



Sagebrush Steppe Vegetation Monitoring in Lake Roosevelt National Recreation Area

2014 Annual Report

Natural Resource Data Series NPS/UCBN/NRDS—2015/803



ON THE COVER

Photograph of sagebrush habitat at Lake Roosevelt National Recreation Area.
Photograph courtesy of the National Park Service.

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June 2015

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

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The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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Please cite this publication as:

Esposito, D. M., and T. J. Rodhouse. 2015. Sagebrush steppe vegetation monitoring in Lake Roosevelt National Recreation Area: 2014 annual report. Natural Resource Data Series NPS/UCBN/NRDS—2015/803. National Park Service, Fort Collins, Colorado.

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Executive Summary

Lake Roosevelt National Recreation Area (LARO) is within the Upper Columbia Basin Inventory and Monitoring Network (UCBN) and is partly comprised of sagebrush steppe. Five monitoring sites within Lake Roosevelt National Recreation Area were sampled in early June 2014 following methodologies described in Yeo et al. (2009). Three of the 5 sites are grazed by cattle annually in spring and in fall, and 1 site contains the Spring Canyon campground and boat launch. Cover of exposed soil, and principle native and non-native plant species were estimated in randomly-located 1-m² plots. Spring (March-June) weather for 2014 was slightly wetter then the long-term average. Cheatgrass (*Bromus tectorum*), a non-native, invasive annual grass, was ubiquitous across the study area, and was the most frequently encountered plant at all 5 sites. Bulbous bluegrass (*Poa bulbosa*), another non-native, invasive annual grass, was occasionally abundant. Invasive forb species were present but rarely abundant. Sandberg's bluegrass (*Poa secunda*) and needlegrasses (*Achnatherum spp.*) were the most abundant native perennial grasses. Two other native perennial grasses, bluebunch wheatgrass (*Pseudoroegneria spicata*) and Idaho fescue (*Festuca idahoensis*), occurred in isolated patches. Comparisons of the sampling data from 2011 and 2014 revealed slightly higher occurrence of cheatgrass in 2011. The difference in frequency between the 2 sample years may be due to the wet, mild spring weather 2011 (Yeo and Rodhouse 2012). Some variation also exists in the individual, non-native species recorded for both years, with species which were recorded in 2011 not appearing in the 2014 data.

Introduction

Prior to Euro-American settlement, sagebrush steppe ecosystems in the Upper Columbia Basin extended across the eastern half of Washington and Oregon, and across the northern Great Basin of southern Idaho. Much of that ecosystem has been lost to development or substantially degraded as a result of improper livestock grazing, altered fire regimes, introduction of non-native invasive plants, and recreational use. The UCBN has identified the ecological condition of sagebrush steppe vegetation as a high priority vital sign and monitoring of its condition is central to its monitoring program (Garrett et al. 2007). A long-term monitoring program that provides for regular evaluation of the status of the health of UCBN steppe communities, and for identification of trends of ecosystem condition over time within and among parks within the network was implemented in 2008 (Yeo et al. 2009). The foundation of the sagebrush steppe monitoring protocol is a view of ecosystem health sustained by natural succession or natural variability within communities of native plants. Divergence of sagebrush steppe communities that are dominated by native perennial vegetation to those that are heavily invaded by non-native annual grasses and by non-native perennial forbs signifies a loss of health, and provides the feedback to park managers for effective adaptive management strategies. Simple monitoring objectives follow directly from this view:

- Determine the status (current condition) and trends (change in condition over time) in the composition and abundance (cover) of principal native plant species in UCBN sagebrush steppe communities.
- Determine the status and trends in composition and abundance (cover) of principal invasive plant species, including annual grasses, in UCBN sagebrush steppe communities.
- Determine the status and trend in the amount of exposed soil (cover), a fundamental indicator of soil stability.

This report summarizes the data collected in 2014, and provides simple comparisons to the data collected in 2011.

Study Area and Methods

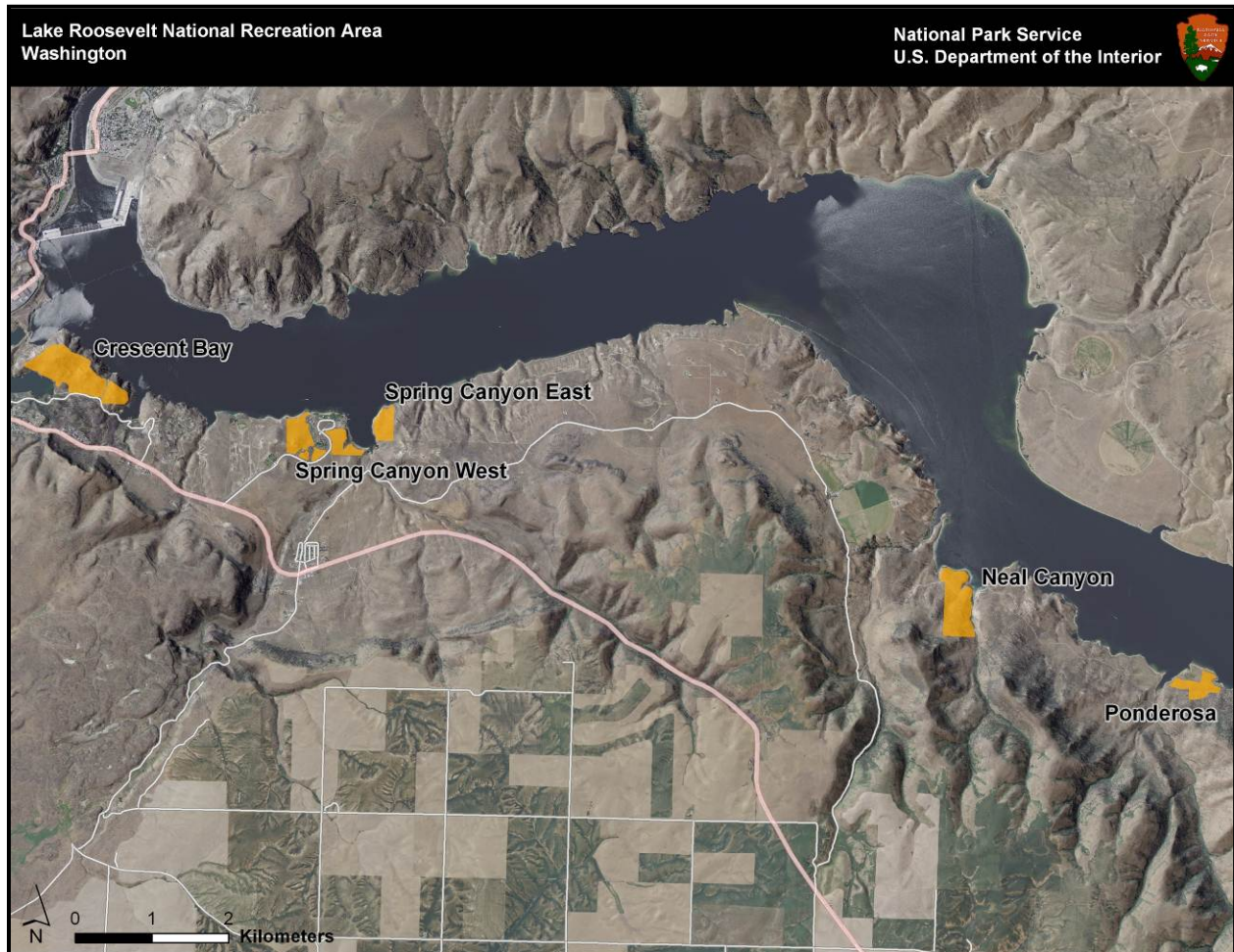


Figure 1. LARO monitoring area showing the 5 permanent monitoring sites (shaded yellow areas) with Roosevelt Lake to the north (Grand Coulee Dam just on the picture to the upper left).

LARO comprises a narrow band of terrestrial habitats surrounding Lake Roosevelt, a reservoir created by Grand Coulee Dam on the Columbia River. Sagebrush steppe communities occur principally along the southwestern periphery of the reservoir continuing upstream from the dam for about a dozen miles. Based on existing vegetation maps and ground surveys in May 2009, we identified 5 permanent areas (“monitoring sites”) containing the largest contiguous patches of sagebrush steppe (Figure 1). Monitoring sites ranged from 8 – 41 ha (Table 1). Three of the monitoring sites (Neal Canyon, Ponderosa, and Spring Canyon East) are grazed by cattle during the spring and fall; the other 2 sites receive some recreational use with the highest use in the Spring Canyon West site that is adjacent to the Spring Canyon campground and boat launch area. All 5 sites were sampled June 1-5, 2011 and more recently, June 2-3, 2014.

Table 1. Monitoring site areas and sample sizes for LARO sagebrush steppe monitoring, 2014.

Monitoring Site	Area (ha)	Sample Size (plots)
Crescent Bay	41	55
Neal Canyon	27	56
Ponderosa	9	51
Spring Canyon East	8	50
Spring Canyon West	19	50

Sampling procedures followed Yeo et al. (2009). Within each site, 1-m² square plots were located using the generalized random tessellation stratified (GRTS) spatially-balanced sampling design (Stevens and Olsen 2004). The GRTS approach provides for randomly located plots and good spatial dispersion across each site. Fifty to fifty-six plots were sampled within each site with more plots allocated to the larger sites (Table 1). Within each 1-m² plot, we estimated cover of exposed soil, and principal native plants and non-native invasive plants. Cover estimates were categorized into the following cover classes: 0, 1-5%, >5-25%, >25-50%, >50-75%, >75-95%, and >95-100% (Daubenmire 1959). Plant cover was defined as the natural spread of current year's growth outlined using a minimum convex polygon with small gaps included in the cover estimate. Exposed soil was defined as soil surface not overlain by plant cover, litter, and rock. Plant common names and their scientific names are listed in Appendix A.

Weather

Long-term weather records for Coulee Dam show an arid period typically extending from May to October (Appendix B). Spring (March – June) 2014 was slightly wetter than the long-term average with temperatures closely mimicking long-term averages (Appendix B). In comparison, spring 2011 was cool and wet with higher precipitation in April and May than the long-term average. In 2011, the cool, wet spring likely delayed plant growth and almost certainly contributed to increased cover of annuals and early season perennials (Yeo and Rodhouse 2012).

Results and Discussion

Crescent Bay

The Crescent Bay monitoring site was sampled June 2, 2014 and included 55 plots. The proportion of plots within each cover class for bare ground and recorded species is summarized in Table 2.

Exposed soil cover was generally $\leq 25\%$ with a small (5%) proportion of plots exceeding 25% exposure of bare ground. Big sagebrush was the most abundant shrub recorded in this area. A large (62%) proportion of the sample plots had some ($>1\%$) cover recorded, with 31% of plots exceeding 25% cover. Needlegrasses and Sandberg's bluegrass were the most abundant native perennial grass species. Needlegrasses occurred in a large (55%) proportion of plots, but with a small (5%) proportion exceeding 25% cover. Sandberg's bluegrass occurred in 16% of plots and never exceeded 25% cover. Bluebunch wheatgrass, another native perennial, was recorded in a similar proportion of plots (4%) exceeding 25% cover, but was sparse occurring in a small (9%) proportion of plots. Native forb cover was generally low. Desert parsley was the most frequently encountered forb, occurring in 22% of plots.

Invasive forbs were present but sparse. Western salsify, tumble mustard, and tansymustard were all recorded in small ($<4\%$) proportions and never over 5% cover. Cheatgrass occurred in 95% of plots with 36% of plots containing $>25\%$ cover. Bulbous bluegrass was the next most abundant non-native annual grass and occupied 16% of plots rarely exceeding 25% cover.

The 2011 survey produced results which were very similar to those noted above for 2014. In 2011 cheatgrass was found with 100% frequency compared to 2014 (95%). Frequency of plots with cheatgrass cover $>25\%$ was also similar in 2011 (35%) to 2014 (36%). Notable discrepancies between 2011 and 2014 include the sparse occurrence of Japanese brome, a non-native invasive annual grass, and presence of the invasive forb dalmatian toadflax. None of these species were recorded in the 2014 survey.

Table 2. Crescent Bay 2014. Proportion of plots (n=55) within each coverclass for exposed bare ground and principle plant species organized by species guilds. Refer to Appendix A for a cross-reference to common names and scientific names.

	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	29	53	13	5	0	0	0
Sagebrush							
<i>Artemisia tridentata</i>	38	13	18	15	7	5	4
<i>Artemisia tripartita</i>	96	4	0	0	0	0	0
Shrubs							
<i>Chrysothamnus viscidiflorus</i>	95	0	5	0	0	0	0
<i>Purshia tridentata</i>	84	5	5	4	2	0	0
Native Perennial Grasses							
<i>Achnatherum spp</i>	45	40	9	4	2	0	0
<i>Aristida purpurea</i>	96	2	2	0	0	0	0
<i>Festuca idahoensis</i>	95	4	2	0	0	0	0
<i>Poa secunda</i>	84	15	2	0	0	0	0
<i>Pseudoroegneria spicata</i>	91	5	0	2	2	0	0
Native Persistent Forbs							
<i>Achillea millefolium</i>	96	0	4	0	0	0	0
<i>Comandra umbellata</i>	98	2	0	0	0	0	0
<i>Eriogonum spp</i>	84	7	9	0	0	0	0
<i>Lomatium spp</i>	78	15	4	2	2	0	0
<i>Lupinus spp</i>	91	2	7	0	0	0	0
<i>Phlox spp</i>	96	2	2	0	0	0	0
Non-native Invasive Forbs							
<i>Descurainia spp</i>	98	2	0	0	0	0	0
<i>Sisymbrium altissimum</i>	98	2	0	0	0	0	0
<i>Tragopogon dubius</i>	96	4	0	0	0	0	0
Non-native Invasive Grasses							
<i>Agropyron cristatum</i>	98	2	0	0	0	0	0
<i>Bromus tectorum</i>	5	31	27	25	7	4	0
<i>Poa bulbosa</i>	84	11	4	0	2	0	0

Note: not all rows sum to 100% because of the error inherent in rounding to whole numbers.

Neal Canyon

The Neal Canyon monitoring site was sampled June 3, 2014 and included 56 plots. The proportion of plots within each cover class for bare ground and recorded species is summarized in Table 3. Exposed soil cover was generally $\leq 25\%$ with a small (4%) proportion of plots exceeding 25% exposure of bare ground. Big sagebrush was present in a small (2%) proportion of plots while threetip sagebrush was found in 9% of plots. Bitterbrush was the most abundant shrub recorded in this area with 41% of the sample plots having some ($>1\%$) cover, and 25% of plots exceeding 25% cover. Green rabbitbrush and grey rabbitbrush were recorded in a moderate (20% and 13% respectively) proportion of plots. Sandberg's bluegrass, needlegrasses, and bluebunch wheatgrass were the most abundant native perennial grass species. Sandberg's bluegrass occurred in a large (41%) proportion of plots, never exceeding 25% cover. Needlegrasses occurred in a moderate (25%) proportion of plots, with a small (2%) proportion exceeding 25% cover. Neal Canyon had the highest recorded proportion of Bluebunch wheatgrass in LARO. Bluebunch wheatgrass was recorded in 14% of plots here, with 4% of plots exceeding 25% cover. Forbs were diverse but sparse. Yarrow, buckwheat, and lupine were the most frequently encountered forb species.

Tumble mustard, and western salsify were the most abundant invasive forb species recorded. Tumble mustard was recorded in 23% of plots and western salsify was recorded with 16% frequency. Cheatgrass occurred in 98% of plots with 55% of plots containing $>25\%$ cover. Bulbous bluegrass was the next most abundant non-native annual grass and occupied 21% of plots, rarely exceeding 25% cover.

The proportion of plots containing native perennial grass cover appeared to be slightly higher in 2014 than 2011. In 2011, cheatgrass was found with 99% frequency compared to 98% in 2014. Frequency of plots with cheatgrass cover $>25\%$ was also similar in 2011 (56%) to 2014 (55%). Tumblemustard only occurred in 2% of plots in 2011 compared to 23% of plots in 2014. Western salsify was also recorded with a higher frequency in 2014 (16%) than 2011 (2%). The 2011 survey reported Japanese brome in 6% of plots while this species was not recorded during 2014.

Table 3. Neal Canyon 2014. Proportion of plots (n=56) within each coverclass for exposed bare ground and principle plant species organized by species guilds.

	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	34	45	18	4	0	0	0
Sagebrush							
<i>Artemisia tridentata</i>	98	2	0	0	0	0	0
<i>Artemisia tripartita</i>	91	2	4	2	0	2	0
Shrubs							
<i>Chrysothamnus viscidiflorus</i>	80	4	7	7	0	2	0
<i>Ericameria nauseosa</i>	88	2	4	4	2	2	0
<i>Leptodactylon pungens</i>	96	4	0	0	0	0	0
<i>Purshia tridentata</i>	59	2	14	11	7	5	2
Native Perennial Grasses							
<i>Achnatherum spp</i>	75	14	9	2	0	0	0
<i>Elymus lanceolatus</i>	96	0	4	0	0	0	0
<i>Poa secunda</i>	59	32	9	0	0	0	0
<i>Pseudoroegneria spicata</i>	86	7	4	2	2	0	0
<i>Sporobolus cryptandrus</i>	95	5	0	0	0	0	0
Native Persistent Forbs							
<i>Achillea millefolium</i>	66	25	9	0	0	0	0
<i>Artemisia dracunculus</i>	98	2	0	0	0	0	0
<i>Aster spp</i>	98	2	0	0	0	0	0
<i>Balsamorhiza sagittata</i>	96	4	0	0	0	0	0
<i>Comandra umbellata</i>	98	2	0	0	0	0	0
<i>Eriogonum spp</i>	66	27	5	2	0	0	0
<i>Lithospermum ruderales</i>	98	2	0	0	0	0	0
<i>Lomatium spp</i>	93	7	0	0	0	0	0
<i>Lupinus spp</i>	75	13	11	2	0	0	0
<i>Phacelia spp</i>	98	2	0	0	0	0	0
<i>Phlox spp</i>	96	4	0	0	0	0	0
Native Other Forbs							
<i>Brodiaea douglasii</i>	91	9	0	0	0	0	0
Non-native Invasive Forbs							
<i>Erodium cicutarium</i>	98	2	0	0	0	0	0
<i>Sisymbrium altissimum</i>	77	16	7	0	0	0	0
<i>Tragopogon dubius</i>	84	16	0	0	0	0	0
Non-native Invasive Grasses							
<i>Bromus tectorum</i>	2	23	20	34	16	5	0
<i>Poa bulbosa</i>	79	7	11	0	2	2	0
<i>Poa pratensis</i>	98	2	0	0	0	0	0

Note: not all rows sum to 100% because of the error inherent in rounding to whole numbers

Ponderosa

The Ponderosa monitoring site was sampled June 3, 2014 and included 51 plots. The proportion of plots within each cover class for bare ground and recorded species is summarized in Table 4. Exposed soil cover was generally $\leq 25\%$ with a small (4%) proportion of plots exceeding 25% exposure of bare ground. Big sagebrush was present in 16% of plots with few plots exceeding 25% cover. Threetip sagebrush was the dominant shrub species in this area with a 43% frequency and with 20% of plots exceeding 25% cover. Bitterbrush was the second most abundant shrub, with 31% of the sample plots having some ($>1\%$) cover, and 16% of plots exceeding 25% cover. Green rabbitbrush and grey rabbitbrush were recorded in a moderate (10% and 16% respectively) proportion of plots. Needlegrasses and Sandberg's bluegrass were the most abundant native perennial grass species. Needlegrass occurred in a large (59%) proportion of plots, and exceeded 25% cover in 16% of plots. Sandberg's bluegrass occurred in a moderate (31%) proportion of plots, with a small (4%) proportion exceeding 25% cover. Bluebunch wheatgrass, another native perennial, was sparse, occurring in 6% of plots, and rarely exceeded 25% cover. Forbs were diverse but sparse. Yarrow, buckwheat, and lupine were the most frequently encountered forb species.

Tumble mustard, and western salsify were the only invasive forb species recorded. Tumble mustard was recorded in 16% of plots and western salsify was recorded with 8% frequency. Cheatgrass occurred in 88% of plots with 27% of plots containing $>25\%$ cover. Bulbous bluegrass was the next most abundant non-native annual grass and occupied 53% of plots, rarely exceeding 25% cover.

The proportion of plots containing needlegrasses and Sandberg's bluegrass appeared to be slightly higher in 2014 than 2011. In 2011, cheatgrass was found with 94% frequency compared to 88% in 2014. Frequency of plots with cheatgrass cover $>25\%$ was similar in 2011 (38%) to 2014 (27%). Tumble mustard only occurred in 2% of plots in 2011 compared to 16% of plots in 2014.

Table 4. Ponderosa 2014. Proportion of plots (n=51) within each cover class for exposed bare ground and principle plant species organized by species guild.

	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	45	41	10	0	2	2	0
Sagebrush							
<i>Artemisia tridentata</i>	84	6	4	2	2	2	0
<i>Artemisia tripartita</i>	57	10	14	14	4	2	0
Shrubs							
<i>Chrysothamnus viscidiflorus</i>	90	8	2	0	0	0	0
<i>Ericameria nauseosa</i>	84	8	6	2	0	0	0
<i>Purshia tridentata</i>	69	8	8	8	4	2	2
Native Perennial Grasses							
<i>Achnatherum spp</i>	41	18	25	14	2	0	0
<i>Festuca idahoensis</i>	96	2	0	0	0	2	0
<i>Poa secunda</i>	69	27	0	4	0	0	0
<i>Poa spp</i>	96	4	0	0	0	0	0
<i>Pseudoroegneria spicata</i>	94	4	0	0	2	0	0
<i>Sporobolus cryptandrus</i>	96	4	0	0	0	0	0
Native Persistent Forbs							
<i>Achillea millefolium</i>	53	37	10	0	0	0	0
<i>Artemisia dracunculus</i>	98	2	0	0	0	0	0
<i>Comandra umbellata</i>	94	6	0	0	0	0	0
<i>Crepis acuminata</i>	96	4	0	0	0	0	0
<i>Erigeron spp</i>	98	2	0	0	0	0	0
<i>Eriogonum spp</i>	78	18	4	0	0	0	0
<i>Lithospermum ruderale</i>	92	2	6	0	0	0	0
<i>Lomatium spp</i>	98	2	0	0	0	0	0
<i>Lupinus spp</i>	63	29	8	0	0	0	0
<i>Phlox spp</i>	94	4	2	0	0	0	0
Native Other Forbs							
<i>Cryptantha spp</i>	98	2	0	0	0	0	0
Non-native Invasive Forbs							
<i>Sisymbrium altissimum</i>	84	16	0	0	0	0	0
<i>Tragopogon dubius</i>	92	8	0	0	0	0	0
Non-native Invasive Grasses							
<i>Bromus tectorum</i>	12	47	14	22	6	0	0
<i>Poa bulbosa</i>	47	27	22	4	0	0	0
<i>Poa pratensis</i>	98	0	2	0	0	0	0

Note: not all rows sum to 100% because of the error inherent on rounding to whole numbers.

Spring Canyon East

The Spring Canyon East monitoring site was sampled June 3, 2014 and included 50 plots. The proportion of plots within each cover class for bare ground and recorded species is summarized in Table 5. Exposed soil cover was generally $\leq 25\%$ with a small (4%) proportion of plots exceeding 25% exposure of bare ground. Big sagebrush was the dominant shrub species in this area and was present in 52% of plots with 16% of plots exceeding 25% cover. Bitterbrush was the second most abundant shrub, with 36% of the sample plots having some ($>1\%$) cover, and 14% of plots exceeding 25% cover. Green rabbitbrush and purple sage were recorded in a moderate (10% and 8% respectively) proportion of plots. Sandberg's bluegrass, needlegrass, and bluebunch wheatgrass were the most abundant native perennial grass species. Sandberg's bluegrass occurred in 36% of plots, and never exceeded 25% cover. Needlegrasses occurred in a moderate (18%) proportion of plots, with a small (4%) proportion exceeding 25% cover. Bluebunch wheatgrass was recorded in a small (10%) proportion of plots, and rarely exceeded 25% cover. Forbs were diverse but sparse. Buckwheat, cryptantha, yarrow, lupine, and desert parsley were the most frequently encountered forb species.

Western salsify, tumble mustard, and tansymustard were the invasive forb species recorded, and all with low frequency ($\leq 4\%$). Cheatgrass occurred in 98% of plots with 40% of plots containing $>25\%$ cover. Bulbous bluegrass was the only other non-native annual grass recorded and occupied a small (6%) proportion of plots, never exceeding 25% cover.

The proportion of plots containing native perennial grasses was slightly higher in 2014 than 2011. In 2011, cheatgrass was found with 96% frequency compared to 98% in 2014. Frequency of plots with cheatgrass cover $>25\%$ was slightly higher in 2011 (60%) compared to 2014 (40%).

Table 5. Spring Canyon East 2014. Proportion of plots (n=50) within each cover class for exposed bare ground and principle plant species organized by species guilds.

	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	26	58	12	0	4	0	0
Sagebrush							
<i>Artemisia tridentata</i>	48	22	14	4	8	2	2
<i>Artemisia tripartita</i>	98	2	0	0	0	0	0
Shrubs							
<i>Chrysothamnus viscidiflorus</i>	90	2	4	2	2	0	0
<i>Ericameria nauseosa</i>	98	2	0	0	0	0	0
<i>Purshia tridentata</i>	64	6	16	6	4	4	0
<i>Salvia dorrii</i>	92	2	6	0	0	0	0
Native Perennial Grasses							
<i>Achnatherum spp</i>	82	8	6	2	2	0	0
<i>Elymus lanceolatus</i>	98	0	2	0	0	0	0
<i>Poa secunda</i>	64	28	8	0	0	0	0
<i>Pseudoroegneria spicata</i>	90	4	4	2	0	0	0
<i>Sporobolus cryptandrus</i>	98	0	2	0	0	0	0
Native Persistent Forbs							
<i>Achillea millefolium</i>	88	8	4	0	0	0	0
<i>Artemisia dracunculus</i>	98	2	0	0	0	0	0
<i>Comandra umbellata</i>	98	2	0	0	0	0	0
<i>Crepis acuminata</i>	98	2	0	0	0	0	0
<i>Eriogonum spp</i>	78	18	2	2	0	0	0
<i>Lomatium spp</i>	90	10	0	0	0	0	0
<i>Lupinus spp</i>	88	8	4	0	0	0	0
<i>Phacelia spp</i>	96	4	0	0	0	0	0
<i>Phlox spp</i>	92	8	0	0	0	0	0
Native Other Forbs							
<i>Agoseris spp</i>	94	6	0	0	0	0	0
<i>Brodiaea douglasii</i>	98	2	0	0	0	0	0
<i>Cryptantha spp</i>	84	16	0	0	0	0	0
<i>Zigadenus spp</i>	98	2	0	0	0	0	0
Non-native Invasive Forbs							
<i>Descurainia spp</i>	98	2	0	0	0	0	0
<i>Sisymbrium altissimum</i>	98	2	0	0	0	0	0
<i>Tragopogon dubius</i>	96	4	0	0	0	0	0
Non-native Invasive Grasses							
<i>Bromus tectorum</i>	2	28	30	30	8	2	0
<i>Poa bulbosa</i>	94	6	0	0	0	0	0

Note: not all rows sum to 100% because of the error inherent in rounding to whole numbers.

Spring Canyon West

The Spring Canyon East monitoring site was sampled June 2, 2014 and included 50 plots. The proportion of plots within each cover class for bare ground and recorded species is summarized in Table 6. Exposed soil cover was generally $\leq 25\%$ with a small (6%) proportion of plots exceeding 25% exposure of bare ground. Big sagebrush was sparse in this area, only occurring in 2% of plots. Shrub cover was dominated by bitterbrush, green rabbitbrush and grey rabbitbrush. Bitterbrush was the dominant shrub species with 32% of the sample plots having some ($>1\%$) cover, and 14% of plots exceeding 25% cover. Green rabbitbrush and grey rabbitbrush had similar frequencies (30% and 22% respectively) to bitterbrush but rarely exceeded 25% cover. Needlegrasses, Sandberg's bluegrass, and thickspike wheatgrass were the most abundant native perennial grass species. Needlegrasses occurred in 44% of plots, and rarely exceeded 25% cover. Sandberg's bluegrass occurred in a similar (40%) proportion of plots, never exceeding 25% cover. Thickspike wheatgrass occurred with low (16%) frequency, rarely over 25% cover. Bluebunch wheatgrass, another native perennial, was recorded in a small (12%) proportion of plots, and rarely exceeded 25% cover. Native forbs were common but with low cover. Tarragon, bastard toadflax, phlox, and buckwheat were the most frequently encountered forb species.

Western salsify, dalmatian toadflax, Russian thistle, and tumble mustard were the invasive forb species recorded, and all with low frequency ($\leq 10\%$). Cheatgrass occurred in 98% of plots with 34% of plots containing $>25\%$ cover. Bulbous bluegrass occupied a moderate (34%) proportion of plots, rarely exceeding 25% cover. Crested wheatgrass, an introduced forage species, was occurred in 16% of plots, rarely exceeding 25% cover.

The proportion of plots containing native perennial grasses was slightly higher in 2014 than 2011. In 2011, cheatgrass was found with 96% frequency compared to 98% in 2014. Frequency of plots with cheatgrass cover $>25\%$ was slightly higher in 2011 (56%) compared to 2014 (34%). The 2011 survey reported bulbous bluegrass in 12% of plots while this species was recorded in 34% of plots during 2014.

Table 6. Spring Canyon West 2014. Proportion of plots (n=50) within each cover class for exposed bare ground and principle plant species organized by species guilds.

	0	1-5%	>5-25%	>25-50%	>50-75%	>75-95%	>95-100%
Bare Ground	18	68	8	4	2	0	0
Sagebrush							
<i>Artemisia tridentata</i>	98	2	0	0	0	0	0
Shrubs							
<i>Chrysothamnus viscidiflorus</i>	70	8	14	8	0	0	0
<i>Ericameria nauseosa</i>	78	14	2	6	0	0	0
<i>Purshia tridentata</i>	68	14	4	10	2	2	0
Native Perennial Grasses							
<i>Achnatherum spp</i>	56	24	14	6	0	0	0
<i>Elymus elymoides</i>	98	0	2	0	0	0	0
<i>Elymus lanceolatus</i>	84	6	6	4	0	0	0
<i>Oryzopsis hymenoides</i>	98	0	2	0	0	0	0
<i>Poa secunda</i>	60	36	4	0	0	0	0
<i>Pseudoroegneria spicata</i>	88	4	2	2	4	0	0
Native Persistent Forbs							
<i>Achillea millefolium</i>	90	8	2	0	0	0	0
<i>Artemisia dracunculus</i>	66	18	8	6	2	0	0
<i>Balsamorhiza sagittata</i>	94	2	2	2	0	0	0
<i>Comandra umbellata</i>	74	20	6	0	0	0	0
<i>Crepis acuminata</i>	96	4	0	0	0	0	0
<i>Eriogonum spp</i>	78	16	4	2	0	0	0
<i>Lomatium spp</i>	92	8	0	0	0	0	0
<i>Lupinus spp</i>	94	4	2	0	0	0	0
<i>Opuntia polyacantha</i>	88	12	0	0	0	0	0
<i>Phacelia spp</i>	96	4	0	0	0	0	0
<i>Phlox spp</i>	74	24	2	0	0	0	0
Native Other Forbs							
<i>Brodiaea douglasii</i>	98	2	0	0	0	0	0
<i>Cryptantha spp</i>	98	2	0	0	0	0	0
<i>Zigadenus spp</i>	98	2	0	0	0	0	0
Non-native Invasive Forbs							
<i>Linaria dalmatica</i>	90	10	0	0	0	0	0
<i>Salsola kali</i>	94	4	2	0	0	0	0
<i>Sisymbrium altissimum</i>	96	2	2	0	0	0	0
<i>Tragopogon dubius</i>	90	10	0	0	0	0	0
Non-native Invasive Grasses							
<i>Agropyron cristatum</i>	84	6	4	6	0	0	0
<i>Bromus tectorum</i>	2	36	28	18	16	0	0
<i>Poa bulbosa</i>	66	22	8	4	0	0	0

Note: not all rows sum to 100% because of the error inherent in rounding to whole numbers.

As is common across sagebrush steppe in the Upper Columbia Basin, cheatgrass dominated these communities at LARO. Frequencies of occurrence ranged from 88 – 98% at the 5 sites. Some variation was noted between the 2011 and 2014 sampling years. The 2011 sampling data reported slightly higher proportions of cheatgrass which may be due to the wet, mild spring of 2011 (Yeo and Rodhouse 2012). Variation in the species of invasive forb species recorded for both years is also striking, with a number of species which were recorded in 2011 not appearing in the 2014 data.

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Appendix A. List of species common and scientific names from the 2014 sagebrush vegetation survey of Lake Roosevelt National Recreation Area

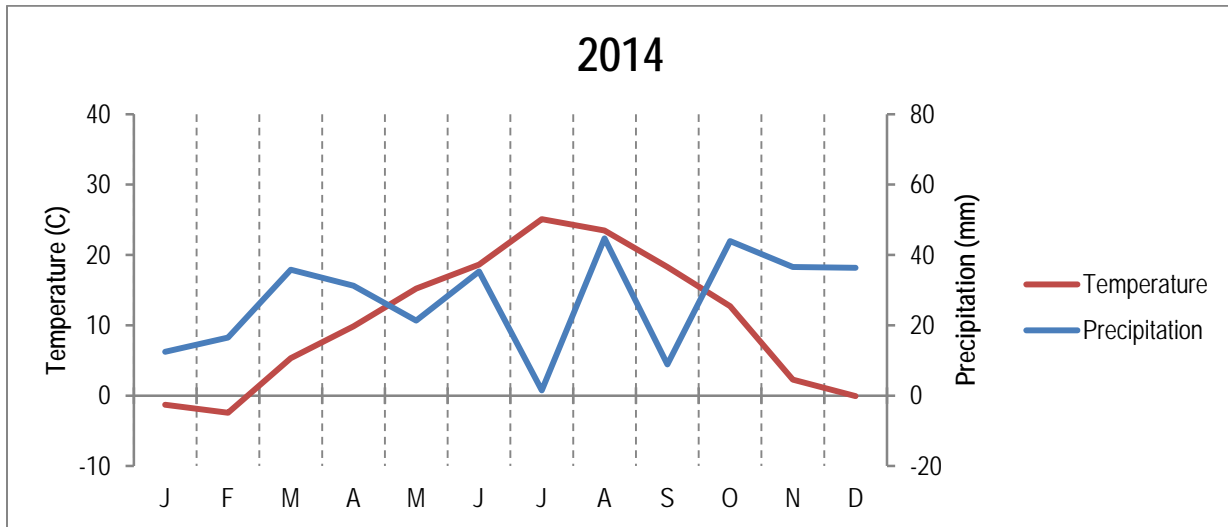
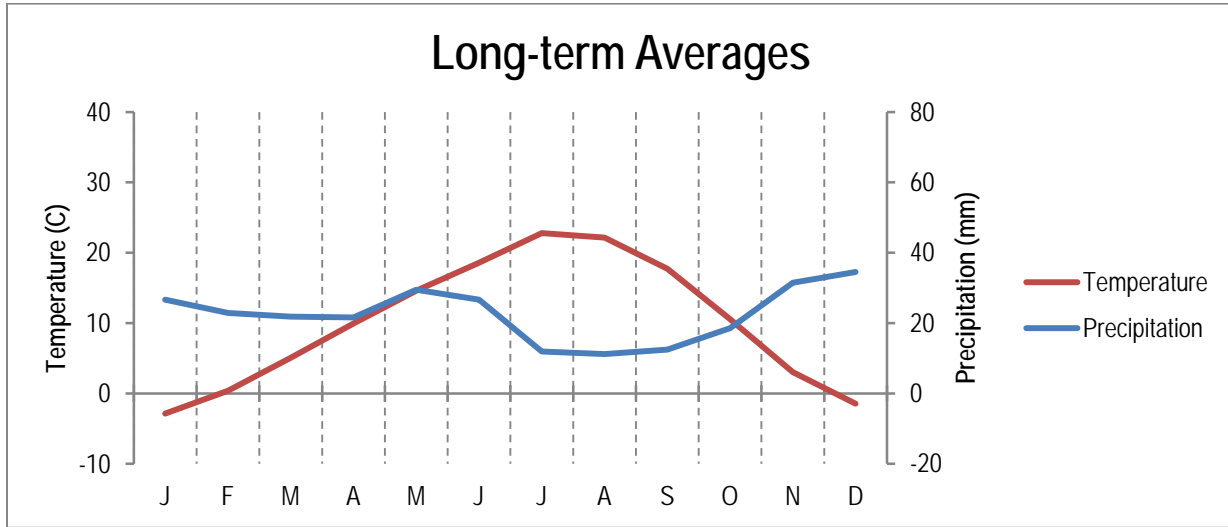
Common Name	Scientific Name
Sagebrush	
Big sagebrush	<i>Artemisia tridentata</i>
Threetip sagebrush	<i>Artemisia tripartita</i>
Shrubs	
Green rabbitbrush	<i>Chrysothamnus viscidiflorus</i>
Grey rabbitbrush	<i>Ericameria nauseosa</i>
Prickly phlox	<i>Leptodactylon pungens</i>
Bitterbrush	<i>Purshia tridentata</i>
Purple sage	<i>Salvia dorrii</i>
Native Perennial Grasses	
Needlegrass	<i>Achnatherum spp</i>
Purple threeawn	<i>Aristida purpurea</i>
Squirreltail	<i>Elymus elymoides</i>
Thickspike wheatgrass	<i>Elymus lanceolatus</i>
Idaho fescue	<i>Festuca idahoensis</i>
Indian ricegrass	<i>Oryzopsis hymenoides</i>
Sandberg's bluegrass	<i>Poa secunda</i>
Bluegrass	<i>Poa spp</i>
Bluebunch wheatgrass	<i>Pseudoroegneria spicata</i>
Sand dropseed	<i>Sporobolus cryptandrus</i>
Native Persistent Forbs	
Yarrow	<i>Achillea millefolium</i>
Tarragon	<i>Artemisia dracunculus</i>
Aster	<i>Aster spp</i>
Arrowleaf Balsamroot	<i>Balsamorhiza sagittata</i>
Bastard toadflax	<i>Comandra umbellata</i>
Tapertip hawksbeard	<i>Crepis acuminata</i>
Daisy	<i>Erigeron spp</i>
Buckwheat	<i>Eriogonum spp</i>
Western stoneseed	<i>Lithospermum ruderale</i>
Desert parsely	<i>Lomatium spp</i>
Lupine	<i>Lupinus spp</i>
Prickly pear cactus	<i>Opuntia polyacantha</i>
Phacelia	<i>Phacelia spp</i>

Appendix A. List of species common and scientific names from the 2014 sagebrush vegetation survey of Lake Roosevelt National Recreation Area (continued).

Common Name	Scientific Name
Native Persistent Forbs	
Phlox	<i>Phlox spp</i>
Native Other Forbs`	
Agoseris	<i>Agoseris spp</i>
Douglas' brodiaea	<i>Brodiaea douglasii</i>
Cryptantha	<i>Cryptantha spp</i>
Death camas	<i>Zigadenus spp</i>
Non-native Invasive Forbs	
Tansymustard	<i>Descurainia spp</i>
Filaree	<i>Erodium cicutarium</i>
Dalmatian toadflax	<i>Linaria dalmatica</i>
Russian thistle	<i>Salsola kali</i>
Tumble mustard	<i>Sisymbrium altissimum</i>
Western salsify	<i>Tragopogon dubius</i>
Non-native Invasive Grasses	
Crested wheatgrass	<i>Agropyron cristatum</i>
Cheatgrass	<i>Bromus tectorum</i>
Bulbous bluegrass	<i>Poa bulbosa</i>
Kentucky bluegrass	<i>Poa pratensis</i>

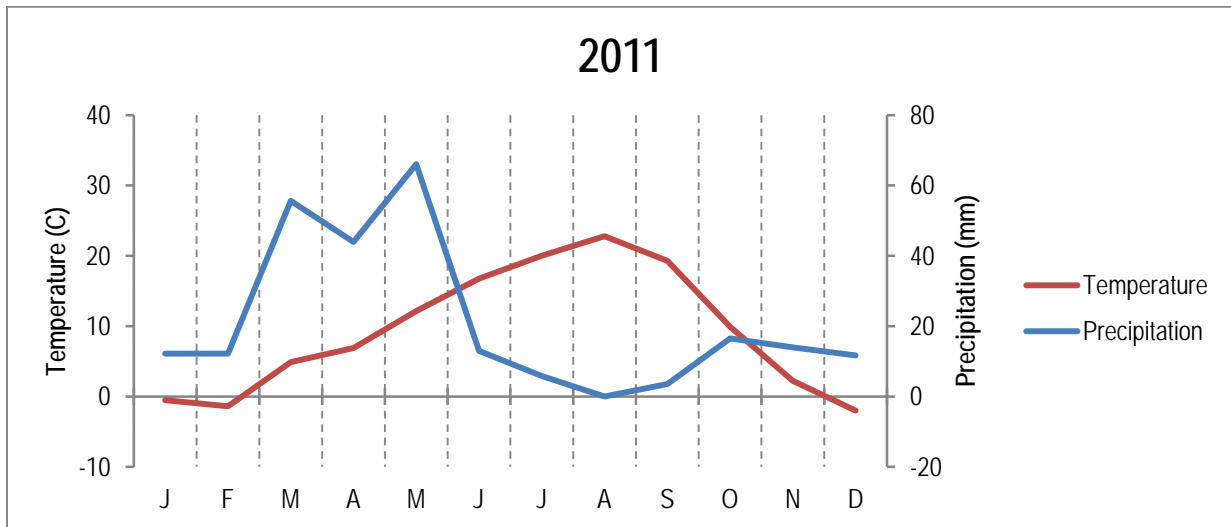
Appendix B. Climate diagrams for Coulee Dam 1 SW weather station, showing long-term averages and climate patterns for 2014 and 2011.

Data are from the Western Regional Climate Center for NOAA/NWS cooperative weather network station 451767.



Appendix B. Climate diagrams for Coulee Dam 1 SW weather station, showing long-term averages and climate patterns for 2014 and 2011 (continued).

Data are from the Western Regional Climate Center for NOAA/NWS cooperative weather network station 451767.



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NPS 606/128753, June 2015

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