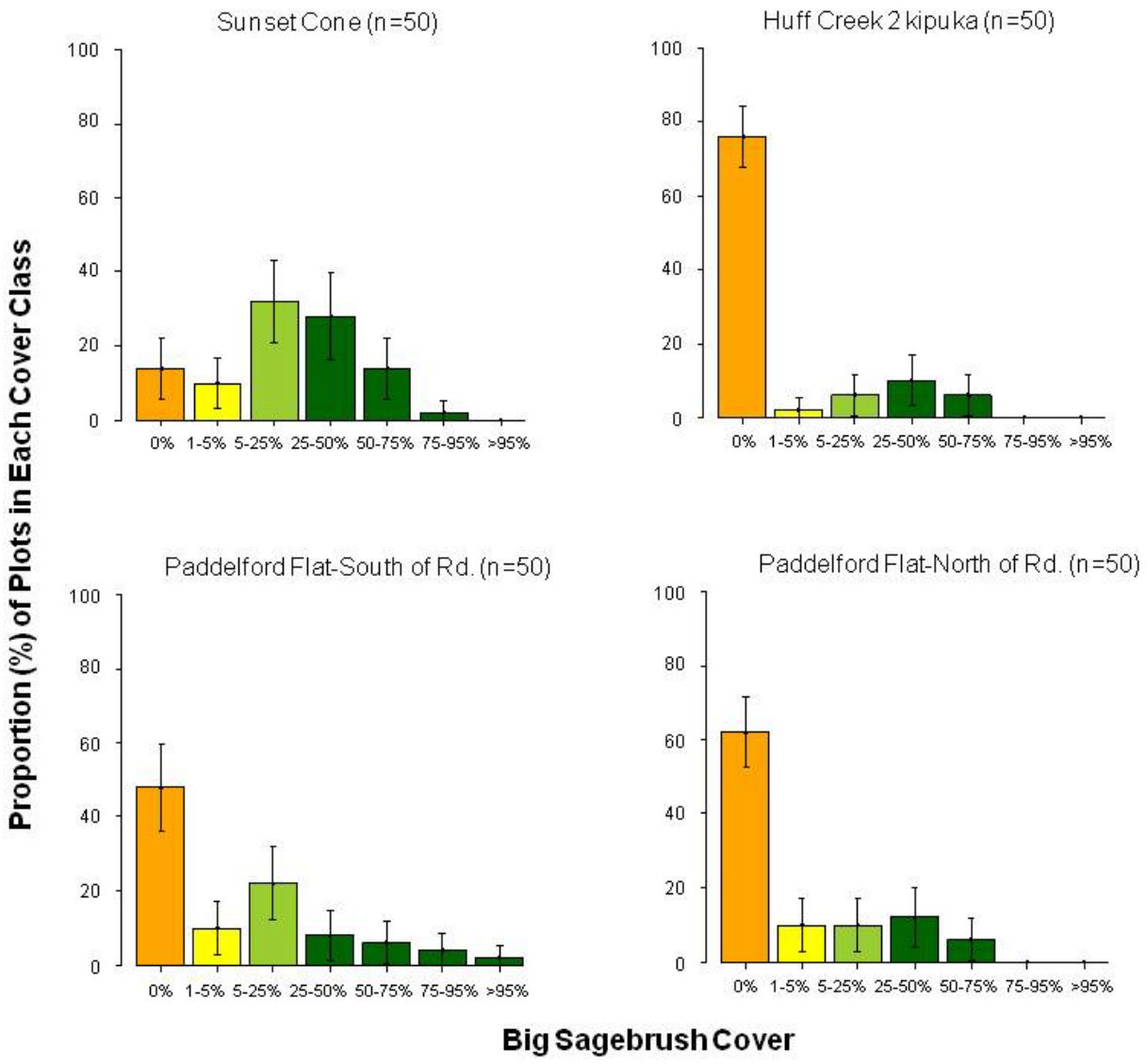

Figure A-6. Big sagebrush cover (continued).

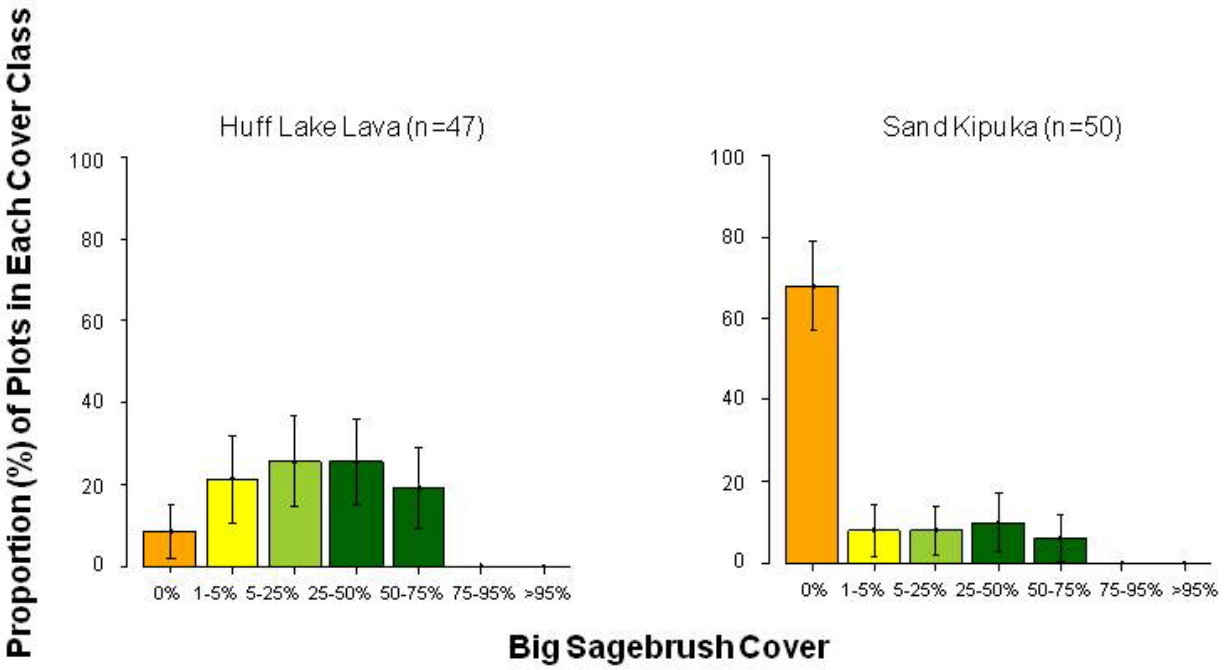

Figure A-6. Big sagebrush cover (continued).

Appendix B. Bar graphs for Hagerman Fossil Beds National Monument

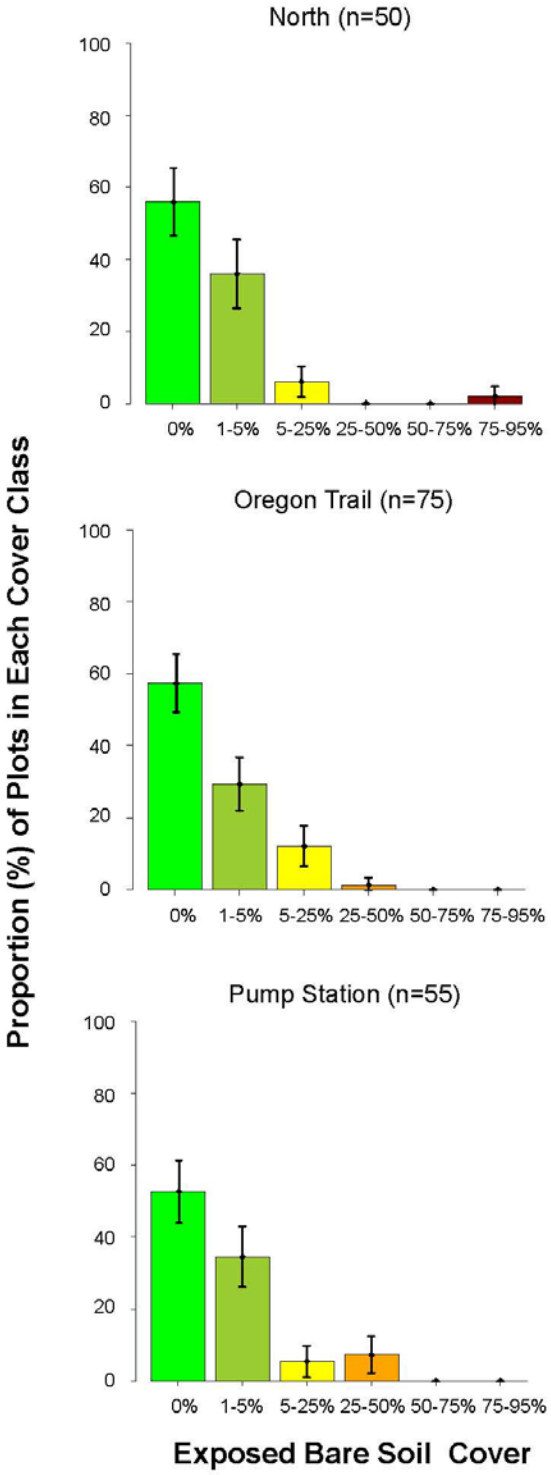

Figure B-1. Exposed bare soil cover.

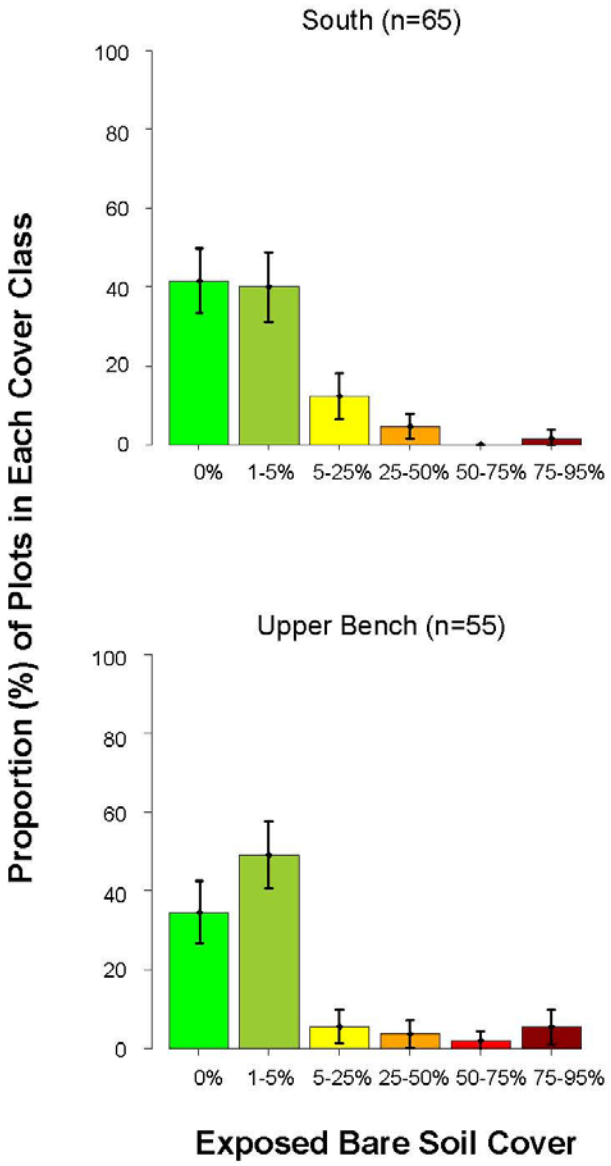

Figure B-1. Exposed bare soil cover (continued).

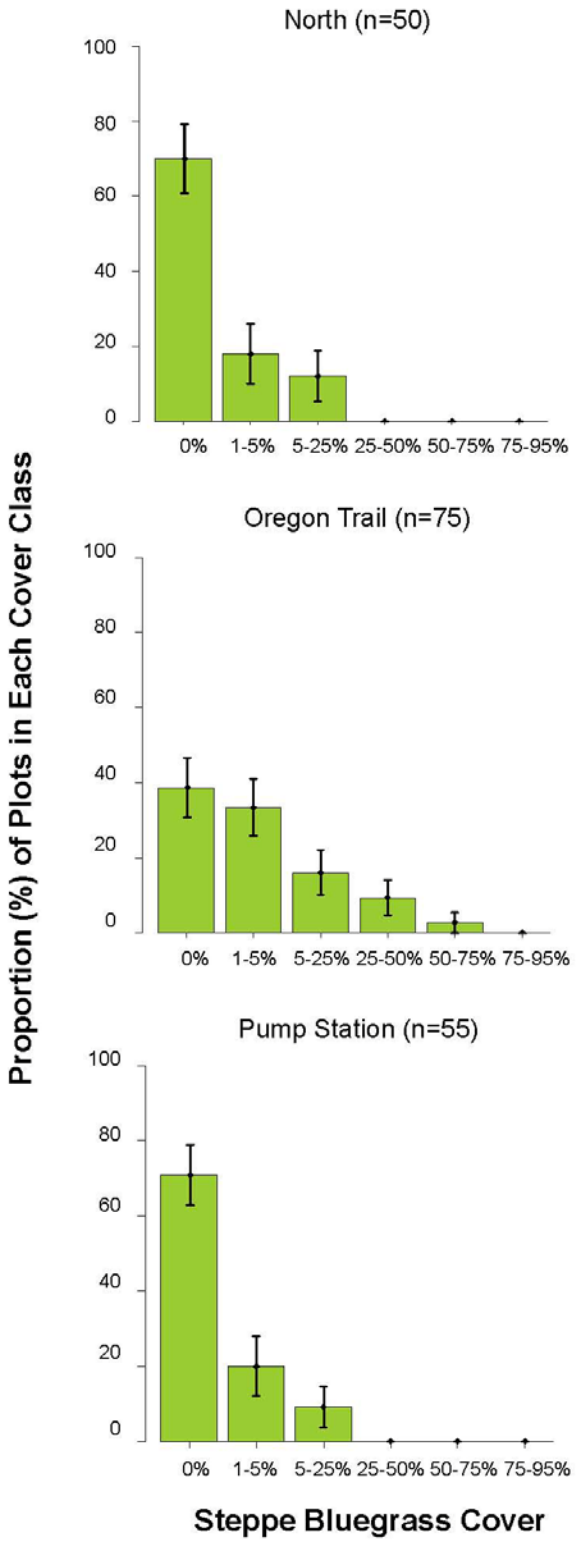

Figure B-2. Steppe bluegrass cover.

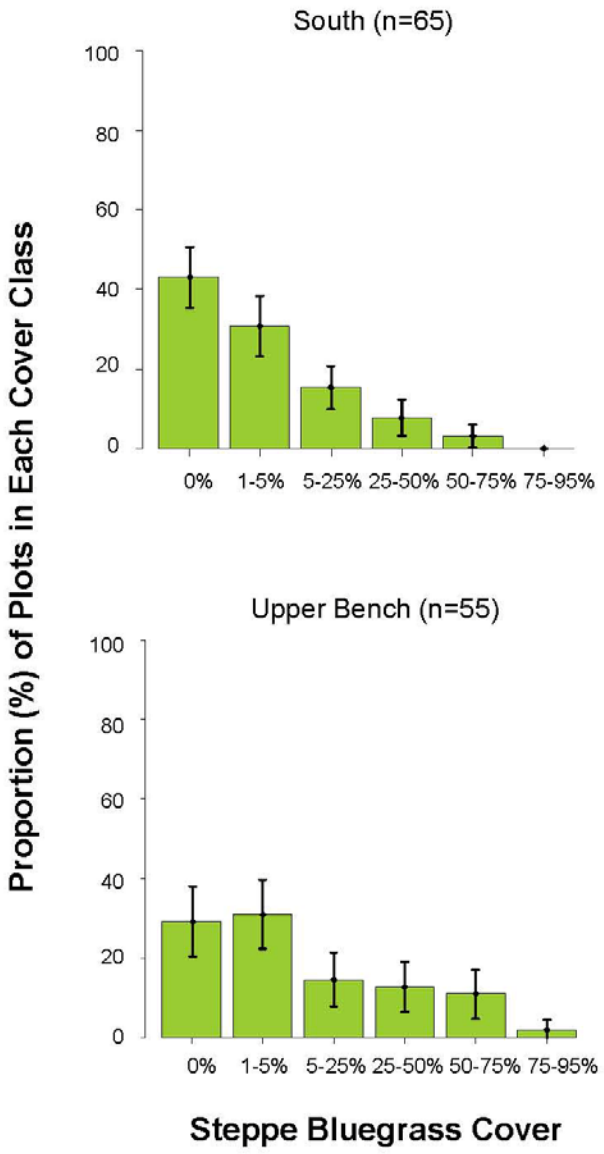

Figure B-2. Steppe bluegrass cover (continued).

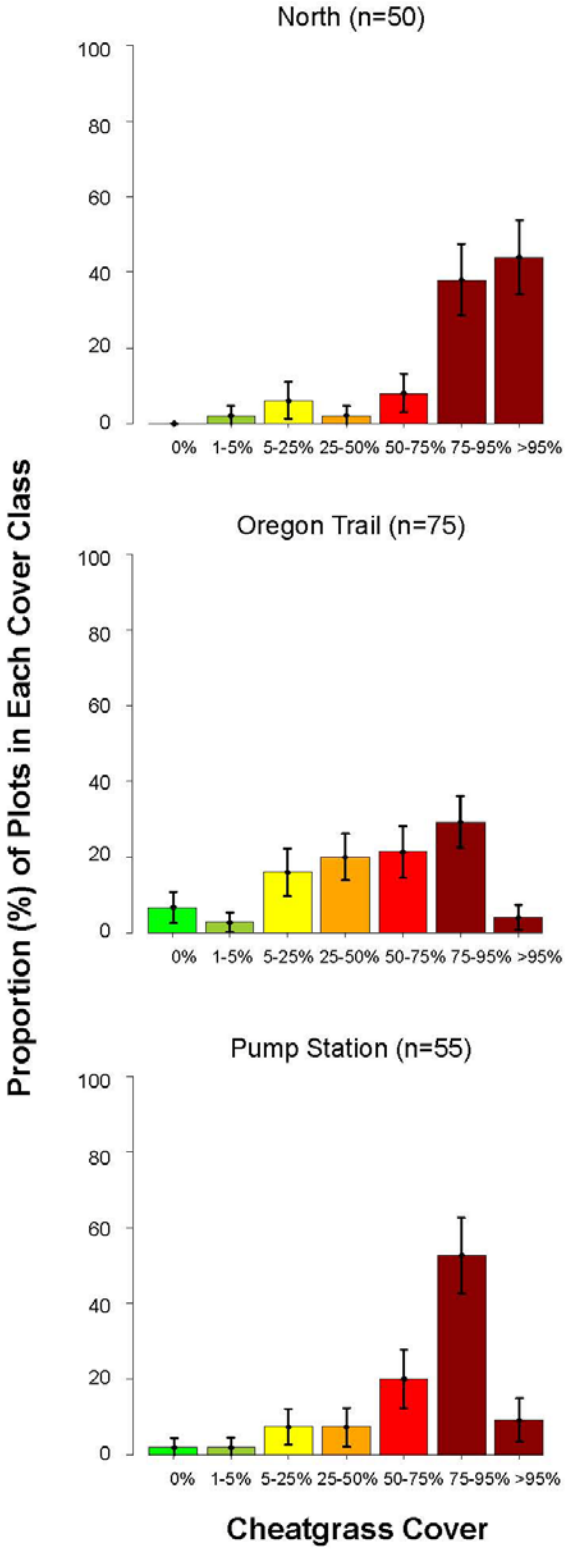

Figure B-3. Cheatgrass cover.

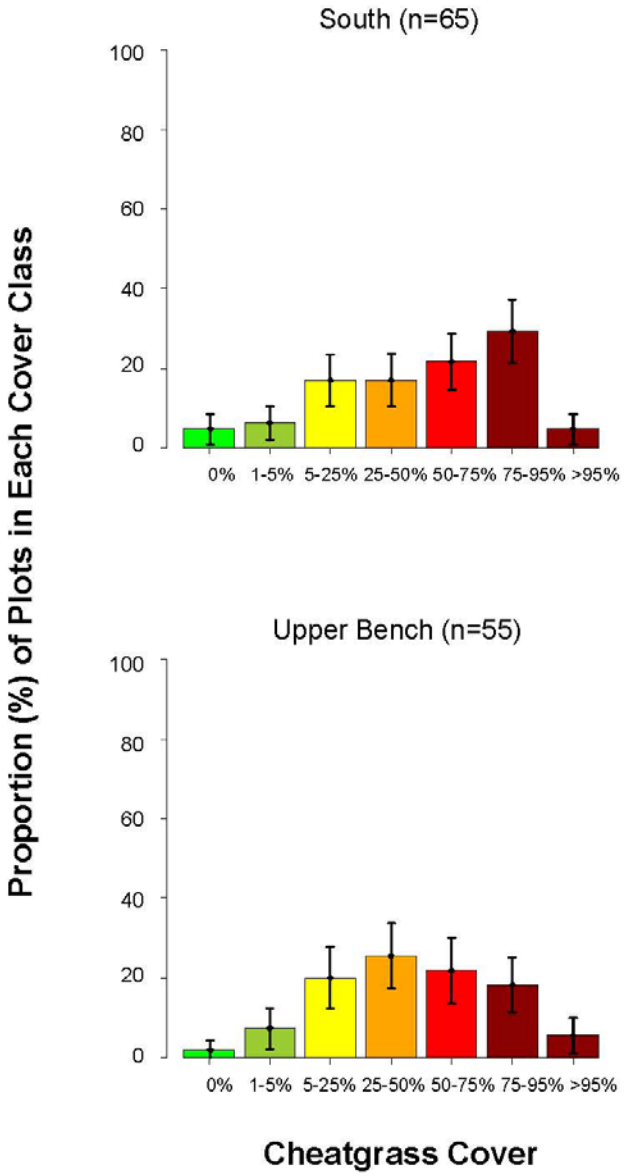

Figure B-3. Cheatgrass cover (continued).

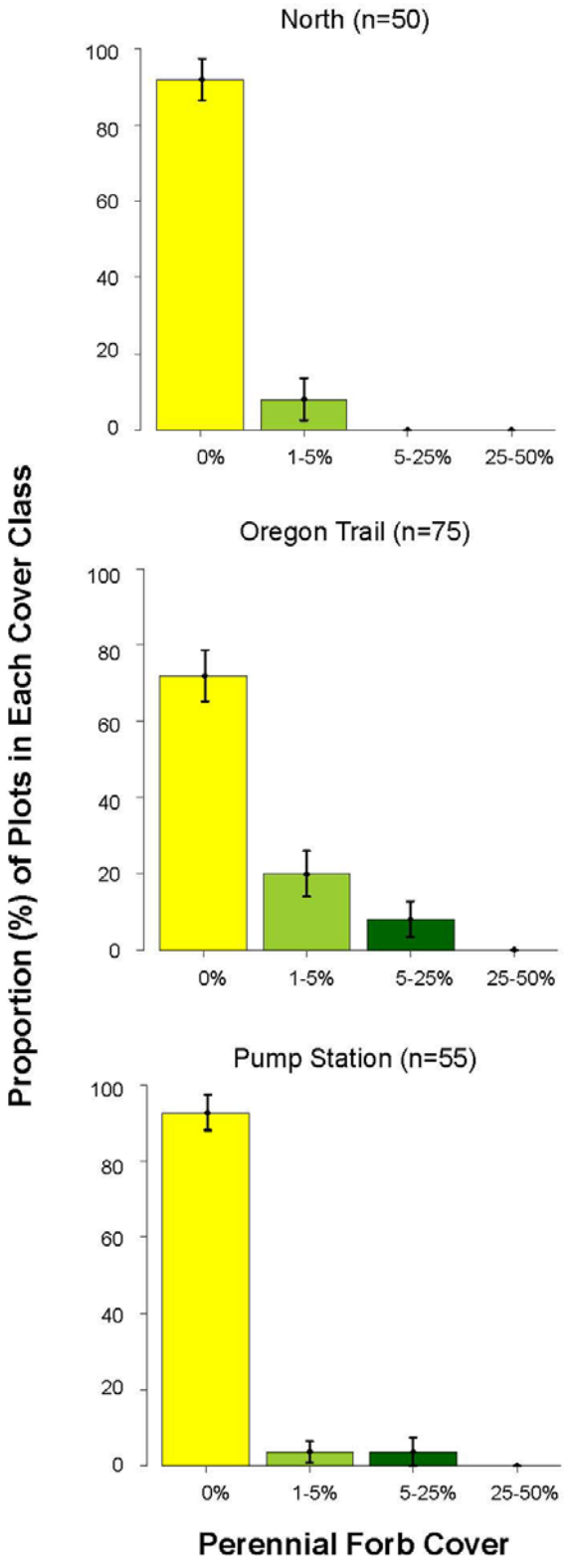

Figure B-4. Native perennial forb cover.

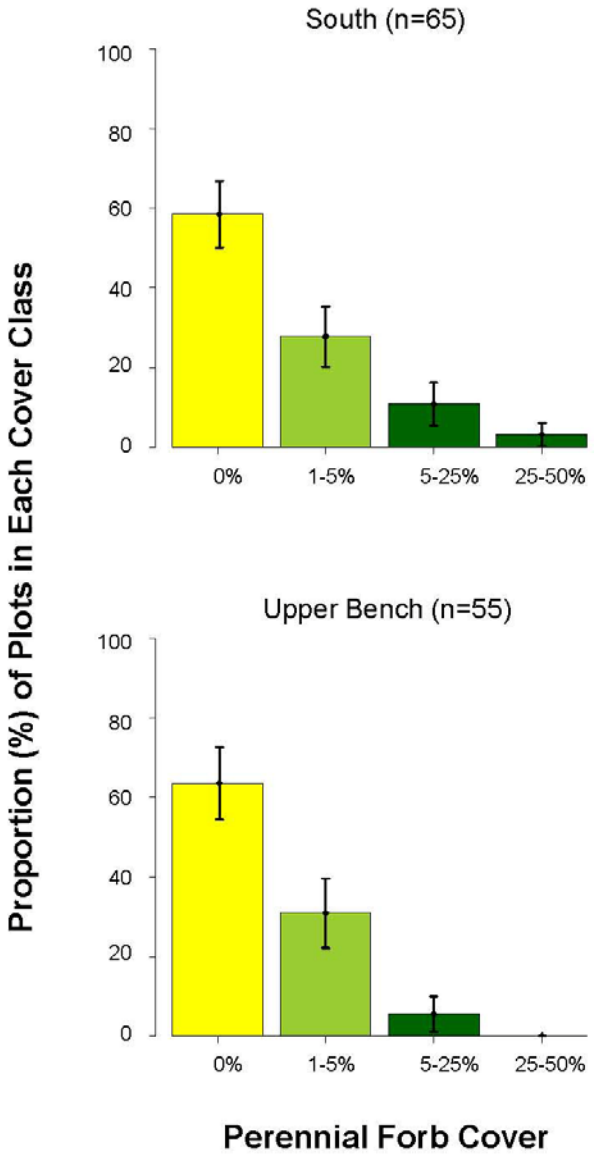

Figure B-4. Native perennial forb cover (continued).

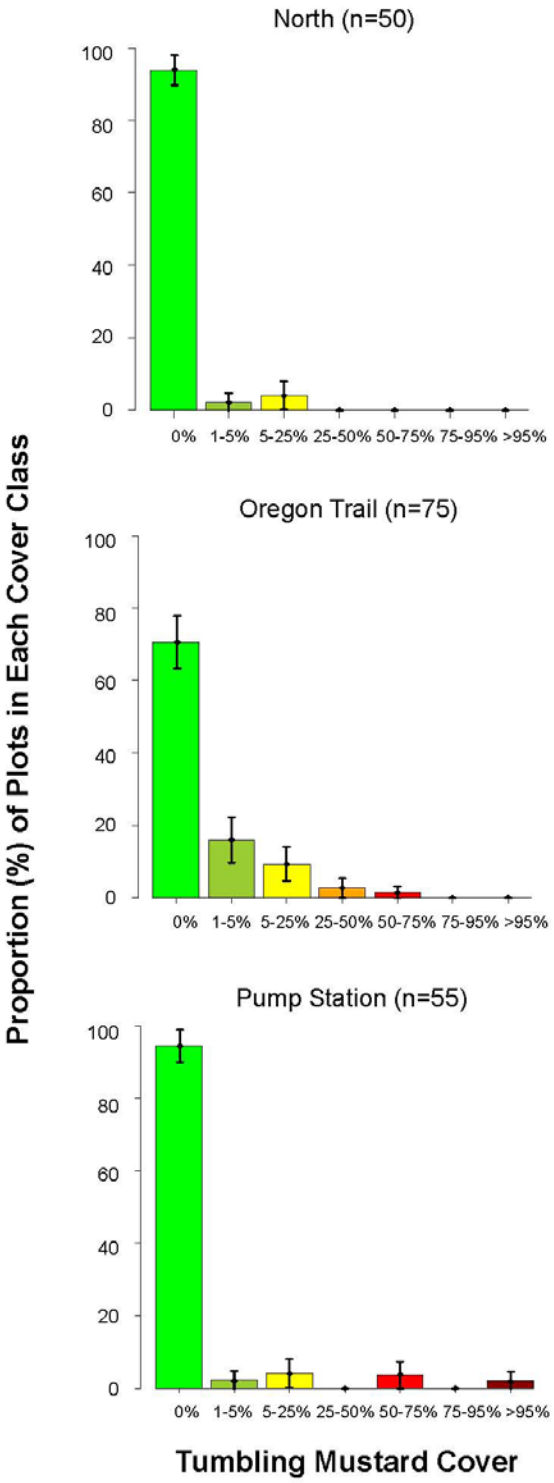

Figure B-5. Tumbling mustard cover.

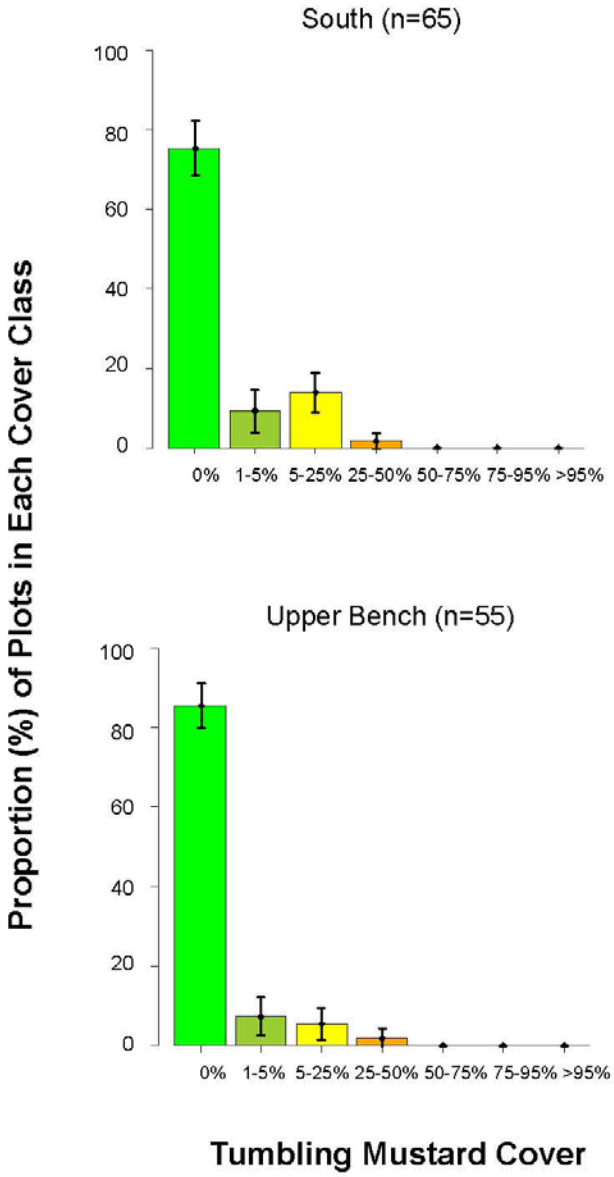

Figure B-5. Tumbling mustard cover (continued).

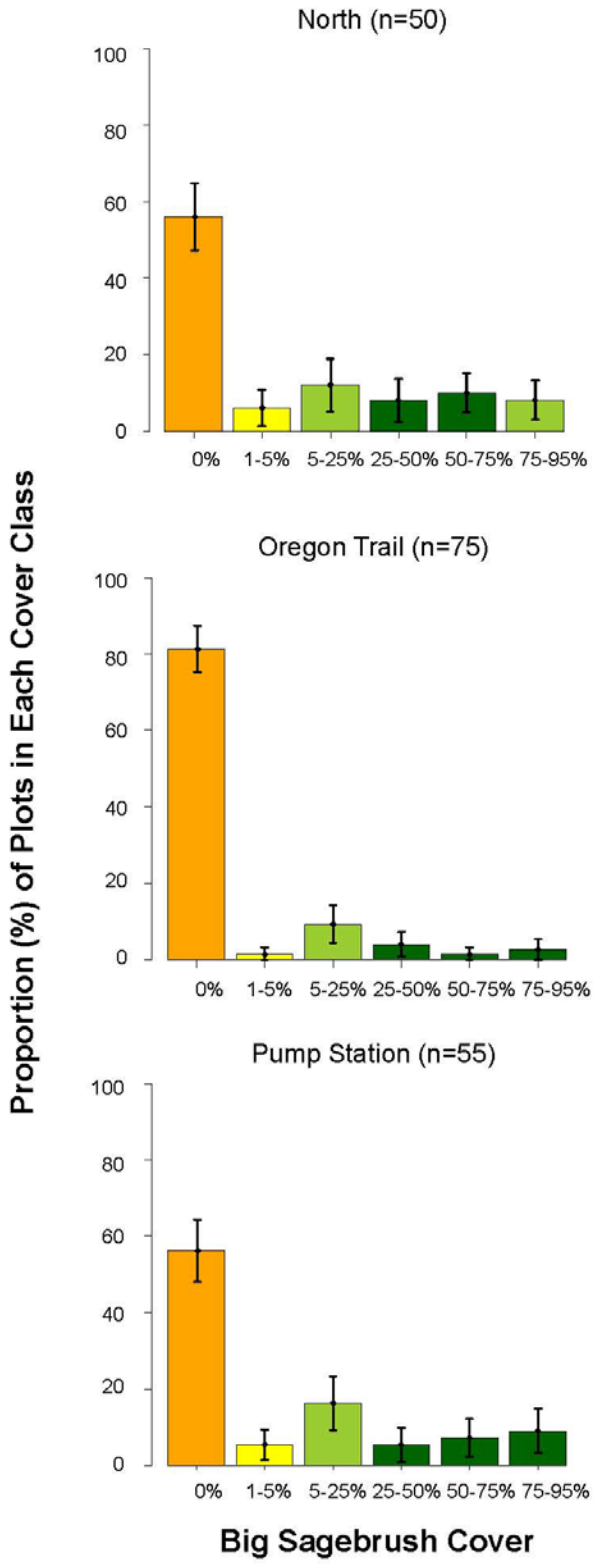

Figure B-6. Big sagebrush cover.

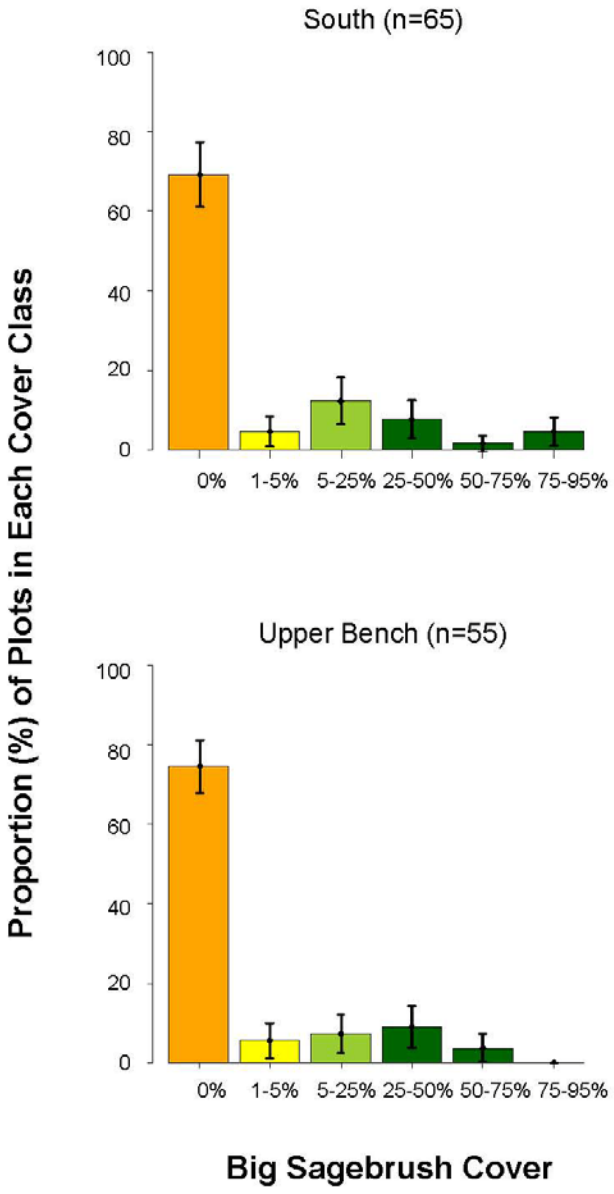

Figure B-6. Big sagebrush cover (continued).

Appendix C. Bar graphs for John Day Fossil Beds National Monument

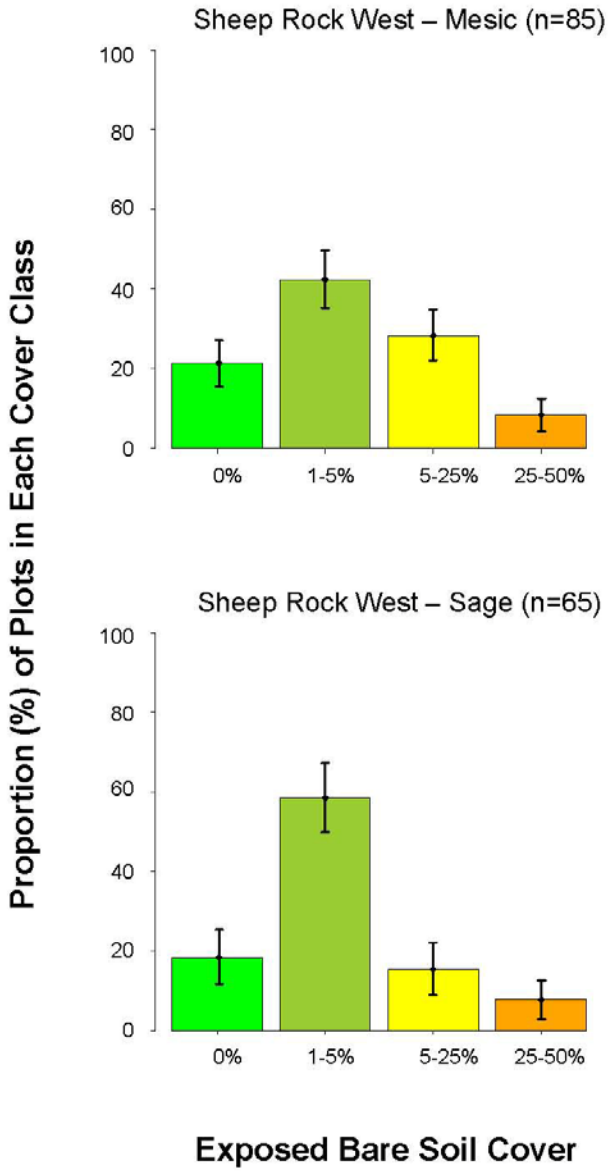

Figure C-1. Exposed bare soil cover.

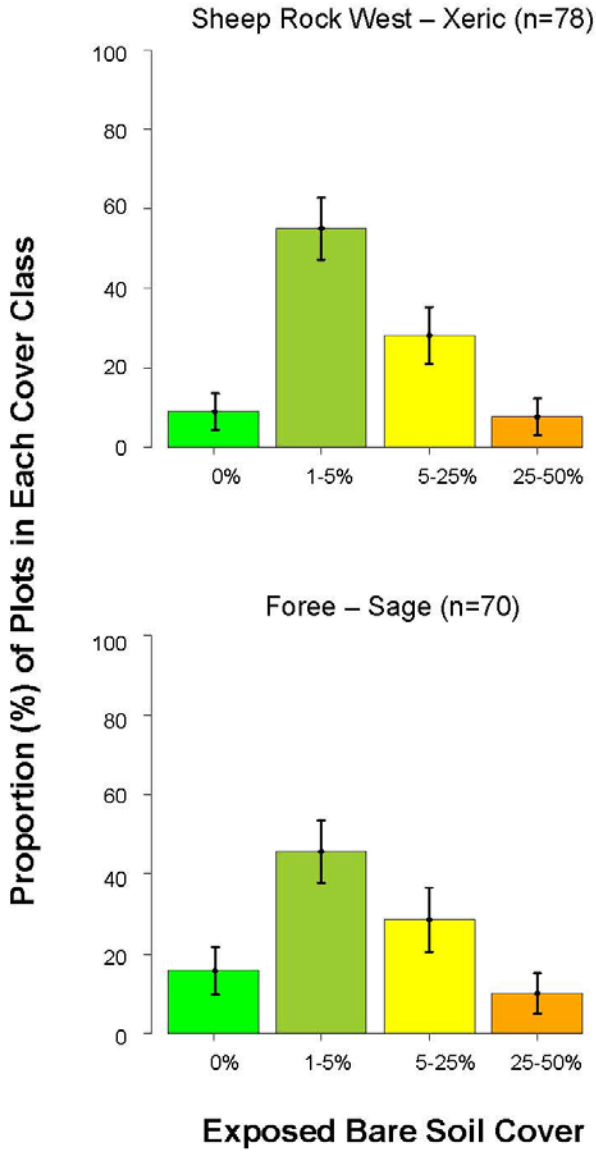

Figure C-1. Exposed bare soil cover (continued).

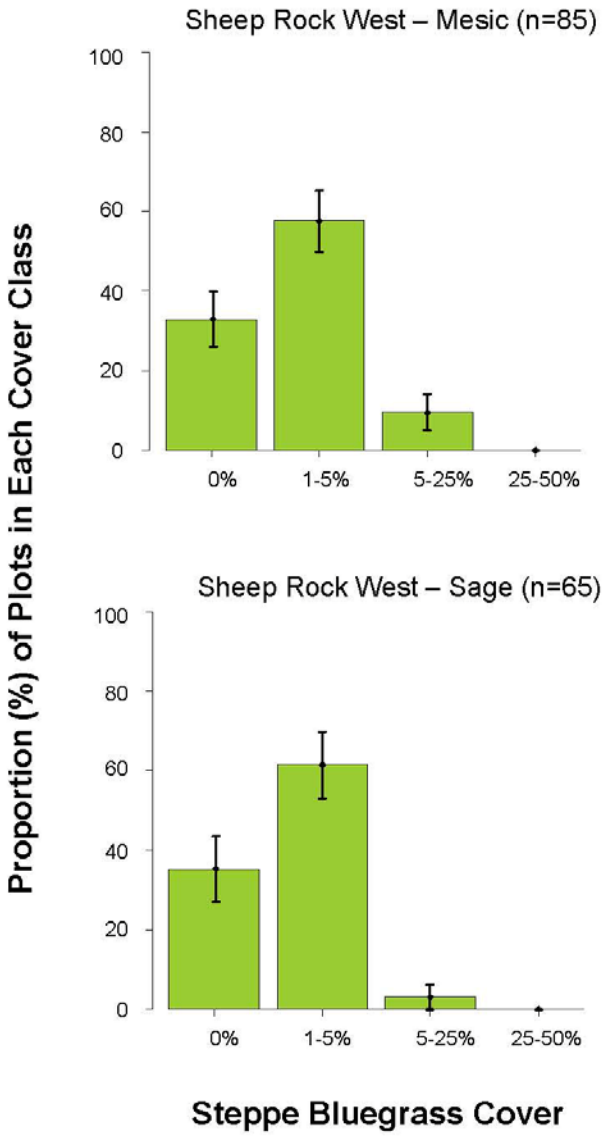

Figure C-2. Steppe bluegrass cover.

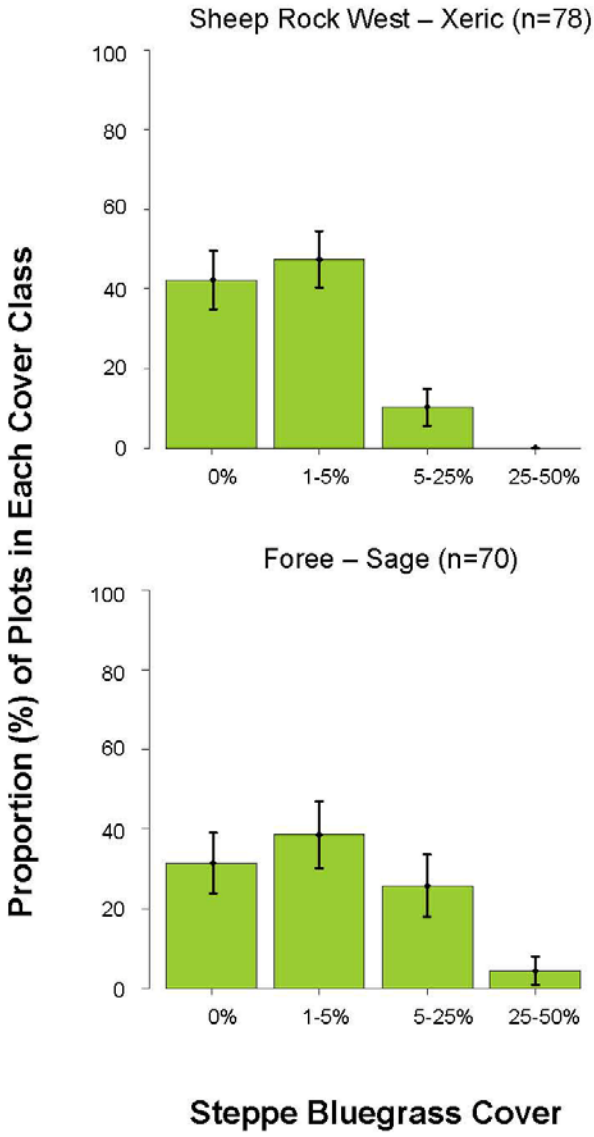

Figure C-2. Steppe bluegrass cover (continued).

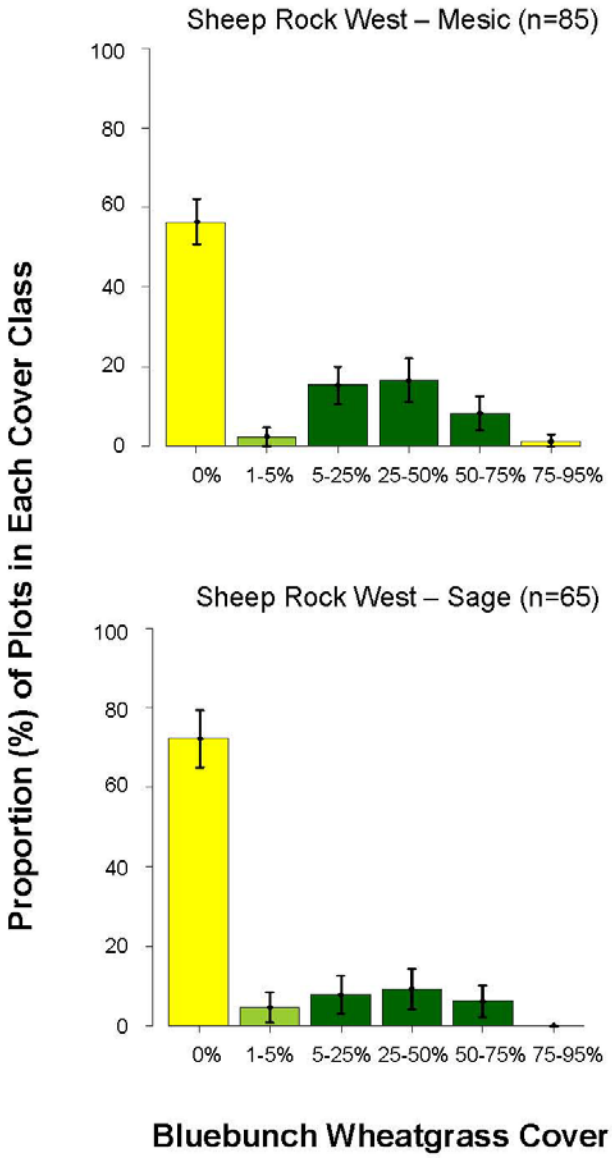

Figure C-3. Bluebunch wheatgrass cover.

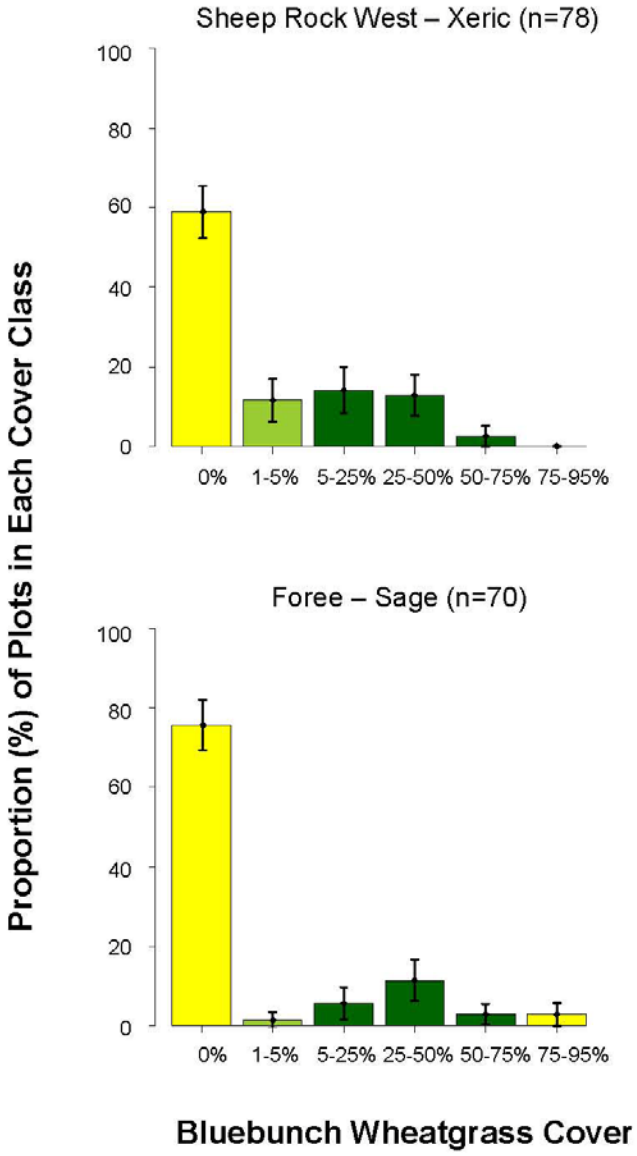

Figure C-3. Bluebunch wheatgrass cover (continued).

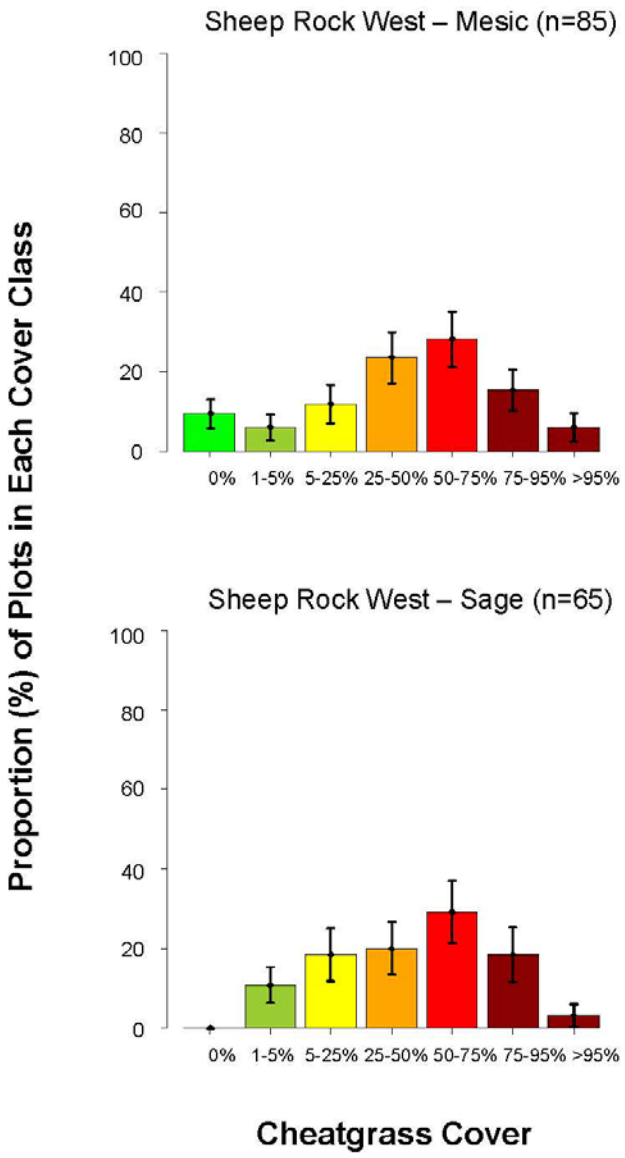

Figure C-4. Cheatgrass cover.

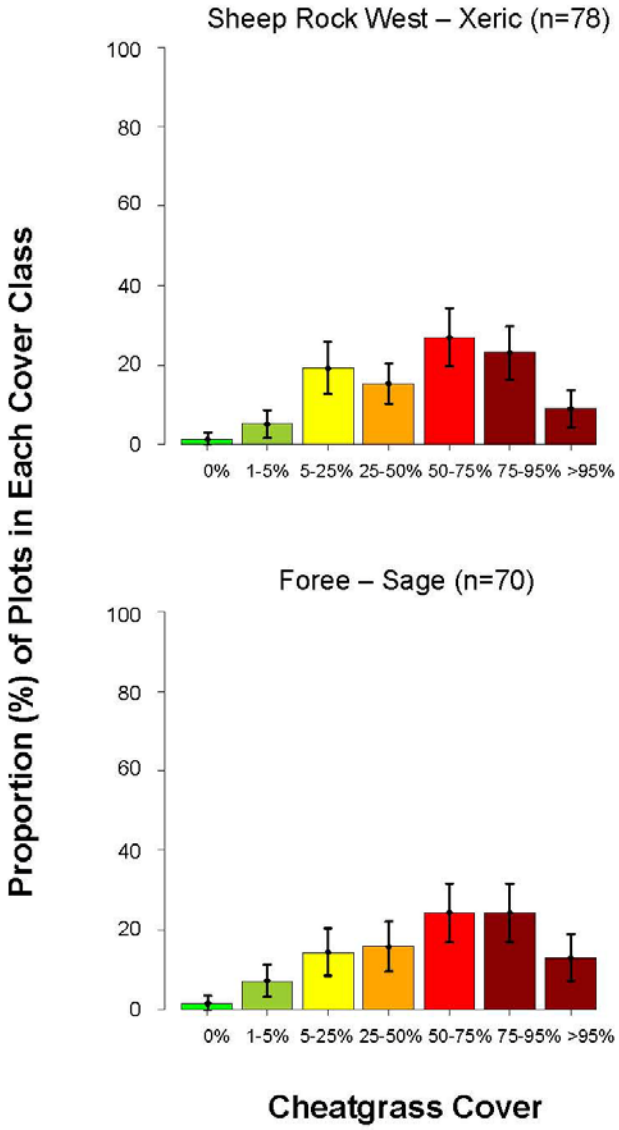

Figure C-4. Cheatgrass cover (continued).

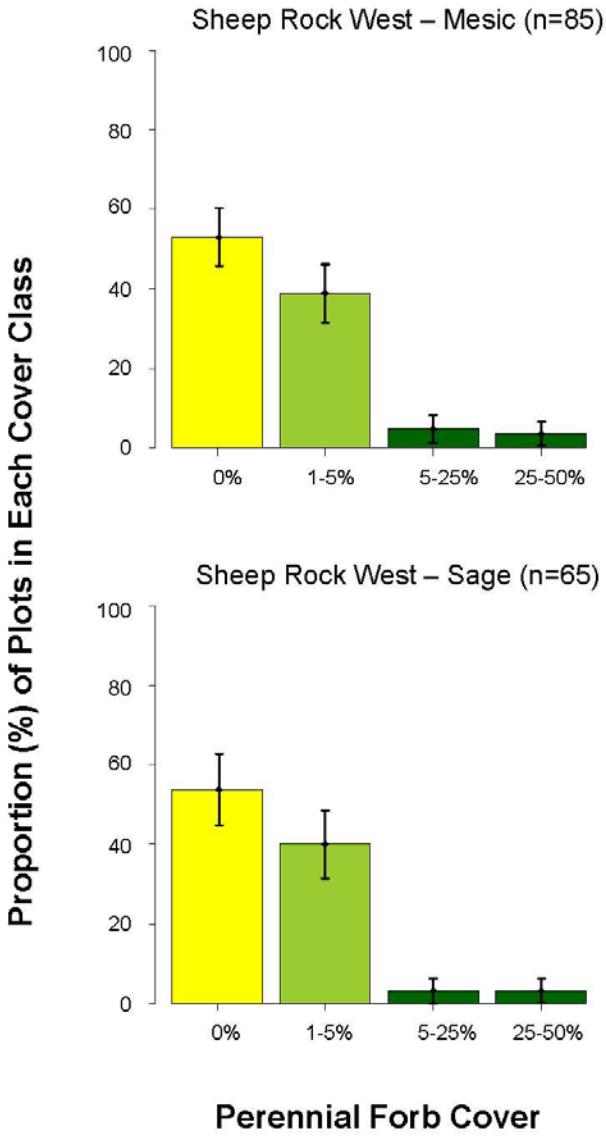

Figure C-5. Native perennial forb cover.

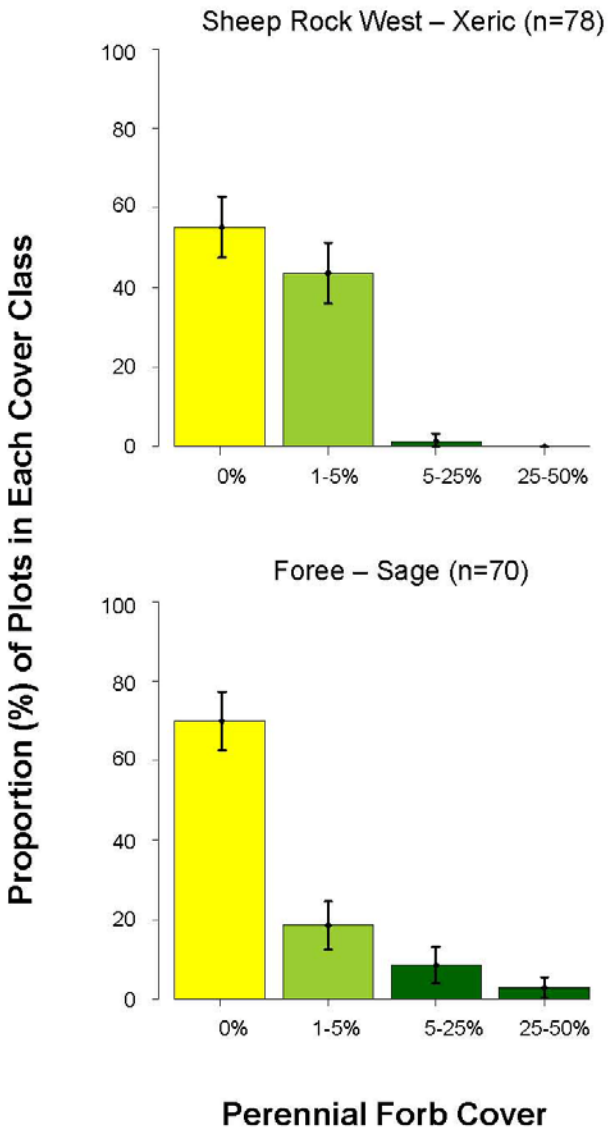

Figure C-5. Native perennial forb cover (continued).

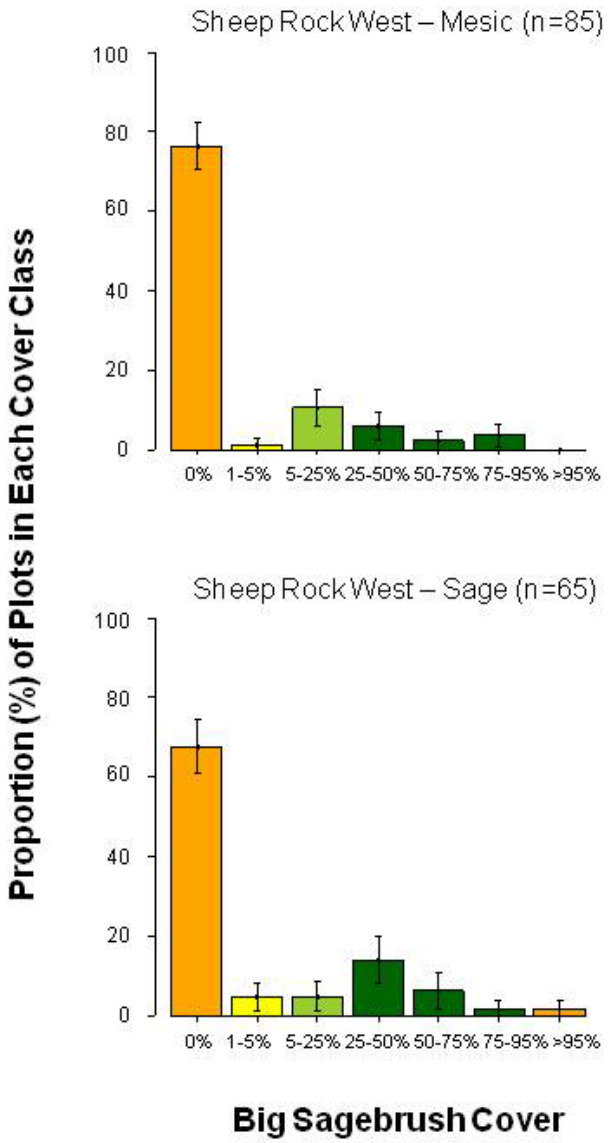

Figure C-6. Big sagebrush cover.

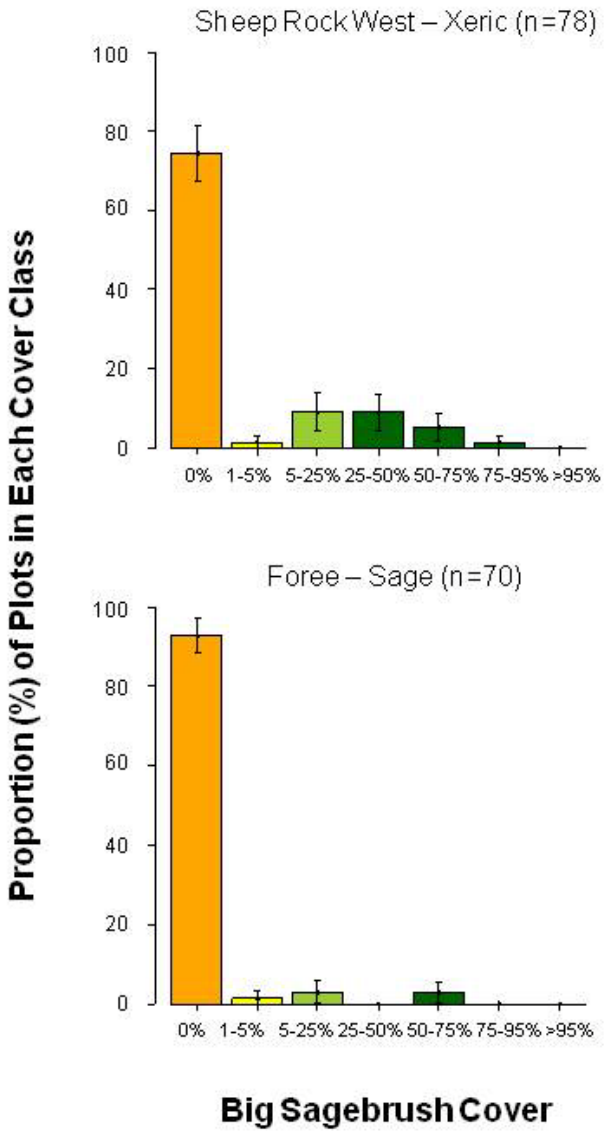

Figure C-6. Big sagebrush cover (continued).

Appendix D. Bar graphs for Lake Roosevelt National Recreation Area

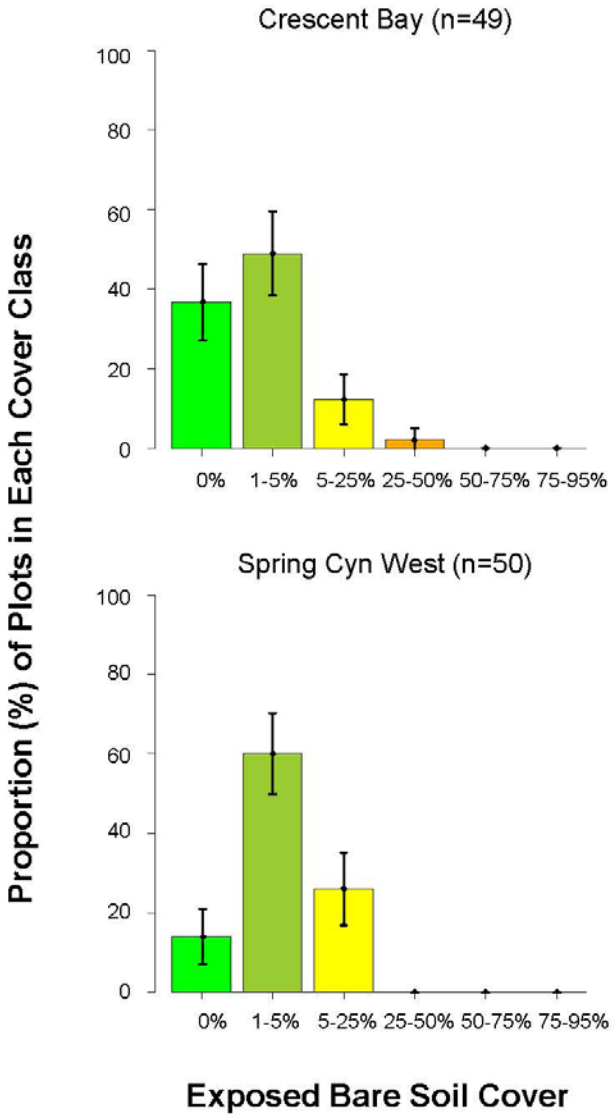

Figure D-1. Exposed bare soil cover.

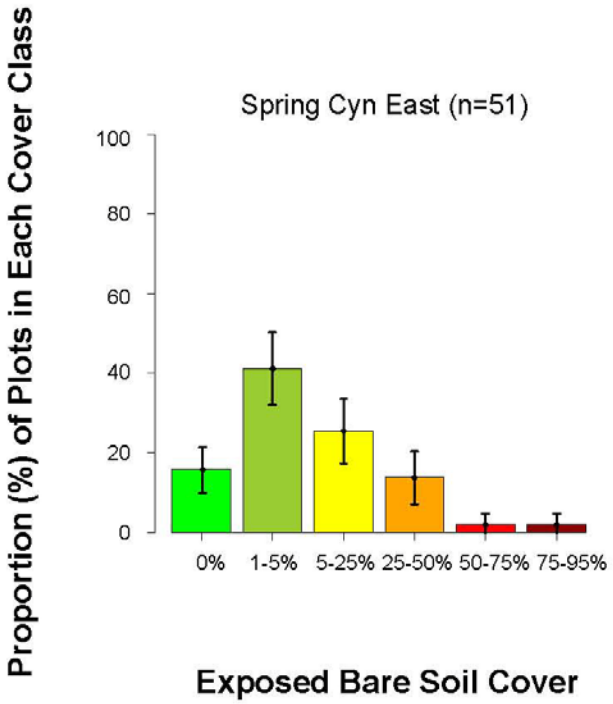

Figure D-1. Exposed bare soil cover (continued).

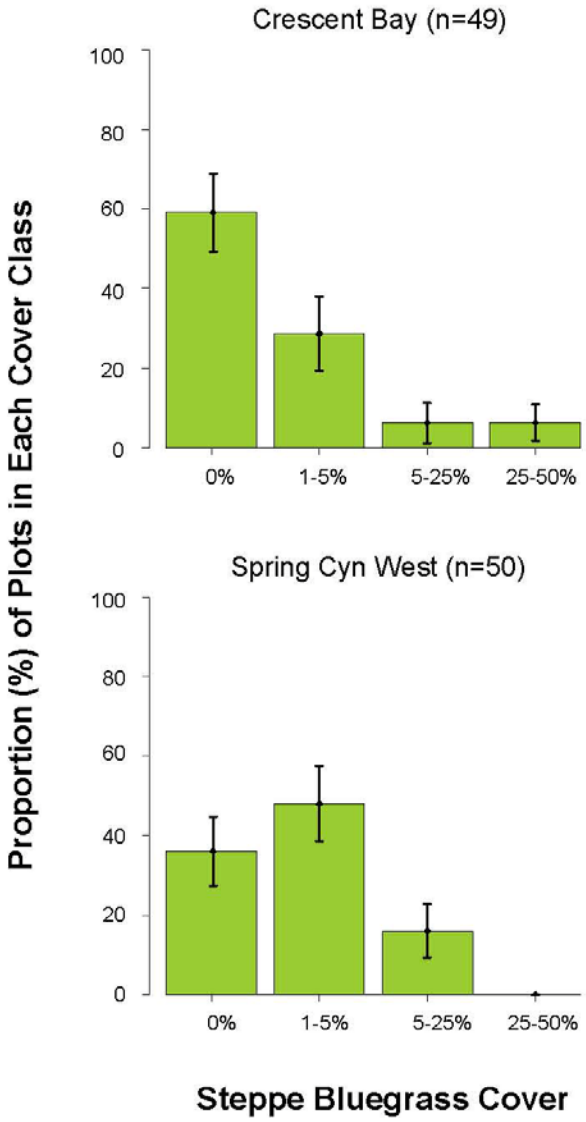

Figure D-2. Steppe bluegrass cover.

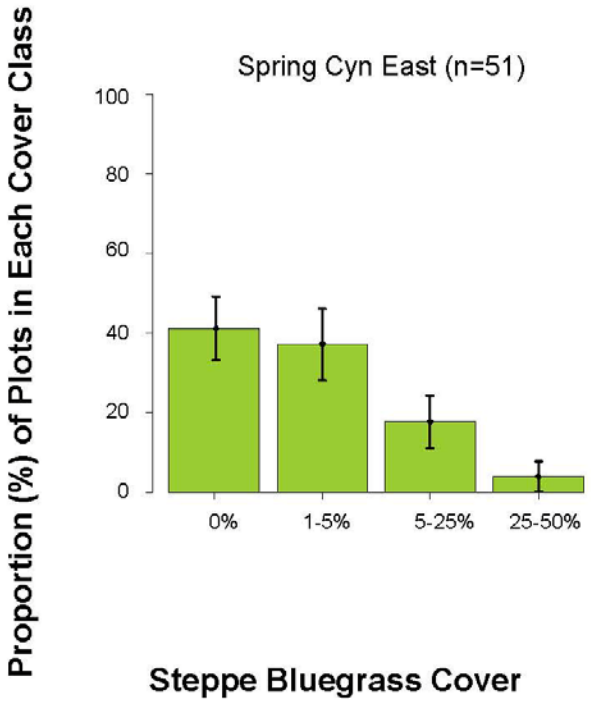

Figure D-2. Steppe bluegrass cover (continued).

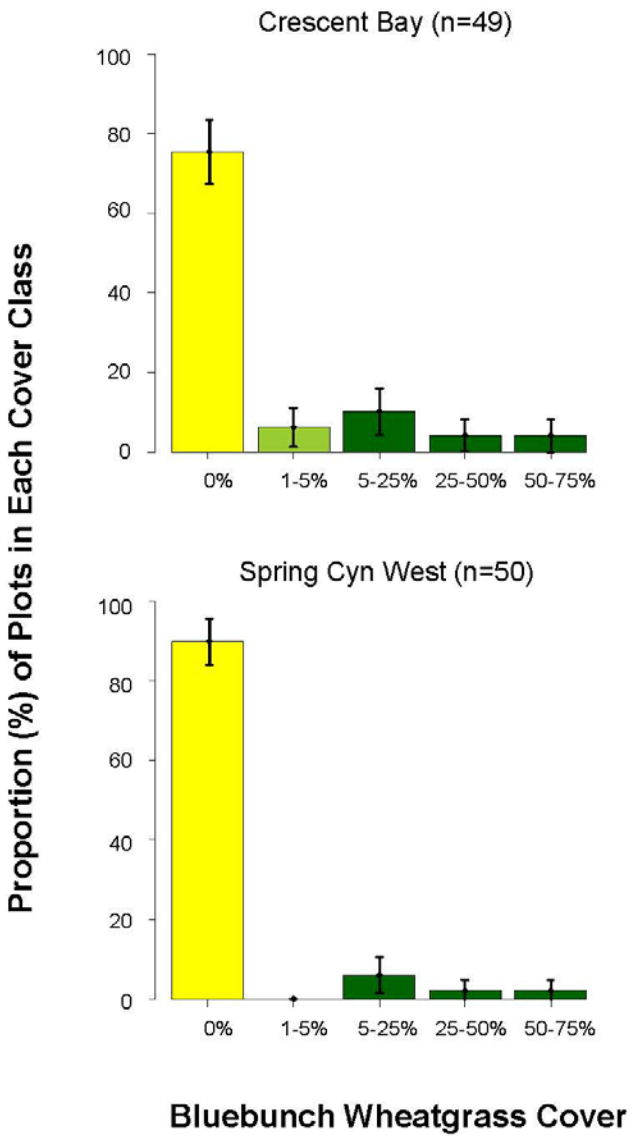

Figure D-3. Bluebunch wheatgrass cover.

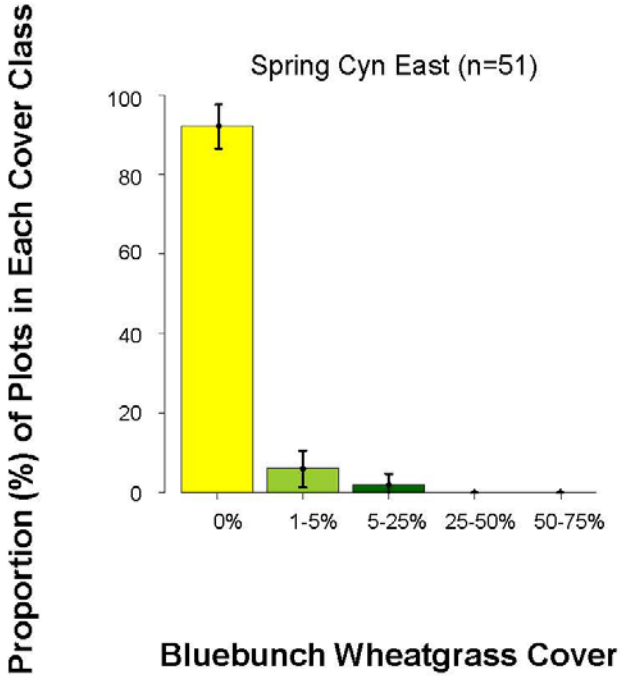

Figure D-3. Bluebunch wheatgrass cover (continued).

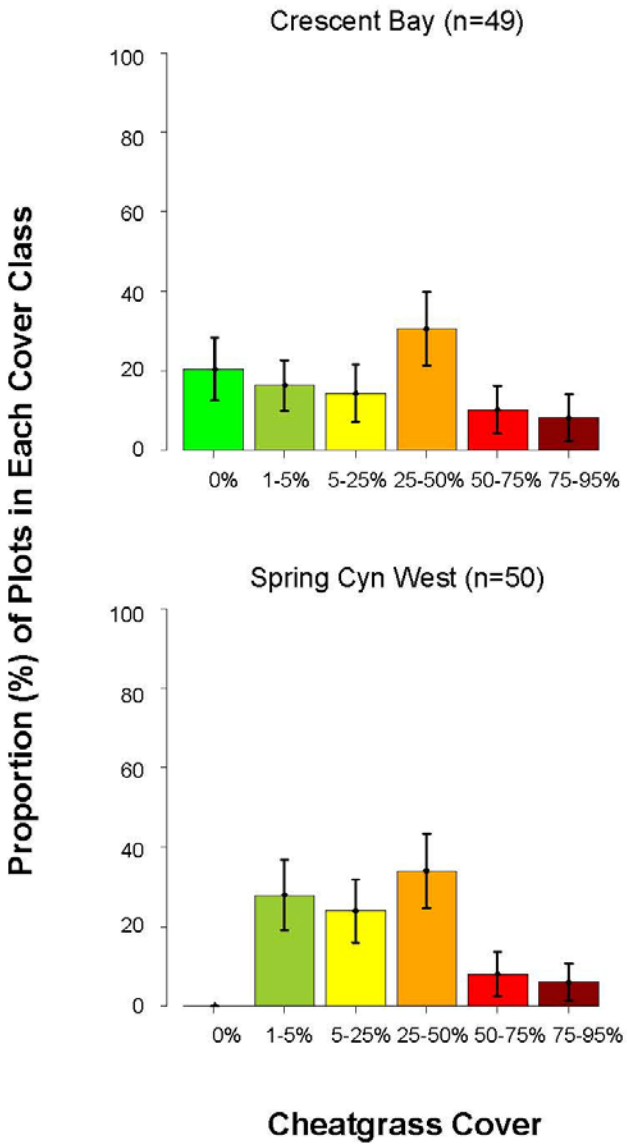

Figure D-4. Cheatgrass cover.

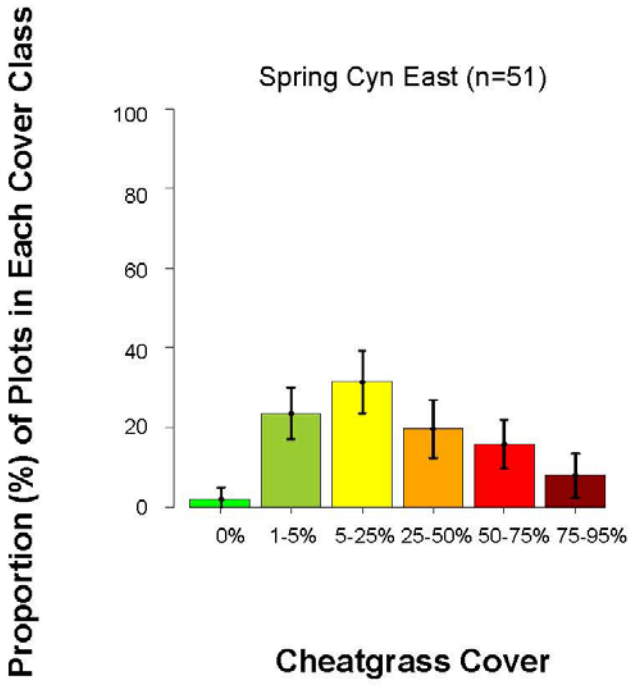

Figure D-4. Cheatgrass cover (continued).

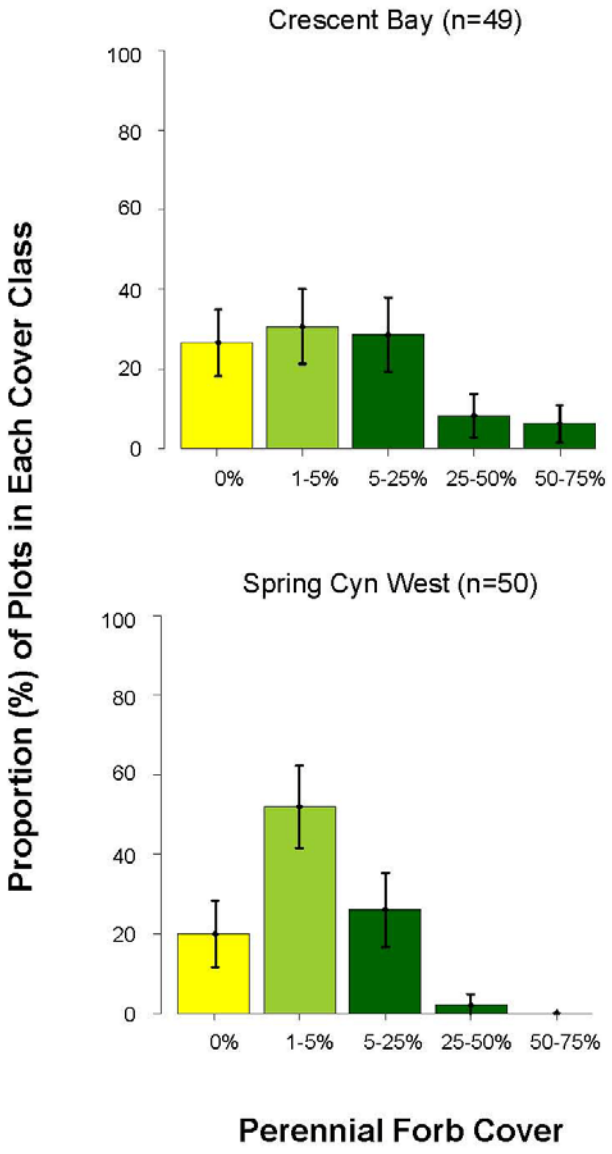

Figure D-5. Native perennial forb cover.

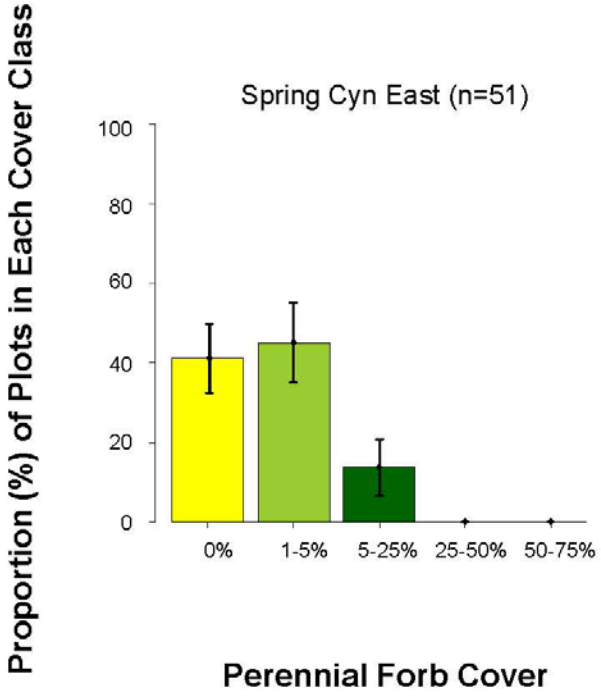

Figure D-5. Native perennial forb cover (continued).

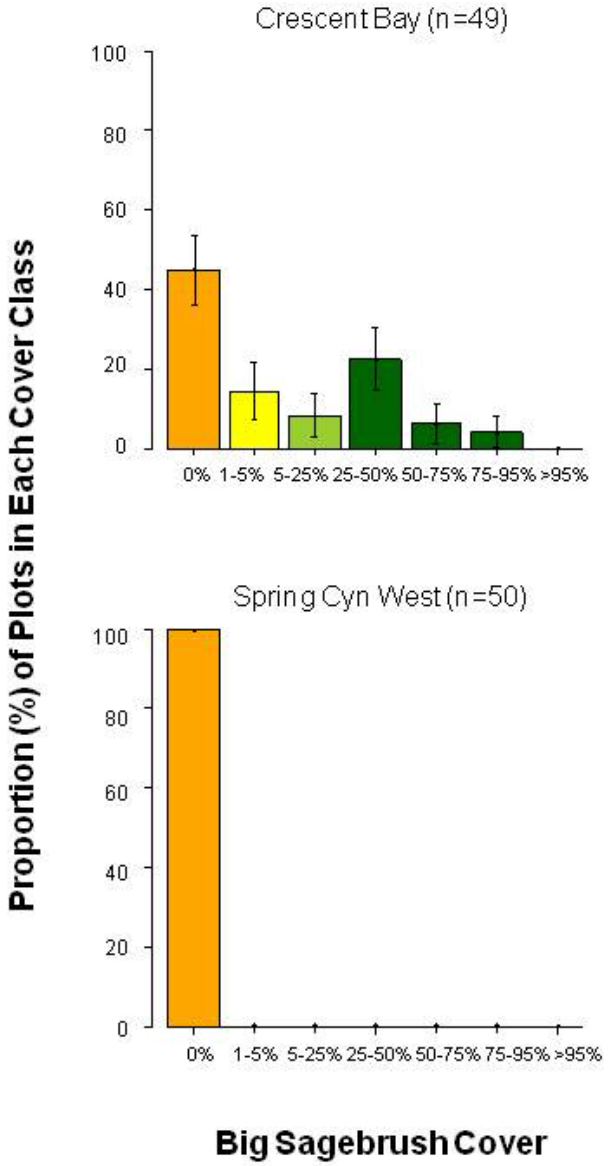

Figure D-6. Big sagebrush cover.

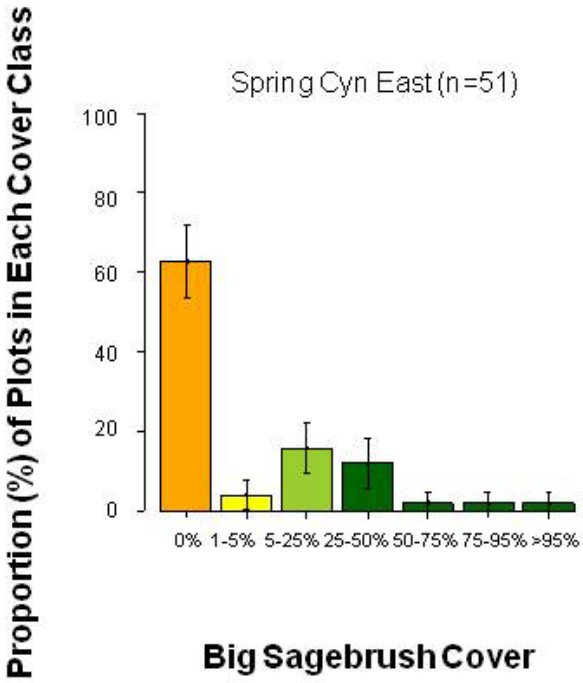

Figure D-6. Big sagebrush cover (continued).

NPS 131/101591, 416/101591, 177/101591, 606/101591, March 2010

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