



Integrated Upland Monitoring in Black Canyon of the Gunnison National Park and Curecanti National Recreation Area, 2008–2009 (*Non-sensitive version*)

Natural Resource Technical Report NPS/NCPN/NRTR—2010/396.N



ON THE COVER

Sagebrush surrounding Blue Mesa Reservoir, Curecanti National Recreation Area. NPS photo.

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(Non-sensitive version)

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Executive Summary

The goal of the Northern Colorado Plateau Network (NCPN) integrated upland monitoring effort is to provide park managers with status and trend information on vegetation and soil attributes. This information is intended to determine natural variability of upland resources and provide early warning of resource degradation.

This report summarizes NCPN upland pilot monitoring in Black Canyon of the Gunnison National Park (BLCA) and Curecanti National Recreation Area (CURE) during 2008 and 2009. It outlines goals and objectives of NCPN upland monitoring, methods of the upland monitoring protocol, and procedures for defining and mapping target populations for monitoring, and describes the results of this year's efforts and plans for future monitoring.

Upland monitoring was initiated at BLCA and CURE in 2008. Based on discussions with park resource staff, sagebrush, pinyon-juniper, Gambel oak/mixed montane shrub, and aspen were selected for monitoring. Sagebrush was additionally stratified by two dominant ecological sites and by grazing status, for a total of four vegetation types monitored in sagebrush. Only four plots will be monitored in aspen due to the small spatial extent of this vegetation type in BLCA and CURE. For all other vegetation types, seven or eight plots will be monitored for three consecutive years to gain understanding of variability. Assessment of these data will guide development of an operational sampling design. In 2008, thirty-seven monitoring plots were established and monitored. In 2009, an additional 15 plots were established and monitored, and the first 37 plots were revisited. One of the sagebrush plots was excluded from monitoring summaries because it was partially underwater in 2009.

In this report, measures were summarized for each vegetation type by year. The only statistical assessment performed was an ordination of species cover. Results of this ordination indicated a high degree of overlap between the four sagebrush site types and good separation between the other vegetation types. Early monitoring data describe status of vegetation types. Interpretation will be limited until additional data are acquired and more rigorously analyzed.

Future monitoring activities include (1) re-measuring the 51 existing upland plots in 2010 and (2) formulating an operational survey design for each vegetation type, using variance measures in conjunction with desired levels of minimum detectable change, as derived from the three years of pilot monitoring data. The full monitoring design will be implemented in 2011.

1 Introduction

Uplands represent the vast majority of land area in national parks of the Colorado Plateau region. Plateau uplands include rock outcrops, badlands, shrublands, grasslands, woodlands, and forests, with local vegetation determined by soil type and depth, topography, climate, and disturbance history. Upland vegetation supplies most regional primary productivity, which translates to energy for other trophic levels. The condition of upland vegetation influences soil stability, which, in turn, determines potential above-ground production of native plant species and the propensity for invasion by non-native species. Vegetation also provides habitat for various organisms. The ability of uplands to retain soil and nutrients, absorb and release water, and buffer high-runoff precipitation events also influences riparian conditions.

Upland ecosystems of the Colorado Plateau are characterized by low resistance and resilience. Even moderate disturbances can affect vegetative composition and structure, and recovery to pre-disturbance conditions is relatively slow. Grazing, which has been a traditional land use throughout much of the plateau, has resulted in shifts in vegetation composition (Harris et al. 2003) and ecological states (Miller 2005). Increasing recreational use and unauthorized social trailing threatens the integrity of upland systems through soil disturbance and resulting increases in soil erosion by water and wind. Global climate change is expected to change levels and seasonality of dominant precipitation events, with unknown implications for plateau systems.

The Northern Colorado Plateau Network (NCPN), as part of the National Park Service's Inventory and Monitoring Program, has identified plant communities, hydrologic function, soil stability, biological soil crust (BSC), and nutrient cycling as important components to understanding the health of upland systems (O'Dell et al. 2005). The indicators that apply to these components are listed below.

- *Plant communities*: species and functional group composition and diversity, and vegetation structure
- *Hydrologic function*: basal-gap size, cover and development of BSC, and infiltration rate
- *Soil stability*: cover of vegetation, litter, and BSC, and soil aggregate stability
- *Biological soil crust*: BSC cover
- *Nutrient cycling* is not currently measured

The goals of NCPN upland monitoring are to increase fundamental understanding of upland systems and provide managers with early warning of undesirable change. These goals will be accomplished partly through sampling design and data analysis. Evaluation of upland monitoring data relative to other vital signs will facilitate identification of drivers and distinguish “natural” from anthropogenic change. This effort will document the variability in upland systems while providing information needed for resource management decisions.

Specific objectives of the NCPN integrated upland monitoring protocol are:

1. To determine annual status and trends in ground cover (live and standing dead vegetation, litter, rock, biological soil crust, and bare ground); vegetation by life form; soil aggregate stability; hydrologic function; and nutrient cycling;
2. To determine annual status and trends in cover of biological soil crusts by morphological group; and
3. To determine annual status and trends in cover of exotic plants in upland areas.

2 Methods

2.1 Integrated upland monitoring in Black Canyon of the Gunnison NP and Curecanti NRA

2.1.1 *Resource issues driving upland monitoring*

Park resource management staff identified big sagebrush shrublands (sagebrush), pinyon-juniper woodlands (PJ), Gambel oak/mixed montane shrublands (oak or oak scrub), and aspen forests as high-priority for long-term monitoring. Sagebrush, PJ, and oak scrub are the dominant vegetation types in the park units. Aspen communities have limited spatial extent but are of special concern to park managers.

The overall goal of monitoring in these park units is to provide information on the natural variability of upland resources and early warning of system degradation. There are additional management concerns associated with sagebrush, the most extensive community type in the units. Although sagebrush was historically grazed over the entire Gunnison Basin, it is not currently grazed in parts of Black Canyon of the Gunnison National Park (BLCA) and Curecanti National Recreation Area (CURE). This provides a unique opportunity to compare grazed and ungrazed sagebrush communities.

Park managers met with Bureau of Land Management (BLM) range conservationists from the Montrose and Gunnison field offices in May and June 2008, to update their grazing data. Information from these meetings was incorporated into the NCPN upland sampling design. In addition, parts of the Grizzly Gulch allotment, on the North Rim of BLCA, had recently expired, and a new fence line was expected to be built in the next few years. This new fence line was approximated for the NCPN upland sampling frame.

2.1.2 *Mapping and selecting target populations*

2.1.2.1 *Accessibility*

Areas that posed safety threats, were inaccessible within budgetary limitations, and/or were anthropogenic in nature were filtered out of the sampling frame. Areas located on slopes of $\geq 50\%$ and/or isolated by steep slopes were eliminated.

Due primarily to costs, areas accessible only by reservoir or river were also eliminated from consideration. Accessibility and slope features were generated using the Landscape Accessibility Model (<http://science.nature.nps.gov/im/units/ncpn/Tools.cfm>).

Creating the accessibility map proved more challenging for BLCA/CURE than for other NCPN park units. BLCA contains numerous parcels of private property within its boundary, and boundaries change regularly as BLM and private parcels are transitioned to National Park Service (NPS) ownership. Only private property with conservation easements and consenting landowners was considered for the accessibility map. Parcels that were heavily managed (e.g., with active hay fields or elk ranching) were eliminated from the accessibility map. After additional discussions with park staff, NPS land in the Blue Creek and Pine Creek areas—accessible by crossing private land with consenting owners or established NPS access easements through private property—was also included.

2.1.2.2 *Selection of target vegetation and ecological-site types*

Defining the target population typically involves determining the ecological sites that correspond to the resource of interest. An ecological site is defined by a combination of soil properties (texture, depth, water-holding capacity), geology, landform, climatic regime, and potential vegetation.

The spatial extent of ecological sites is largely determined by soil map units within a soil survey, although the location of an ecological site within a soil map unit is not explicit. Two old soil surveys (NRCS 1975; 1981) covered much of the area of the park units; however, neither BLCA nor CURE had a complete survey. To complicate matters further, the existing soil surveys only provided limited range-site descriptions, instead of more thorough ecological-site descriptions. As such, ecological sites for aspen were not well defined by the soil surveys, and soil map units with PJ were not paired with any ecological sites. Existing ecological-site descriptions for Major Land Resource Area (MLRA) 48 largely did not match range sites from the soil surveys. Therefore, delineating ecological sites for BLCA and CURE upland monitoring was a challenge, and ecological sites are approximate, based on both range sites and available ecological-site descriptions for MLRA 48. Draft NCPN vegetation maps of

BLCA and CURE provided a more recent spatial distribution of target vegetation types, and were used to help develop a sampling frame for monitoring.

Field scouting was performed to assess the suitability of vegetation map units for delineating target vegetation types and the extent of ecological sites associated with target vegetation types. The most common sagebrush ecological sites were Mountain Loam and Dry Mountain Loam, and we decided that the sagebrush sampling frame should cover the range of these two ecological sites. However, these two sites seemed to form a continuum across the landscape, making it extremely difficult to classify sites in the middle of the range. Initially, we will attempt to distinguish Mountain Loam and Dry Mountain Loam—but eventually, we may have to lump these sites.

The dominant ecological sites for PJ were Upland Shallow Loam and Upland Stony Loam. Because these ecological sites are similar and were often mixed on the landscape, we decided to monitor both sites and any combination of the two. Oak scrub within the park units was predominantly the Brushy Loam ecological site, and this was used to define the target oak community for monitoring. We did not attempt to determine ecological sites of aspen communities due to issues with the soil survey and the small number of monitoring plots in this vegetation type. Details and photos of target ecological sites and vegetation types are provided in Figure 2-1 and Table 2-1.

2.1.2.3 Mapping of target vegetation types

A sampling frame was created using the vegetation map to predict the location of target ecological sites and vegetation types. Changes were made to specific polygons based on field assessments. The sampling frame delineated accessible sagebrush, PJ, oak scrub, and aspen vegetation types in BLCA and CURE (Figures 2-2 and 2-3). Sagebrush was additionally divided into grazed and ungrazed areas.

2.1.3 Selection of monitoring locations

Monitoring plots were selected using the Reversed Randomized Quadrant Recursive Raster (RRQRR) method (Theobald et al. 2007) to create a spatially balanced design within the sampling frame. RRQRR provides an ordered list of centroids for all possible monitoring plots in the sampling frame. The sampling frame was buffered by 20 m, and any points within the buffer

were not used for monitoring. This reduced the number of points rejected for overlapping multiple vegetation types, roads, trails, or the park boundary. Within each vegetation type, plots were established in ascending order of plot number. If a plot was rejected (e.g., due to incorrect vegetation type), the next sequentially ordered plot was used.

For pilot monitoring, a total of 52 plots were monitored, including 8 ungrazed Dry Mountain Loam sagebrush, 8 grazed Dry Mountain Loam sagebrush, 8 ungrazed Mountain Loam sagebrush, 8 grazed Dry Mountain Loam sagebrush, 8 PJ, 8 oak scrub, and 4 aspen (see Figures 2-2 and 2-3). Plots will be monitored for three consecutive years to gain an understanding of variability, and assessment of these data will guide the development of an operational survey design.

2.2 Integrated upland monitoring procedures

2.2.1 Response design

The response design (methods used to collect observations) for integrated upland monitoring in NCPN parks is based largely on rangeland assessment procedures (Herrick et al. 2004) and standard forest, woodland, and fuels procedures (NPS 2003; Brown 1974), with modifications by Miller et al. (2007). Specific measurements taken at each plot depend on the structure of the vegetation type (Table 2-2).

2.2.2 Grasslands and shrublands

At each plot, observations are recorded along three parallel, 50-m transects spaced 25 m apart (Figure 2-4). A point-intercept method is used to record percent cover of understory (<2 m) and ground-cover attributes at 0.5-m intervals along each transect (Table 2-2). The number of shrubs (by species and height class) and exotic perennials (by species) is recorded in a 1-m belt upslope of each transect. Canopy and basal-gap measures are acquired along each of the transects using line-intercept methods. Six surface-soil samples are taken along each of the transects to assess soil aggregate stability. All measures recorded along transects are sub-samples scaled to the plot level. The plot-level measures are the primary values used in summaries and statistical analyses. Disturbances observed on and around the site are also recorded.



Figure 2-1. Examples of target vegetation (ecological-site) types monitored in Black Canyon of the Gunnison National Park and Curecanti National Recreation Area. See Table 2-2 for description of vegetation types and ecological sites.

Table 2-1. Description of target vegetation and ecological sites selected for upland monitoring in Black Canyon of the Gunnison NP and Curecanti NRA.

Vegetation type	Ecological sites	Physiognomic type	Soil properties	Geological properties	Vegetative properties	Disturbance-mediated alternative states	Potential non-target areas
Sagebrush	Mountain Loam	Shrubland	Deep loams on valleys, benches, and hillslopes	Alluvium, slope alluvium, or glacial deposits	Tall big sagebrush with dense cover of grasses; may also include small amounts of mixed montane shrubs	<u>Grazing</u> : decreased perennial grasses, increased sagebrush. <u>Fire</u> : decreased sagebrush, increased rabbitbrush and snowberry.	Very shallow sandy areas with black sagebrush; depressions with basin big sagebrush and basin wildrye
	Dry Mountain Loam	Shrubland	Shallow to moderately deep loams to stony loams on benches, ridges, and hills	Residuum, alluvium, glacial deposits	Smaller big sagebrush with bunchgrasses and gravelly/stony interspaces	<u>Grazing</u> : decreased perennial grasses, increased sagebrush and snakeweed. <u>Fire</u> : decreased sagebrush.	
Pinyon pine/ Utah juniper	Upland Shallow/Stony Loam	Woodland	Shallow to moderately deep loams and stony loams on ridges and mountain sides	Residuum or colluvium	Pinyon pine and Utah juniper with sparse to moderate understory cover of shrubs, grasses and forbs	<u>Grazing</u> : decreased understory plants, increased PJ. <u>Fire</u> : temporarily decreased PJ, increased perennial grasses and shrubs.	Sparse PJ on badlands; sparse PJ in dense oak scrub, PJ on deep soils
Gambel oak/mixed montane shrubs	Brushy Loam	Shrubland	Deep loams on uplands and mountain sides	Alluvium, slope alluvium, or glacial deposits	Dominated by Gambel oak, serviceberry, snowberry, mountain big sagebrush	<u>Grazing</u> : Decreased perennial grasses, increased woody shrubs. <u>Fire</u> : increased Gambel oak, snowberry, and rabbitbrush, decreased perennial grasses, forbs, and other shrubs.	Shallow, rocky areas dominated by grasses and forbs; steep colluvial slopes with oak scrub/mixed montane shrubs
Aspen	No stratification	Forest	Deep loams on mountain sides	Alluvium, glacial till, or colluvium	Dominated by aspen, chokecherry, Saskatoon serviceberry, snowberry	Ranges from skeleton to climax forest.	Areas with no live aspen

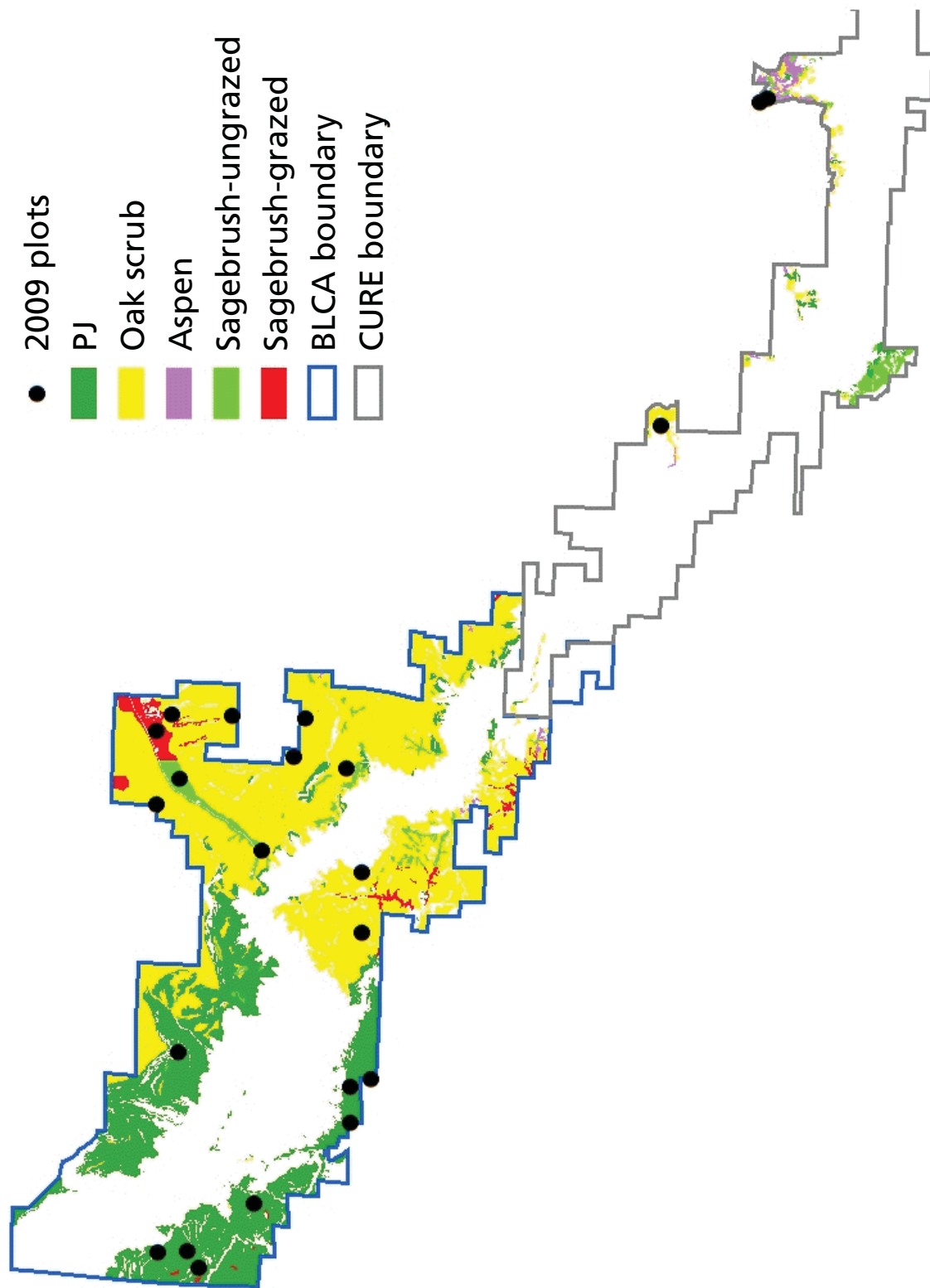


Figure 2-2. Location of pilot monitoring plots in Black Canyon of the Gunnison National Park and on the west side of Curecanti National Recreation Area.

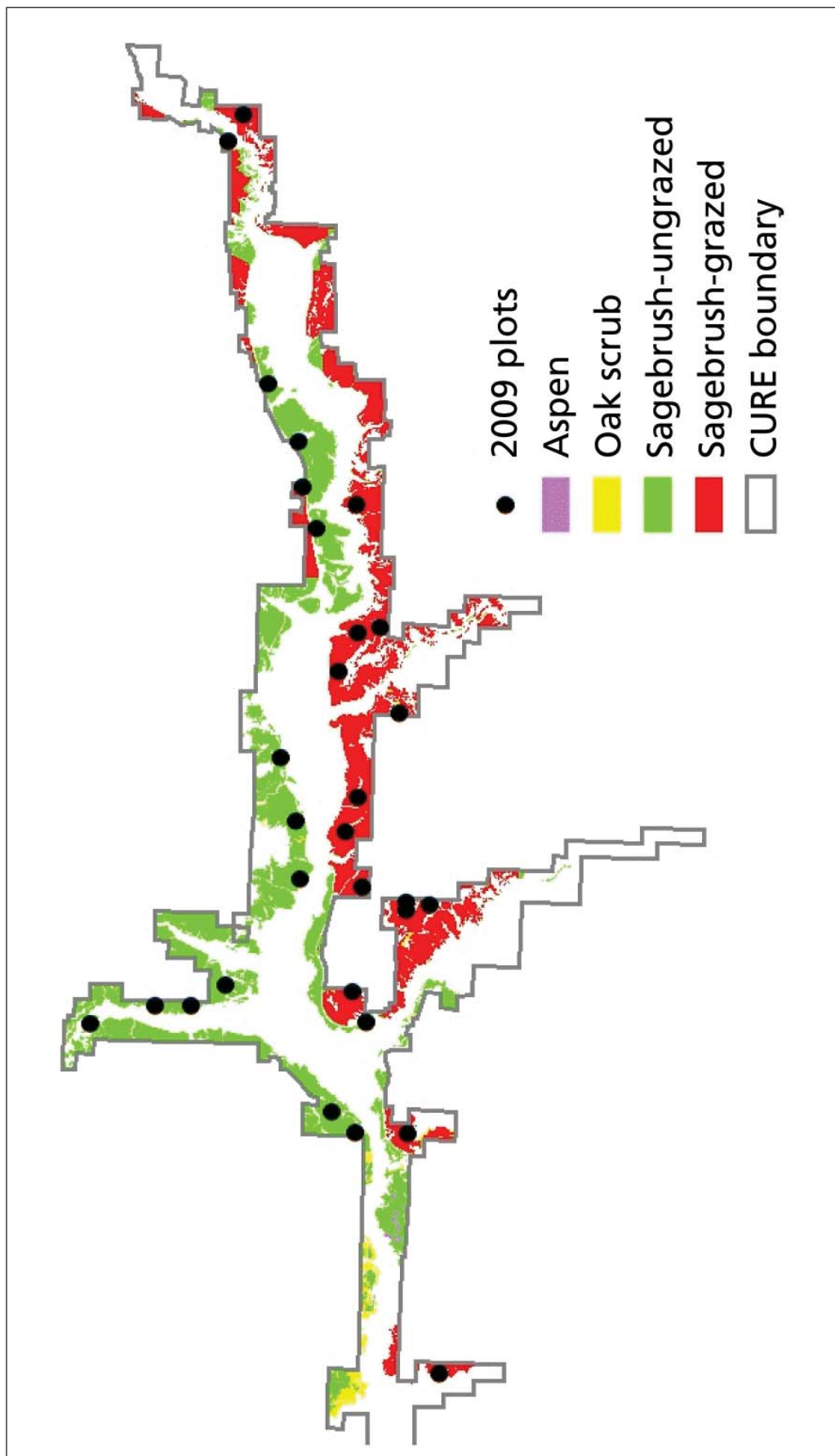


Figure 2-3. Location of pilot monitoring plots on the east side of Curecanti National Recreation Area.

Table 2-2. Plot-level measures for grasslands/shrublands, woodlands, forests, and oak scrub.

Measure	Attribute or Context	Spatial scale(s) of observation	Grassland/ Shrubland	Woodland	Forest	Oak
Plant species richness	Number of species detected	Point-intercept for understory, 1-m belt transects for shrubs & tree seedlings, 5-m belt transect for saplings, ¼ plot for trees	X	X	X	X
Percent cover	Life form (trees, shrubs, annual and perennial grasses, forbs/herbs)	Point-intercept along all three transects	X	X	X	X
	Individual plant species	Point-intercept along all three transects	X	X	X	X
	Overstory canopy cover	15 point samples across plot			X	
	Surface features (undifferentiated crust, cyanobacteria, lichen, moss, bare soil, litter, woody debris, small and large rock, bedrock)	Point-intercept along all three transects	X	X	X	X
	Disturbance features (livestock and wildlife scat, ant mound, wildlife excavation, tracks from wildlife, livestock, humans, bicycles, or motor vehicles, other)	Point-intercept along all three transects	X	X	X	X
Density	Individual tree species and total tree density	Quadrant 1 for trees; one 5-m belt for saplings		X	X	
	Individual tree seedlings, shrubs, and exotic perennials by species; total tree seedlings, shrubs, and exotic perennials combined by group	1-m belt transects upslope of all three transects	X	X	X	
Mean canopy gap size; distribution of canopy gap sizes	Line-intercept length of canopy gaps; percentage of transects with different gap size classes	Along all three transects (150 m)	X			
Mean basal gap size; distribution of basal gap sizes	Line-intercept length of gaps between plant bases; percentage of transects with different gap size classes	Along all three transects (150 m)	X			
Soil stability class (from all samples, protected areas, and unprotected areas)	Slake test stability class (1–6). Protected-area samples are collected under vegetation. Unprotected-area samples lack overstory vegetation.	18 point samples across plot	X	X		
Fuel loading	Woody fuel volumes; duff and litter depth	Four ~15-m transects (3 transects for oak)		X	X	X

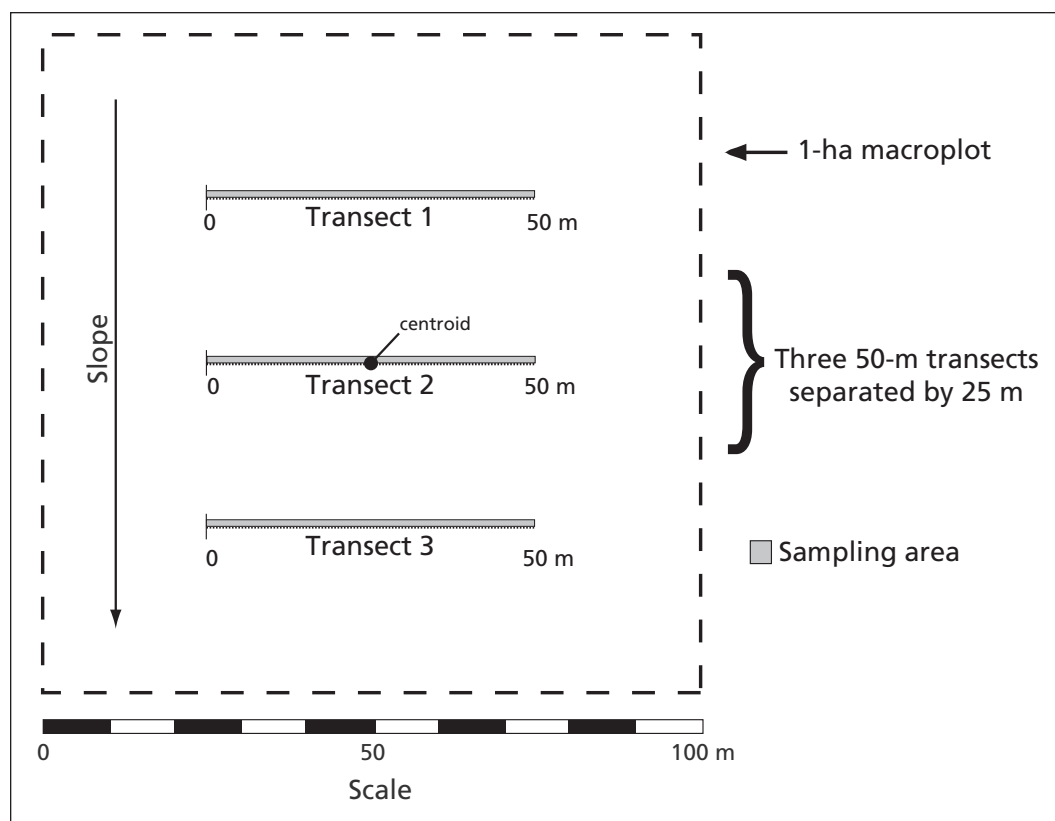


Figure 2-4. Plot layout for upland monitoring of grasslands and shrublands.

2.2.3 Forests and woodlands

Additional measurements are taken in forest and woodland systems in order to capture the dynamics of stand replacement or gap dynamics (Table 2-2). Saplings are identified to species, and density is tallied in a 5-m belt transect centered on Transect 2 (Figure 2-5). Within Quadrant 1, species and dbh (diameter at breast height) are recorded for all mature trees. For forest plots, overstory cover is recorded along each transect using a concave spherical densiometer. Fuels are measured using Brown's planar method (Brown 1974) along four 15-m transects that extend beyond the plot on two corners. Gaps are not recorded in forest or woodland systems, but soil stability is recorded at pinyon-juniper sites with potential erosion issues.

2.2.4 Gambel oak/mixed montane shrublands

Gambel oak/mixed montane shrublands are structurally different than other vegetation types on the Colorado Plateau, and the dense, tall vegetation is not easily sampled using standard up-

land methods. Instead, plot size is reduced to 20 × 20 m, point-intercept is collected at 0.25-m intervals, and fuel measurements are collected along the three existing transects (Figure 2-6, Table 2-2). Shrubs are recorded by species along each transect using a line-intercept method. Within the 20 × 20-m plot, species and dbh are recorded for all mature trees and *Quercus gambelii* (Gambel oak). Additionally, the percentage of Gambel oak cover affected by top kill, or completely dead, is estimated in the 20 × 20-m plot. Density, gaps, and soil stability are not recorded in this vegetation type.

2.3 Database

All observations recorded in the field are stored in an Access database maintained by the NCPN. Quality assurance and quality control (QA/QC) procedures include domain checking in data-entry procedures, checks for missing values, and logic checks. All spatial data used in selecting monitoring locations, the sampling frame, and the RRQRR-generated sampling locations are GIS-ArcMap shape files and are stored with the Access database on NCPN servers.

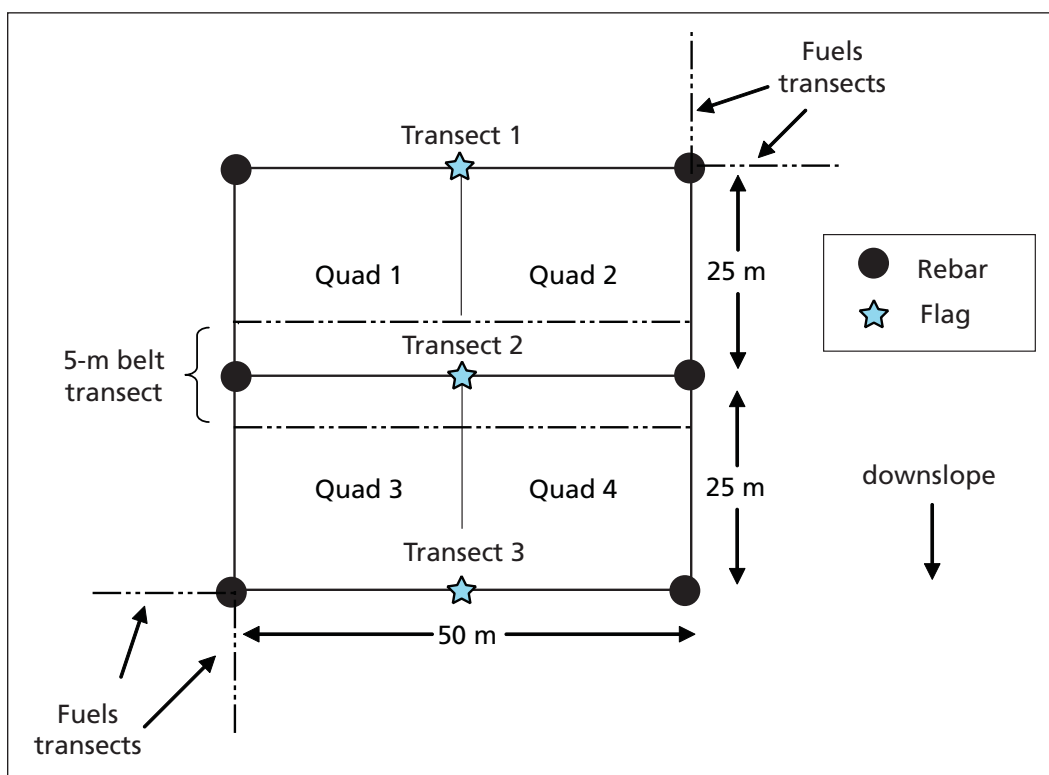


Figure 2-5. Plot layout for upland monitoring of forests and woodlands.

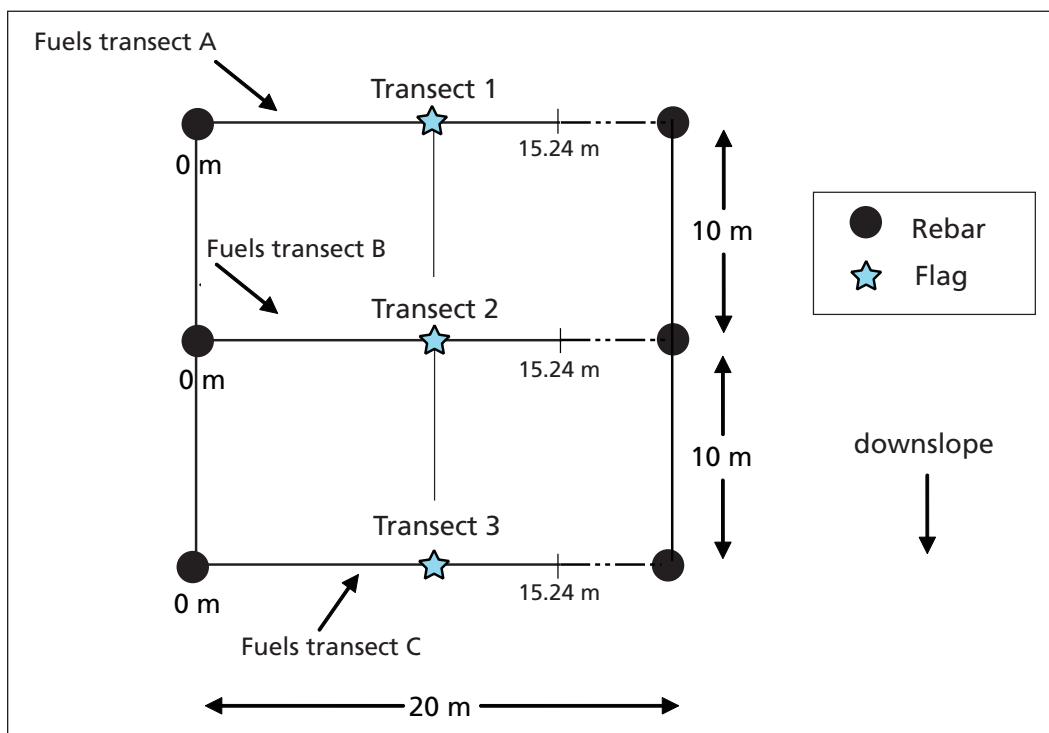


Figure 2-6. Plot layout for upland monitoring of Gambel oak/mixed montane shrublands.

3 Results

3.1 Monitored plots

In 2008, thirty-seven plots were established and monitored as part of pilot sampling. In 2009, an additional 15 plots were established and monitored, and the first 37 plots were revisited (see Figures 2-2 and 2-3). Table 3-1 summarizes plot visits by vegetation, ecological site, grazing status, and year. Each plot was sampled using the suite of measures appropriate for that vegetation type (Table 3-1; tables begin on page 15). Appendix A lists physical attributes of individual plots visited in 2008 and 2009.

Only seven ungrazed Mountain Loam sagebrush plots, instead of the eight original plots, are included in this report. One of the plots established in 2008 was partially underwater at the edge of Blue Mesa Reservoir when revisited in 2009. Due to the unpredictable riparian influence on this plot, rebar will be removed from this plot in 2010, and it will not be included in the long-term data set. Crews are now instructed to make sure that all upland monitoring plots do not extend below the high-water mark of any reservoir.

3.2 Vegetation type summaries

Status and trend assessments are more meaningful after many years of monitoring, and as the number of monitoring plots increases. More intensive evaluation of monitoring data is slated to commence after five full years of monitoring have been completed.

For this annual report, plot-level summaries of the measures listed in Table 2-1 were generated for each monitoring plot, then summarized by vegetation type and year. Summaries are simply a mean and the range (minimum, maximum) for a measured attribute. Given the limited data, measures were not statistically compared among vegetation types. Comparing data between years could be particularly misleading for PJ, oak, or aspen, because only a small number of plots was monitored in 2008 (see Table 3-1). The reader is cautioned not to draw wide-reaching conclusions from this initial set of results.

The only statistical assessment provided is a multivariate assessment of the similarity of vegetative conditions within and among vegetation types (see Section 3.2.11). Data from 2009 were ordi-

nated using NMS (non-metric multidimensional scaling), which involves scaling plots on the basis of similarity (or dissimilarity) of species composition and cover. Plots are distributed in multivariate space, typically along 1–3 axes, and within this space, plots with similar composition are located closer together and correlated with dominant species.

3.2.1 Species richness

A total of 154 species were detected in BLCA and CURE in 2009. Species richness by life form is reported in Table 3-2 for all vegetation types. Recorded species were compared to the NPSpecies database to determine first-time observations in BLCA and CURE. In 2008, a voucher was created for James cryptantha (*Cryptantha cinerea*) in CURE. In 2009, three new species—nodding brome (*Bromus anomalus*), crustweed (*Glyptopleura marginata*), and seemly sweatpea (*Lathyrus eucosmus*)—were reported in BLCA. Two new species, alpine leafybract aster (*Aster foliaceus*) and false hellebore (*Veratrum californicum*), were reported in CURE. All new species detected were native. A voucher was created for crustweed.

3.2.2 Overstory cover and understory cover by life form and dominant species

Percent cover of live and total vegetation in the understory by life form is shown in Table 3-3 for all vegetation types. Live cover includes photosynthetic and live woody tissue. Total cover additionally includes dead plants, dead parts of live plants, and senesced tissue that was alive earlier in the growing season. Percent cover of overstory is also shown in this table for aspen.

Live and total percent cover of dominant understory species for each vegetation type are shown in Table 3-4 for all vegetation types. Dominant species were selected using species predicted by ecological-site descriptions and species frequently detected in plots. The percent cover of all species recorded for each plot by year is included in the electronic appendices that accompany this report (blca08_species.xls, cure08_species.xls, blca09_species.xls, and cure09_species.xls).

Cover of shrub species in oak plots was additionally measured using the line-intercept method (Table 3-5). In oak plots, 0% of Gambel oak was completely dead and 0.5% was affected by top kill.

3.2.3 Shrub density

Density of shrub species is shown in Table 3-6 for all vegetation types except oak.

3.2.4 Tree density

Density of live seedlings, saplings, and overstory trees is shown in Table 3-7 for PJ, oak, and aspen. Density and dbh for all overstory trees >15 cm dbh are shown in Table 3-8 for these same vegetation types. Crown health classes that describe the percent of live foliage for each tree were additionally recorded for aspen plots and were used to indicate standing dead trees in the other vegetation types. Crown classes that describe the relative position of a tree in the canopy were recorded for aspen plots. The NCPN uses the following crown classes (Figure 3-1):

- **Dominant:** Crowns extend above the general level of the main canopy of adjacent trees. They receive full light from above and partial light from the sides.
- **Codominant:** Crowns form the general level of the main canopy of adjacent trees. They receive full light from above and comparatively little from the sides.
- **Intermediate:** Crowns extend into the lower portion of the main canopy of adjacent trees, but are shorter in height than the codominants. They receive little direct light from above and none from the sides. Intermediate crown-classed trees usually have small crowns that are crowded on the sides.

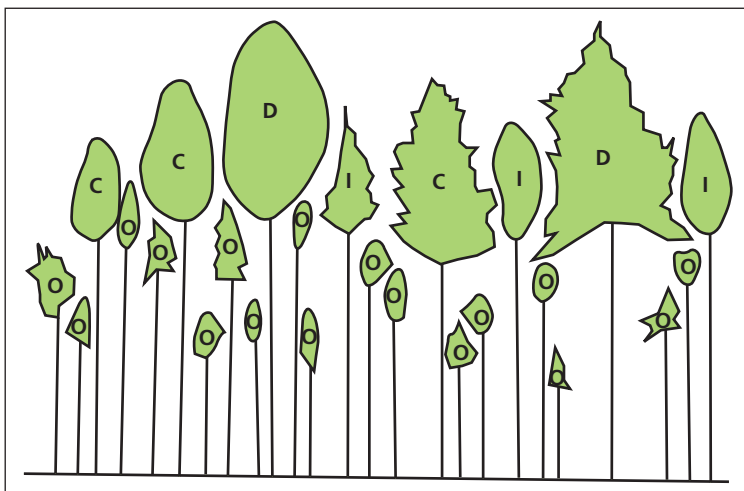


Figure 3-1. The relative positions of trees using four classes for crown classification. D=Dominant, C=Codominant, I=Intermediate, O=Overtopped.

- **Overtopped:** Crowns are entirely below the general level of the canopy of adjacent trees, and receive no direct light from above or from the sides.

3.2.5 Exotic species

Cover of exotic plant species is shown in Table 3-9 for all vegetation types. When exotic species were detected, cover was summarized for all plots in the vegetation type. NCPN upland sampling methods are not intended as an early detection survey; therefore, lack of detection does not mean that other exotic species were not present in plots.

In 2009, exotic species were detected in all vegetation types, and exotic perennial species were detected in all vegetation types except PJ. Kentucky bluegrass (*Poa pratensis*) was detected in the largest number of plots and had high cover in some vegetation types (up to 62% cover in aspen plots). Common dandelion (*Taraxacum officinale*) was also found at all aspen plots. Cheatgrass (*Bromus tectorum*) was detected at over half of the PJ plots, with cover as high as 50%. Cover and density of exotics was relatively low in sagebrush; however, a total of nine exotic species was detected in ungrazed Mountain Loam sagebrush, more than any other vegetation type.

3.2.6 Threatened and endangered species

Threatened and endangered plant species are not common in the areas of BLCA and CURE monitored by the network, and the NCPN does not specifically monitor them in these park units. No threatened or endangered species were found on any plots in 2008 or 2009.

3.2.7 Biological soil crust and surface features

Biological soil crust and surface-feature cover are shown in Table 3-10 for all vegetation types. Litter was the dominant surface cover for all vegetation types. In 2008, bare soil cover was much higher in grazed sagebrush than ungrazed sagebrush. In 2009, however, bare soil cover was low in both ungrazed and grazed sagebrush.

3.2.8 Canopy and basal gaps

Canopy- and basal-gap sizes are shown in Table 3-11 for all sagebrush sites. The distribution of gaps by size class is illustrated in Figures 3-2 through 3-5 for all sagebrush sites. Dry Mountain Loam had larger canopy and basal gaps than Mountain Loam. There was little difference between grazed and ungrazed sites or between years.

3.2.9 Soil aggregate stability

Measures of soil aggregate stability are reported in Table 3-12 for all sagebrush sites and PJ. Soil stability numbers range from 1 (least stable) to 6 (most stable) and are correlated with current erosion resistance and soil biotic integrity. They also usually reflect hydrologic function, because stable soils are less likely to disperse and clog soil pores during rainstorms. Because the numbers are affected by soil texture, it is important to limit comparisons to similar soils that have comparable amounts of sand, silt, and clay. Extremely sandy soils may not have maximum soil stability values of 6.

3.2.10 Fuels

Fuel volumes and depth of litter and duff are reported in Table 3-13 for all vegetation types except sagebrush. Fuels ranged from very low, in oak, to high, in aspen. Fuels in PJ varied greatly among plots.

3.2.11 Plot ordinations

Non-metric multidimensional scaling (NMS) ordination was performed using live species with relative cover values of >10% from all plots (Figure 3-6). Relative cover is the percent cover of the species divided by the total cover on a plot. This requirement was imposed to emphasize dominant species. The direction and relative magnitude of correlations of species are shown in the graphs for each combination of axes. The species vector from the origin shows the direction of positive correlation. The ordination illustrates both the separation of vegetation types and the high degree of overlap between the four sagebrush sites.

Table 3-1. Response design and number of plots by dominant vegetation, ecological site, and grazing status monitored in Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009.

Dominant vegetation	Response design	Ecological site ^a	Grazing status	2008 ^b	2009 ^c
Sagebrush	Grassland/shrubland	Dry Mountain Loam	Ungrazed	8	8
			Grazed	8	8
		Mountain Loam	Ungrazed	7 ^d	7 ^d
			Grazed	7	8
PJ	Woodland	Upland Shallow/Stony Loam	na	1	8
Oak	Oak	Brushy Loam	na	4	8
Aspen	Forest	na	na	1	4
Total				36	51

^a See Table 2-2 for description of ecological sites and vegetation types.

^b observations recorded August–September

^c observations recorded July–September

^d One plot from this group was excluded from summaries in this report due to riparian influence at the plot.

Table 3-2. Mean (range) number of plant species detected per monitoring plot by life form and vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009.

Number of species detected						
Year	Tree	Shrubs	Perennial grasses	Annual grasses	Forbs/ Herbs	Total
Sagebrush-Dry Mountain Loam, ungrazed						
2009	0.3 (0–1)	5.9 (3–10)	5.6 (3–9)	0	3.6 (1–8)	15.4 (9-26)
2008	0.4 (0–1)	5.3 (2–9)	6.3 (1–9)	0	4.6 (2–9)	16.5 (8-27)
Sagebrush-Dry Mountain Loam, grazed						
2009	0	8.9 (2–14)	5.1 (4–7)	0	3.8 (3–5)	17.8 (12–25)
2008	0	7.0 (2–10)	4.8 (3–6)	0	4.3 (2–7)	16.0 (10–19)
Sagebrush-Mountain Loam, ungrazed						
2009	0.3 (0–1)	8.4 (7–11)	6.3 (5–8)	0.1 (0–1)	7.0 (2–16)	22.1 (18–34)
2008	0.3 (0–1)	8.1 (5–11)	6.1 (4–7)	0.3 (0–1)	9.3 (3–14)	23.1 (17–30)
Sagebrush-Mountain Loam, grazed						
2009	0	7.6 (5–10)	5.5 (4–6)	0.1 (0–1)	4.6 (2–7)	17.9 (15–23)
2008	0	7.0 (3–11)	5.6 (3–8)	0.1 (0–1)	4.0 (2–6)	16.7 (11–20)
PJ						
2009	2.0 (2–2)	2.9 (0–5)	1.5 (0–3)	0.6 (0–1)	0.9 (0–3)	7.9 (4–12)
2008	2	4	0	0	1	7
Oak						
2009	0.3 (0–2)	5.3 (3–7)	4.3 (3–6)	0.1 (0–1)	6.8 (3–10)	16.6 (13–20)
2008	0	5.8 (5–7)	5.8 (4–7)	0.3 (0–1)	3.8 (2–6)	15.5 (13–17)
Aspen						
2009	1.5 (1–2)	7.0 (5–9)	8.0 (5–13)	0	11.0 (5–15)	27.5 (25–29)
2008	1	4	5	0	9	19

Table 3-3. Mean (range) percent cover of overstory, and understory vegetation by life form for each vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009.

Year	Overstory	Tree		Shrubs		Perennial grasses		Annual grasses		Forbs/Herbs	
		Live	Total	Live	Total	Live	Total	Live	Total	Live	Total
Sagebrush- Dry Mountain Loam, ungrazed											
2009	na	0.5 (0-3.0)	0.5 (0-3.3)	23.4 (17.7-42.7)	32.2 (23.7-54.0)	11.8 (5.0-21.3)	18.2 (9.0-35.3)	0	0.1 (0-0.7)	2.8 (0.3-5.3)	3.0 (0.3-6.0)
2008	na	0.7 (0-4.0)	0.7 (0-4.0)	29.8 (21.0-52.0)	31.1 (22.0-52.0)	16.4 (7.0-29.0)	16.4 (7.0-29.0)	0.04 (0-0.3)	0.04 (0-0.3)	3.8 (1.0-7.3)	3.8 (1.0-7.3)
Sagebrush- Dry Mountain Loam, grazed											
2009	na	0	0	26.1 (16.3-42.0)	33.9 (25.7-51.3)	10.9 (5.7-18.7)	15.4 (7.0-27.0)	0	0	5.3 (2.0-11.0)	5.8 (2.0-11.0)
2008	na	0	0	31.0 (18.3-47.0)	32.2 (19.3-48.3)	16.3 (5.0-33.7)	16.3 (5.0-34.3)	0	0	5.8 (2.0-12.3)	5.8 (2.0-12.3)
Sagebrush- Mountain Loam, ungrazed											
2009	na	0.5 (0-2.3)	0.6 (0-3.0)	27.2 (15.7-38.0)	36.3 (27.3-42.7)	25.9 (7.0-51.0)	35.6 (9.7-73.0)	0.1 (0-0.7)	0.1 (0-0.7)	7.4 (1.3-13.0)	9.6 (1.3-18.3)
2008	na	0.8 (0-3.7)	0.8 (0-3.7)	33.2 (22.3-45.0)	34.9 (24.3-46.0)	29.9 (9.0-43.7)	29.9 (8.0-44.0)	0.7 (0-3.0)	0.7 (0-3.0)	8.8 (2.0-12.7)	8.8 (2.0-12.7)
Sagebrush- Mountain Loam, grazed											
2009	na	0	0	27.2 (16.7-38.7)	36.0 (24.3-43.7)	24.8 (7.3-45.7)	31.8 (7.3-59.3)	0	0.3 (0-2.0)	7.0 (2.3-12.3)	7.8 (2.3-13.7)
2008	na	0	0	32.2 (17.3-40.7)	34.7 (22.3-41.3)	26.7 (12.3-43.3)	26.7 (12.3-43.3)	0.8 (0-5.3)	0.8 (0-5.3)	6.5 (1.0-12.0)	6.5 (1.0-12.0)
PJ											
2009	na	24.2 (5.7-39.0)	28.3 (6.7-41.3)	3.3 (0.3-8.3)	4.2 (0.7-10.3)	2.0 (0-8.0)	3.5 (0-18.0)	0.04 (0-0.3)	9.4 (0-50.0)	0.8 (0-2.0)	1.2 (0-2.3)
2008	na	24.7	25.7	5.7	5.7	0	0	0	0	1.0	1.0
Oak											
2009	na	0.6 (0-4.6)	0.6 (0-4.6)	44.7 (33.3-55.0)	53.2 (40.0-67.5)	25.6 (9.6-41.7)	35.3 (20.0-50.0)	0.1 (0-0.4)	0.2 (0-1.3)	11.2 (1.7-25.4)	16.3 (2.9-29.2)
2008	na	0	0	44.2 (42.5-46.7)	45.6 (44.2-46.7)	25.0 (15.8-40.8)	25.0 (15.8-40.8)	0.2 (0-0.8)	0.2 (0-0.8)	9.2 (2.5-16.7)	9.2 (2.5-16.7)
Aspen											
2009	46.3 (37.4-56.0)	1.0 (0.7-1.3)	1.2 (0.7-2.0)	21.2 (7.3-49.3)	24.3 (9.0-55.3)	41.8 (30.7-61.0)	54.8 (42.7-70.3)	0	0	13.3 (1.7-21.3)	21.3 (6.7-35.7)
2008	45.2	1.0	1.3	27.7	28.3	45.0	45.0	0	0	18.7	18.7

Table 3-4. Mean (range) percent cover of dominant understory species by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009.

Scientific name	Common name	Life form	Duration	Nativity	Percent cover			
					2009		2008	
					Live	Total	Live	Total
Sagebrush-Dry Mountain Loam, ungrazed								
<i>Artemisia tridentata</i>	big sagebrush	Shrub	Perennial	Native	17.2 (10.3–31.7)	24.6 (16.3–37.0)	22.5 (15.3–36.7)	23.8 (15.7–36.7)
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	Shrub	Perennial	Native	1.7 (0–6.7)	1.9 (0–7.3)	0.9 (0–2.7)	0.9 (0–2.7)
<i>Elymus elymoides</i>	squirreltail	Graminoid	Perennial	Native	1.1 (0–3.0)	1.5 (0–5.0)	1.3 (0–4.7)	1.3 (0–4.7)
<i>Koeleria macrantha</i>	Junegrass	Graminoid	Perennial	Native	0.6 (0–2.7)	0.9 (0–3.3)	0.5 (0–1.7)	0.5 (0–1.7)
<i>Poa fendleriana</i>	muttongrass	Graminoid	Perennial	Native	4.1 (0–18.0)	6.8 (0–30.7)	4.5 (0–17.0)	4.5 (0–17.0)
<i>Stipa comata</i>	needle and thread	Graminoid	Perennial	Native	1.8 (0–9.3)	2.3 (0–11.7)	4.5 (0–14.3)	4.5 (0–14.3)
<i>Stipa hymenoides</i>	Indian ricegrass	Graminoid	Perennial	Native	1.4 (0–4.3)	2.1 (0–5.0)	1.1 (0–2.7)	1.1 (0–2.7)
<i>Stipa lettermanii</i>	Letterman's needlegrass	Graminoid	Perennial	Native	1.0 (0–4.7)	1.6 (0–7.7)	1.8 (0–6.7)	1.8 (0–6.7)
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Shrub	Perennial	Native	0	0	0.04 (0–0.3)	0.04 (0–0.3)
Sagebrush-Dry Mountain Loam, grazed								
<i>Artemisia tridentata</i>	big sagebrush	Shrub	Perennial	Native	17.4 (6.7–23.7)	24.5 (9.0–33.7)	21.9 (6.3–36.7)	23.1 (6.7–37.7)
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	Shrub	Perennial	Native	1.2 (0–4.3)	1.3 (0–4.3)	1.2 (0–3.0)	1.3 (0–3.0)
<i>Elymus elymoides</i>	squirreltail	Graminoid	Perennial	Native	1.3 (0.3–2.0)	2.0 (0.3–4.0)	1.2 (0–4.3)	1.2 (0–4.3)
<i>Koeleria macrantha</i>	Junegrass	Graminoid	Perennial	Native	0.8 (0–3.3)	0.8 (0–3.3)	0.1 (0–0.7)	0.1 (0–0.7)
<i>Poa fendleriana</i>	muttongrass	Graminoid	Perennial	Native	3.8 (0.3–15.3)	5.6 (1.0–22.7)	7.0 (0–26.7)	7.1 (0–27.3)
<i>Stipa comata</i>	needle and thread	Graminoid	Perennial	Native	0.4 (0–1.3)	0.9 (0–5.0)	2.2 (0–7.3)	2.2 (0–7.3)
<i>Stipa hymenoides</i>	Indian ricegrass	Graminoid	Perennial	Native	1.0 (0–4.3)	1.4 (0–5.7)	1.2 (0–4.3)	1.2 (0–4.3)

Table 3-4. Mean (range) percent cover of dominant understory species by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009, cont.

Scientific name	Common name	Life form	Duration	Nativity	Percent cover			
					2009		2008	
					Live	Total	Live	Total
<i>Stipa lettermanii</i>	Letterman's needlegrass	Graminoid	Perennial	Native	1.7 (0-7.7)	2.3 (0-10.0)	1.8 (0-5.0)	1.8 (0-5.0)
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Shrub	Perennial	Native	0.3 (0-1.0)	0.4 (0-1.3)	0.8 (0-2.3)	0.8 (0-2.3)
Sagebrush-Mountain Loam, ungrazed								
<i>Artemisia tridentata</i>	big sagebrush	Shrub	Perennial	Native	15.0 (10.3-21.7)	23.1 (17.3-30.0)	20.0 (13.7-27.3)	21.6 (14.7-31.0)
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	Shrub	Perennial	Native	3.1 (0.7-5.7)	3.5 (0.7-6.7)	3.5 (0-12.7)	3.5 (0-12.7)
<i>Elymus elymoides</i>	squirreland	Graminoid	Perennial	Native	2.2 (0-5.7)	3.3 (0.3-8.0)	2.6 (0.3-6.0)	2.6 (0.3-6.0)
<i>Koeleria macrantha</i>	Junegrass	Graminoid	Perennial	Native	0.3 (0-1.3)	0.3 (0-1.3)	2.6 (0-9.3)	2.6 (0-9.3)
<i>Poa fendleriana</i>	muttongrass	Graminoid	Perennial	Native	11.8 (0.7-25.3)	14.6 (0.7-29.7)	11.9 (0-28.0)	11.9 (0-28.0)
<i>Stipa comata</i>	needle and thread	Graminoid	Perennial	Native	1.3 (0-6.3)	2.1 (0-11.0)	3.2 (0-15.7)	3.2 (0-15.7)
<i>Stipa hymenoides</i>	Indian ricegrass	Graminoid	Perennial	Native	0.7 (0-2.3)	1.1 (0-3.7)	0.9 (0-4.0)	0.9 (0-4.0)
<i>Stipa lettermanii</i>	Letterman's needlegrass	Graminoid	Perennial	Native	6.0 (1.0-16.3)	9.4 (2.0-24.7)	5.1 (1.3-13.0)	5.1 (1.3-13.0)
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Shrub	Perennial	Native	0.7 (0-3.7)	0.8 (0-3.7)	1.1 (0-4.7)	1.1 (0-4.7)
Sagebrush-Mountain Loam, grazed								
<i>Artemisia tridentata</i>	big sagebrush	Shrub	Perennial	Native	17.1 (9.0-27.0)	24.8 (16.0-38.7)	21.7 (10.3-31.0)	24.2 (15.3-32.7)
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	Shrub	Perennial	Native	3.8 (0.3-7.7)	4.4 (0.7-9.7)	5.0 (1.0-12.0)	5.0 (1.0-12.0)
<i>Elymus elymoides</i>	squirreland	Graminoid	Perennial	Native	1.8 (0.3-5.0)	2.0 (0.3-5.7)	1.2 (0-3.0)	1.2 (0-3.0)
<i>Koeleria macrantha</i>	Junegrass	Graminoid	Perennial	Native	2.3 (0-9.0)	2.8 (0-12.0)	1.9 (0-12.0)	1.9 (0-12.0)
<i>Poa fendleriana</i>	muttongrass	Graminoid	Perennial	Native	10.3 (1.0-23.3)	13.2 (1.3-27.7)	11.3 (1.3-21.0)	11.3 (1.3-21.0)

Table 3-4. Mean (range) percent cover of dominant understory species by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009, cont.									
					Percent cover				
					2009		2008		
Scientific name	Common name	Life form	Duration	Nativity	Live	Total	Live	Total	
<i>Stipa comata</i>	needle and thread	Graminoid	Perennial	Native	1.0 (0-4.0)	1.8 (0-6.0)	3.4 (0-10.3)	3.4 (0-10.3)	
<i>Stipa hymenoides</i>	Indian ricegrass	Graminoid	Perennial	Native	0.4 (0-2.3)	0.4 (0-2.7)	0.5 (0-2.7)	0.5 (0-2.7)	
<i>Stipa lettermanii</i>	Letterman's needlegrass	Graminoid	Perennial	Native	7.2 (1.0-23.3)	9.6 (1.0-35.0)	5.4 (0.3-14.7)	5.4 (0.3-14.7)	
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Shrub	Perennial	Native	0.8 (0-2.7)	0.9 (0-3.3)	1.0 (0-4.0)	1.0 (0-4.0)	
PJ									
<i>Cercocarpus montanus</i>	alder-leaf mountain mahogany	Shrub	Perennial	Native	1.5 (0-5.3)	2.0 (0-7.0)	1.7	1.7	
<i>Ephedra viridis</i>	Mormon tea	Shrub	Perennial	Native	0.8 (0-2.3)	0.9 (0-2.3)	2.0	2.0	
<i>Juniperus osteosperma</i>	Utah juniper	Tree	Perennial	Native	16.2 (5.7-28.0)	19.2 (6.7-36.0)	9.0	9.0	
<i>Pinus edulis</i>	two-needle pinyon	Tree	Perennial	Native	8.3 (0-29.0)	9.8 (0-30.3)	17.0	17.0	
Oak									
<i>Amelanchier utahensis</i>	Utah serviceberry	Shrub	Perennial	Native	21.5 (9.2-47.1)	26.9 (11.7-60.8)	18.5 (10.0-27.5)	19.4 (10.0-27.5)	
<i>Artemisia tridentata</i>	big sagebrush	Shrub	Perennial	Native	5.5 (0-13.3)	8.6 (1.3-17.9)	5.4 (0-10.8)	5.8 (0-10.8)	
<i>Poa fendleriana</i>	muttongrass	Graminoid	Perennial	Native	8.6 (1.3-23.3)	12.4 (1.3-25.8)	6.7 (2.5-9.2)	6.7 (2.5-9.2)	
<i>Quercus gambelii</i>	Gambel oak	Shrub	Perennial	Native	16.9 (0-35.4)	17.8 (0-37.1)	17.3 (8.3-30.0)	17.7 (8.3-31.7)	
<i>Stipa lettermanii</i>	Letterman's needlegrass	Graminoid	Perennial	Native	2.0 (0-5.8)	3.1 (0-7.9)	1.0 (0-1.7)	1.0 (0-1.7)	
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Shrub	Perennial	Native	7.4 (0-21.7)	9.0 (0-25.8)	5.4 (0.8-10.8)	5.4 (0.8-10.8)	

Table 3-4. Mean (range) percent cover of dominant understory species by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009, cont.

Scientific name	Common name	Life form	Duration	Nativity	Percent cover			
					2009		2008	
					Live	Total	Live	Total
Aspen								
<i>Achillea millefolium</i>	common yarrow	Forb	Perennial	Native	2.7 (0-4.7)	3.9 (0.3-7.7)	5.3	5.3
<i>Bromus carinatus</i>	mountain brome	Graminoid	Perennial	Native	2.5 (0-5.3)	3.2 (0-7.0)	8.3	8.3
<i>Bromus ciliatus</i>	fringed brome	Graminoid	Perennial	Native	2.5 (0.3-7.3)	2.8 (0.3-8.7)	0	0
<i>Carex geyeri</i>	elk sedge	Graminoid	Perennial	Native	6.7 (0.7-12.7)	7.7 (0.7-15.3)	0	0
<i>Elymus glaucus</i>	blue wildrye	Graminoid	Perennial	Native	1.4 (0.3-2.3)	1.8 (0.3-2.7)	0	0
<i>Geranium richardsonii</i>	Richardson's crane's-bill	Forb	Perennial	Native	0.3 (0-0.7)	0.5 (0-0.7)	0	0
<i>Populus tremuloides</i>	quaking aspen	Tree	Perennial	Native	1.0 (0.7-1.3)	1.2 (0.7-2.0)	1.0	1.3
<i>Rosa woodsii</i>	Woods' rose	Shrub	Perennial	Native	0.4 (0-1.0)	0.4 (0-1.0)	0.7	0.7
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Shrub	Perennial	Native	11.8 (4.7-24.7)	14.4 (5.7-29.0)	23.3	24.0
<i>Vicia americana</i>	American vetch	Forb	Perennial	Native	3.3 (0-5.3)	6.5 (0-15.0)	4.0	4.0

Table 3-5. Mean (range) total percent cover of all shrubs from the line-intercept method, Oak vegetation type, Black Canyon of the Gunnison National Park, 2008 and 2009.

Scientific name	Common name	2009		2008	
		No. of plots with species present	Percent cover	No. of plots with species present	Percent cover
<i>Amelanchier utahensis</i>	Utah serviceberry	8	29.2 (14.1–63.3)	4	21.2 (15.6–26.6)
<i>Artemisia tridentata</i>	big sagebrush	8	9.8 (1.2–22.9)	4	8.1 (3.1–13.2)
<i>Cercocarpus montanus</i>	alder-leaf mountain mahogany	3	0.7 (0–2.5)	1	0.9 (0–3.4)
<i>Chrysothamnus depressus</i>	dwarf rabbitbrush	1	0.02 (0–0.2)	0	
<i>Chrysothamnus vicidiflorus</i>	green rabbitbrush	1	0.01 (0–0.1)	0	
<i>Pachystima myrsinites</i>	mountain-lover	1	0.04 (0–0.4)	0	
<i>Peraphyllum ramosissimum</i>	squaw-apple	1	0.1 (0–0.7)	1	0.2 (0–0.7)
<i>Quercus gambelii</i>	Gambel oak	7	22.3 (0–51.3)	4	19.7 (9.6–30.2)
<i>Symphoricarpos oreophilus</i>	mountain snowberry	7	9.3 (0–31.3)	4	5.6 (2.8–10.5)
<i>Tetradymia canescens</i>	spineless horsebrush	1	0.1 (0–1.1)	1	0.3 (0–1.1)

Table 3-6. Mean (range) density of shrub species per hectare by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009.

Scientific name	Common name	2009		2008	
		No. of plots with species present	Density (number of shrubs/ha)	No. of plots with species present	Density (number of shrubs/ha)
Sagebrush-Dry Mountain Loam, ungrazed					
<i>Amelanchier utahensis</i>	Utah serviceberry	2	17 (0–67)	2	17 (0–67)
<i>Artemisia frigida</i>	fringed sagebrush	4	917 (0–4,000)	0	0
<i>Artemisia nova</i>	black sagebrush	1	383 (0–3,067)	0	0
<i>Artemisia tridentata</i>	big sagebrush	8	9,658 (4,267–14,000)	8	10,608 (6,067–14,533)
<i>Chrysothamnus depressus</i>	dwarf rabbitbrush	5	3,908 (0–21,867)	0	0
<i>Chrysothamnus nauseosus</i>	rubber rabbitbrush	2	1,292 (0–10,267)	2	825 (0–6,533)
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	8	5,667 (533–24,333)	5	1,367 (0–6,600)
<i>Eriogonum lonchophyllum</i>	spearleaf buckwheat	1	42 (0–333)	0	0
<i>Juniperus scopulorum</i>	Rocky Mountain juniper	1	67 (0–533)	3	67 (0–400)
<i>Krascheninnikovia lanata</i>	winterfat	1	975 (0–7,800)	1	817 (0–6,533)
<i>Leptodactylon pungens</i>	prickly-phlox	2	617 (0–4,600)	0	0
<i>Prunus virginiana</i>	chokecherry	1	142 (0–1,133)	1	225 (0–1,800)
<i>Purshia tridentata</i>	antelope bitterbrush	1	175 (0–1,400)	1	125 (0–1,000)
<i>Quercus gambelii</i>	Gambel oak	0	0	2	133 (0–933)
<i>Symphoricarpos oreophilus</i>	mountain snowberry	3	117 (0–600)	3	33 (0–133)
<i>Tetradymia canescens</i>	spineless horsebrush	4	417 (0–2,800)	2	233 (0–1,733)
Sagebrush-Dry Mountain Loam, grazed					
<i>Amelanchier utahensis</i>	Utah serviceberry	5	292 (0–800)	4	300 (0–933)
<i>Artemisia frigida</i>	fringed sagebrush	5	650 (0–3,000)	0	0
<i>Artemisia nova</i>	black sagebrush	2	1,167 (0–9,133)	0	0
<i>Artemisia tridentata</i>	big sagebrush	8	11,058 (7,867–17,200)	8	11,792 (8067–17,133)
<i>Cercocarpus montanus</i>	alder-leaf mountain mahogany	1	483 (0–3,867)	1	442 (0–3,533)
<i>Chrysothamnus depressus</i>	dwarf rabbitbrush	4	2,558 (0–18,867)	0	0
<i>Chrysothamnus nauseosus</i>	rubber rabbitbrush	1	17 (0–133)	0	0
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	8	3,225 (67–10,200)	6	3,042 (0–11,667)
<i>Eriogonum lonchophyllum</i>	spearleaf buckwheat	3	500 (0–3,533)	0	0
<i>Eriogonum microthecum</i>	slender wild buckwheat	1	117 (0–933)	0	0
<i>Krascheninnikovia lanata</i>	winterfat	4	633 (0–3,867)	4	308 (0–1,133)

Table 3-6. Mean (range) density of shrub species per hectare by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009, cont.

Scientific name	Common name	2009		2008	
		No. of plots with species present	Density (number of shrubs/ha)	No. of plots with species present	Density (number of shrubs/ha)
Sagebrush-Dry Mountain Loam, grazed, cont.					
<i>Leptodactylon pungens</i>	prickly-phlox	2	42 (0–200)	0	0
<i>Mahonia repens</i>	Oregon-grape	1	83 (0–667)	0	0
<i>Purshia tridentata</i>	antelope bitterbrush	2	225 (0–1,733)	1	208 (0–1,667)
<i>Quercus gambelii</i>	Gambel oak	1	17 (0–133)	5	2,350 (0–13,133)
<i>Rhus trilobata</i>	skunkbush sumac	1	8 (0–67)	1	8 (0–67)
<i>Symphoricarpos oreophilus</i>	mountain snowberry	7	1,425 (0–3,733)	7	1,083 (0–2,933)
<i>Tetradymia canescens</i>	spineless horsebrush	5	458 (0–3,200)	5	483 (0–3,400)
Sagebrush-Mountain Loam, ungrazed					
<i>Amelanchier utahensis</i>	Utah serviceberry	6	371 (0–733)	6	467 (0–867)
<i>Artemisia frigida</i>	fringed sagebrush	3	229 (0–800)	0	0
<i>Artemisia tridentata</i>	big sagebrush	7	8,295 (5,533–10,733)	7	11,543 (8,333–1,7333)
<i>Ceanothus fendleri</i>	Fendler's mountain-lilac	1	267 (0–1,867)	1	190 (0–1,333)
<i>Cercocarpus montanus</i>	alder-leaf mountain mahogany	1	76 (0–533)	1	114 (0–800)
<i>Chrysothamnus depressus</i>	dwarf rabbitbrush	2	1,181 (0–8,067)	0	0
<i>Chrysothamnus nauseosus</i>	rubber rabbitbrush	1	57 (0–400)	0	0
<i>Chrysothamnus parryi</i>	Parry's rabbitbrush	2	857 (0–3,133)	2	476 (0–3,000)
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	7	6,990 (1,267–23,400)	5	7,210 (0–20,200)
<i>Eriogonum lonchophyllum</i>	spearleaf buckwheat	1	10 (0–67)	0	0
<i>Juniperus scopulorum</i>	Rocky Mountain juniper	2	19 (0–67)	2	76 (0–267)
<i>Leptodactylon pungens</i>	prickly-phlox	3	352 (0–2,200)	0	0
<i>Peraphyllum ramosissimum</i>	squaw-apple	1	10 (0–67)	1	10 (0–67)
<i>Prunus virginiana</i>	chokecherry	2	276 (0–1,867)	1	181 (0–1267)
<i>Purshia tridentata</i>	antelope bitterbrush	4	914 (0–5,400)	3	1,219 (0–7,533)
<i>Quercus gambelii</i>	Gambel oak	1	1,533 (0–10,733)	3	3,048 (0–12,133)
<i>Rhus trilobata</i>	skunkbush sumac	1	19 (0–133)	1	19 (0–133)
<i>Ribes cereum</i>	wax currant	0	0	1	10 (0–67)
<i>Rosa woodsii</i>	Woods' rose	1	19 (0–133)	0	0
<i>Symphoricarpos oreophilus</i>	mountain snowberry	7	1,267 (67–6,800)	6	1,057 (0–4,667)
<i>Tetradymia canescens</i>	spineless horsebrush	2	19 (0–67)	3	38 (0–200)

Table 3-6. Mean (range) density of shrub species per hectare by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009, cont.

Scientific name	Common name	2009		2008	
		No. of plots with species present	Density (number of shrubs/ha)	No. of plots with species present	Density (number of shrubs/ha)
Sagebrush-Mountain Loam, grazed					
<i>Amelanchier utahensis</i>	Utah serviceberry	5	600 (0–2,600)	4	990 (0–3,267)
<i>Artemisia frigida</i>	fringed sagebrush	2	58 (0–333)	0	0
<i>Artemisia nova</i>	black sagebrush	2	1,392 (0–9,667)	0	0
<i>Artemisia tridentata</i>	big sagebrush	8	9,267 (6,133–12,267)	7	10,057 (6,733–12,733)
<i>Cercocarpus montanus</i>	alder-leaf mountain mahogany	2	200 (0–867)	2	248 (0–1,267)
<i>Chrysothamnus depressus</i>	dwarf rabbitbrush	3	2,292 (0–7,867)	0	0
<i>Chrysothamnus nauseosus</i>	rubber rabbitbrush	1	167 (0–1,333)	1	229 (0–1,600)
<i>Chrysothamnus parryi</i>	Parry's rabbitbrush	1	42 (0–333)	0	0
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	8	9,008 (733–25,200)	7	8,810 (1,667–19,867)
<i>Eriogonum lonchophyllum</i>	spearleaf buckwheat	1	17 (0–133)	0	0
<i>Krascheninnikovia lanata</i>	winterfat	1	8 (0–67)	0	0
<i>Leptodactylon pungens</i>	prickly-phlox	2	325 (0–1,667)	0	0
<i>Mahonia repens</i>	Oregon-grape	1	50 (0–400)	0	0
<i>Peraphyllum ramosissimum</i>	squaw-apple	1	8 (0–67)	1	29 (0–200)
<i>Purshia tridentata</i>	antelope bitterbrush	3	225 (0–867)	3	267 (0–1,200)
<i>Quercus gambelii</i>	Gambel oak	2	1,500 (0–11,867)	3	476 (0–2,733)
<i>Rosa woodsii</i>	Woods' rose	1	50 (0–400)	0	0
<i>Symphoricarpos oreophilus</i>	mountain snowberry	5	2,242 (0–9,400)	5	1,933 (0–6,333)
<i>Tetradymia canescens</i>	spineless horsebrush	5	150 (0–533)	3	114 (0–600)
PJ					
<i>Amelanchier utahensis</i>	Utah serviceberry	2	17 (0–67)	0	0
<i>Artemisia tridentata</i>	big sagebrush	2	25 (0–133)	0	0
<i>Brickellia microphylla</i>	littleleaf brickellbush	1	42 (0–333)	0	0
<i>Cercocarpus montanus</i>	alder-leaf mountain mahogany	5	442 (0–1,200)	1	800
<i>Ephedra viridis</i>	green ephedra	5	442 (0–1,267)	1	267
<i>Eriogonum microthecum</i>	slender wild buckwheat	1	108 (0–867)	0	0
<i>Glossopetalon spinescens</i>	spiny greasebush	1	25 (0–200)	0	0
<i>Mahonia fremontii</i>	Fremont's mahonia	1	58 (0–467)	1	333
<i>Quercus gambelii</i>	Gambel oak	1	92 (0–733)	0	0

Table 3-6. Mean (range) density of shrub species per hectare by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009, cont.

Scientific name	Common name	2009		2008	
		No. of plots with species present	Density (number of shrubs/ha)	No. of plots with species present	Density (number of shrubs/ha)
Aspen					
<i>Amelanchier alnifolia</i>	Saskatoon serviceberry	3	767 (0–2,333)	0	0
<i>Amelanchier utahensis</i>	Utah serviceberry	3	417 (0–1,133)	1	533
<i>Artemisia tridentata</i>	big sagebrush	1	17 (0–67)	0	0
<i>Chrysothamnus parryi</i>	Parry's rabbitbrush	1	33 (0–133)	0	0
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	1	17 (0–67)	0	0
<i>Juniperus communis</i>	common juniper	1	17 (0–67)	0	0
<i>Pachystima myrsinites</i>	mountain-lover	1	367 (0–1,467)	0	0
<i>Prunus virginiana</i>	chokecherry	3	1,717 (0–5,333)	1	667
<i>Quercus gambelii</i>	Gambel oak	1	517 (0–2,067)	0	0
<i>Ribes wolfii</i>	wolf currant	1	17 (0–67)	0	0
<i>Rosa woodsii</i>	Woods' rose	4	1,233 (600–2,867)	1	733
<i>Salix scouleriana</i>	Scouler's willow	1	167 (0–667)	0	0
<i>Symphoricarpos oreophilus</i>	mountain snowberry	2	1,267 (0–2,733)	1	7,067

Species for which no mean is shown were not detected in 2008.

Table 3-7. Mean (range) density of live seedlings, saplings, and overstory trees by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009.

			Density of trees by dbh class (no. of trees/ha)				
Scientific name	Common name	Year	Seedling	Sapling			Tree
			<2.5 cm	2.5–5.0 cm	5.1–10.0 cm	10.1–15.0 cm	>15 cm
PJ							
<i>Juniperus osteosperma</i>	Utah juniper	2009	367 (67–1,067)	63 (0–240)	80 (0–240)	63 (0–360)	170 (64–288)
		2008	0	120	0	40	NR
<i>Pinus edulis</i>	two-needle pinyon	2009	525 (133–1,200)	100 (0–160)	160 (0–280)	33 (0–120)	50 (0–176)
		2008	667	160	120	120	0
Oak							
<i>Pseudotsuga menziesii</i>	Douglas-fir	2009	na	na	na	na	16
<i>Quercus gambelii</i>	Gambel oak	2009	na	na	na	na	64
Aspen							
<i>Juniperus scopulorum</i>	Rocky mountain juniper	2009	33 (0–67)	0	10 (0–40)	20 (0–80)	0
<i>Populus tremuloides</i>	quaking aspen	2009	1,367 (200–2,600)	90 (0–160)	350 (0–640)	200 (0–440)	256 (160–448)
		2008	1,267	40	360	80	160

NR = not recorded in 2008

Table 3-8. Mean (range) density, diameter at breast height (dbh), crown class, and crown health for all trees >15 cm dbh by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009.

Scientific name	Common name	Year	Density (no. of trees/ha)	dbh (cm)	Crown class			Crown health					
					% O	% I	% C	% D	1	2	3	4	5
PJ													
<i>Juniperus osteosperma</i> *	Utah juniper	2009	190 (64–288)	25 (17–36)	na	na	na	na	na	na	na	na	9 (0–28)
<i>Pinus edulis</i>	two-needle pinyon	2009	53 (16–176)	20 (15–24)	na	na	na	na	na	na	na	na	14 (0–100)
Oak													
<i>Pseudotsuga menzies</i>	Douglas-fir	2009	2.0 (0–16)	22 (22–22)	na	na	na	na	na	na	na	na	0
<i>Quercus gambelii</i>	Gambel oak	2009	8.0 (0–64)	15 (15–15)	na	na	na	na	na	na	na	na	0
Aspen													
<i>Populus tremuloides</i>	quaking aspen	2009	420 (320–576)	22 (19–24)	1 (0–6)	11 (0–20)	32 (19–57)	15 (0–20)	45 (26–67)	12 (0–30)	3 (0–4)	0	41 (22–62)
		2008	480	23.2	0	3.3	23.3	3.3	13.3	16.7	0	0	66.7

* not recorded in 2008

Crown class codes: O=Overtopped, I=Intermediate, C=Codominant, D=Dominant. Crown health codes: 1=90–100% live foliage, 2=50–89% live foliage, 3=16–49% live foliage, 4=0.1–15% live foliage, 5=standing dead.

Table 3-9. Mean (range) cover and density of exotic plant species detected in Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009.

Scientific name	Common name	Life form	Duration	Year	No. of plots with exotic species detected	Percent cover*		Density (number of exotic perennials/ha)
						Live	Total	
Sagebrush-Dry Mountain Loam, ungrazed								
<i>Agropyron cristatum</i>	crested wheatgrass	Graminoid	Perennial	2009	2	0.1 (0–0.7)	0.1 (0–1.0)	25 (0–200)
				2008	1	0.1 (0–0.7)	0.1 (0–1.0)	17 (0–133)
<i>Bromus inermis</i>	smooth brome	Graminoid	Perennial	2009	1	0.04 (0–0.3)	0.04 (0–0.3)	17 (0–133)
<i>Capsella bursa-pastoris</i>	shepherd's-purse	Forb	Annual	2008	1	0.04 (0–0.3)	0.04 (0–0.3)	na
<i>Melilotus officinalis</i>	yellow sweet-clover	Forb	Biennial	2009	1	0	0	8 (0–67)
<i>Poa pratensis</i>	Kentucky bluegrass	Graminoid	Perennial	2008	1	0	0.04 (0–0.3)	0
Sagebrush-Dry Mountain Loam, grazed								
<i>Agropyron cristatum</i>	crested wheatgrass	Graminoid	Perennial	2009	1	0.04 (0–0.3)	0.04 (0–0.3)	17 (0–133)
<i>Bromus inermis</i>	smooth brome	Graminoid	Perennial	2009	1	0	0	8 (0–67)
<i>Elymus hispidus</i>	intermediate wheatgrass	Graminoid	Perennial	2009	1	0.04 (0–0.3)	0.04 (0–0.3)	17 (0–133)
Sagebrush-Mountain Loam, ungrazed								
<i>Agropyron cristatum</i>	crested wheatgrass	Graminoid	Perennial	2009	1	0	0	10 (0–67)
				2008	1	0.05 (0–0.3)	0.05 (0–0.3)	0
<i>Bromus inermis</i>	smooth brome	Graminoid	Perennial	2009	2	0.05 (0–0.3)	0.05 (0–0.3)	57 (0–333)
				2008	1	0.1 (0–0.7)	0.1 (0–0.7)	0
<i>Bromus tectorum</i>	cheatgrass	Graminoid	Annual	2009	1	0.1 (0–0.7)	0.1 (0–0.7)	na
				2008	2	0.6 (0–3.0)	0.6 (0–3.0)	na
<i>Elymus hispidus</i>	intermediate wheatgrass	Graminoid	Perennial	2009	1	0.05 (0–0.3)	0.05 (0–0.3)	48 (0–333)
<i>Melilotus officinalis</i>	yellow sweet-clover	Forb	Biennial	2009	2	0.05 (0–0.3)	0.05 (0–0.3)	171 (0–733)
				2008	1	0.05 (0–0.3)	0.05 (0–0.3)	0
<i>Poa pratensis</i>	Kentucky bluegrass	Graminoid	Perennial	2009	3	2.9 (0–14.3)	5.0 (0–17.7)	257 (0–1,333)
				2008	3	3.4 (0–11.7)	3.4 (0–11.7)	57 (0–200)
<i>Polygonum aviculare</i>	yard knotweed	Forb	Annual	2009	1	0.1 (0–0.7)	0.1 (0–0.7)	na
<i>Taraxacum officinale</i>	common dandelion	Forb	Perennial	2009	1	0.05 (0–0.3)	0.2 (0–1.3)	19 (0–133)
				2008	2	0.2 (0–1.0)	0.2 (0–1.0)	0
<i>Tragopogon dubius</i>	yellow salsify	Forb	Biennial	2009	1	0	0	19 (0–133)

Table 3-9. Mean (range) cover and density of exotic plant species detected in Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009, cont.

Scientific name	Common name	Life form	Duration	Year	No. of plots with exotic species detected	Percent cover*		Density (number of exotic perennials/ha)
						Live	Total	
Sagebrush-Mountain Loam, grazed								
<i>Bromus inermis</i>	smooth brome	Graminoid	Perennial	2009	1	0	0.3 (0–2.0)	17 (0–133)
<i>Bromus tectorum</i>	cheatgrass	Graminoid	Annual	2009	1	0	0.3 (0–2.0)	na
				2008	1	0.8 (0–5.3)	0.8 (0–5.3)	na
<i>Poa pratensis</i>	Kentucky bluegrass	Graminoid	Perennial	2009	1	0.3 (0–2.3)	0.7 (0–5.3)	NM
				2008	1	1.9 (0–13.3)	1.9 (0–13.3)	29 (0–200)
PJ								
<i>Alyssum desertorum</i>	desert madwort	Forb	Annual	2009	1	0.1 (0–0.7)	0.2 (0–1.3)	na
<i>Bromus tectorum</i>	cheatgrass	Graminoid	Annual	2009	5	0.04 (0–0.3)	9.4 (0–50.0)	na
<i>Sisymbrium altissimum</i>	tumble mustard	Forb	Annual	2009	1	0	0.1 (0–0.7)	na
Oak								
<i>Bromus tectorum</i>	cheatgrass	Graminoid	Annual	2009	1	0.1 (0–0.4)	0.2 (0–1.3)	na
				2008	1	0.2 (0–0.8)	0.2 (0–0.8)	na
<i>Poa pratensis</i>	Kentucky bluegrass	Graminoid	Perennial	2009	5	10.8 (0–37.9)	13.9 (0–45.4)	na
				2008	3	8.5 (0–24.2)	8.5 (0–24.2)	na
<i>Taraxacum officinale</i>	common dandelion	Forb	Perennial	2009	1	0.5 (0–3.8)	0.7 (0–5.4)	na
Aspen								
<i>Cirsium arvense</i>	Canada thistle	Forb	Perennial	2009	1	0.3 (0–1.0)	0.3 (0–1.0)	1,183 (0–4,733)
<i>Poa pratensis</i>	Kentucky bluegrass	Graminoid	Perennial	2009	4	25.4 (9.3–53.3)	36.4 (10.7–61.7)	417 (0–1,667)
				2008	1	38.3	38.7	66,667
<i>Taraxacum officinale</i>	common dandelion	Forb	Perennial	2009	4	0.8 (0–1.0)	1.2 (0.3–2.3)	1,600 (133–3,067)

*Mean and range are based on all plots within a vegetation type where an exotic species was detected.
 NM = not measured at this plot in 2009

Table 3-10. Mean (range) percent cover of surface features by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009.

Year	Crust, undifferentiated	Cyanobacteria	Lichen	Moss	Bare soil	Litter	Woody debris	Small rock	Large rock	Bedrock
Sagebrush-Dry Mountain Loam, ungrazed										
2009	18.3 (0–49.0)	0	0	0.9 (0–3.3)	4.3 (0.7–12.3)	43.6 (21.3–66.3)	0.7 (0–4.0)	15.8 (0–41.0)	8.0 (0–22.0)	0
2008	27.7 (0–57.7)	2.3 (0–18.0)	0	0.9 (0–4.0)	5.3 (0–22.3)	25.5 (5.0–57.0)	1.4 (0–6.3)	18.0 (0–41.7)	8.1 (0–20.3)	0
Sagebrush-Dry Mountain Loam, grazed										
2009	16.2 (5.0–31.0)	0	1.0 (0–5.0)	0.5 (0–2.3)	5.4 (0–16.0)	39.0 (24.3–51.7)	0.3 (0–1.0)	22.1 (9.0–38.7)	4.7 (0–17.7)	0
2008	7.1 (0–23.0)	0	0.6 (0–4.0)	0.4 (0–2.0)	32.3 (1.7–75.7)	24.2 (0.3–48.3)	0	20.0 (9.3–28.7)	7.1 (0–16.7)	0
Sagebrush-Mountain Loam, ungrazed										
2009	9.8 (0–17.3)	0	0	0.1 (0–0.7)	3.1 (0–7.3)	60.9 (45.3–77.3)	0.4 (0–1.7)	9.0 (0–25.3)	3.6 (0–14.3)	0
2008	18.4 (3.0–34.7)	0.05 (0–0.3)	0.1 (0–0.3)	0.1 (0–0.7)	10.3 (0–39.7)	40.0 (12.0–67.0)	0.7 (0–3.3)	11.3 (0–29.3)	4.2 (0–17.0)	0
Sagebrush-Mountain Loam, grazed										
2009	12.0 (2.7–34.3)	0	0	0	2.3 (0–7.0)	59.6 (40.3–81.3)	0.4 (0–1.3)	8.9 (0–26.0)	3.0 (0–11.7)	0.2 (0–1.3)
2008	6.5 (0–17.0)	0.05 (0–0.3)	0	0.3 (0–0.7)	20.0 (0.3–60.3)	47.6 (10.0–76.3)	0.3 (0–2.0)	10.7 (0–29.3)	3.4 (0–17.0)	0
PJ										
2009	11.5 (0–35.0)	0	0	0.8 (0–3.3)	2.8 (0–6.7)	52.3 (29.7–72.3)	1.3 (0–7.0)	13.8 (5.7–20.3)	6.5 (0–11.3)	0.7 (0–5.3)
2008	19.7	0	0	0	2.0	41.7	2.7	10.0	7.0	0
Oak										
2009	6.8 (2.5–13.3)	0	0	0.2 (0–0.8)	1.5 (0–3.8)	80.2 (61.3–92.9)	0.4 (0–2.5)	2.3 (0.4–6.3)	2.3 (0–8.3)	0.2 (0–1.7)
2008	12.9 (10.8–15.0)	0	0	0	0.8 (0–1.7)	73.1 (62.5–80.0)	0.6 (0–1.7)	3.3 (0–9.2)	2.1 (0–6.7)	0
Aspen										
2009	0	0	0	0	2.0 (0.3–3.3)	83.7 (76.3–88.3)	7.0 (4.0–11.7)	0.1 (0–0.3)	1.2 (0–2.7)	0.3 (0–1.0)
2008	0	0	0	0	2.0	86.7	6.0	0	2.3	1.3

Table 3-11. Mean (range) canopy- and basal-gap size by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009.

Vegetation type	2008		2009	
	Canopy gap (cm)	Basal gap (cm)	Canopy gap (cm)	Basal gap (cm)
Sagebrush-Dry Mountain Loam, ungrazed	65 (44–84)	102 (75–155)	61 (49–81)	108 (74–146)
Sagebrush-Dry Mountain Loam, grazed	63 (44–96)	91 (65–168)	63 (47–81)	105 (62–235)
Sagebrush-Mountain Loam, ungrazed	57 (37–101)	77 (47–139)	54 (45–77)	81 (56–140)
Sagebrush-Mountain Loam, grazed	57 (36–94)	82 (54–107)	54 (36–90)	76 (43–181)

Table 3-12. Mean (range) soil-aggregate stability measures by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009.

Vegetation type	2008			2009		
	Total	Protected	Unprotected	Total	Protected	Unprotected
Sagebrush-Dry Mountain Loam, ungrazed	1.7 (1.1–2.2)	1.7 (1.0–2.4)	1.6 (1.1–2.2)	2.2 (1.7–2.7)	2.2 (1.6–2.8)	2.1 (1.3–2.7)
Sagebrush-Dry Mountain Loam, grazed	1.2 (1.0–1.6)	1.1 (1.0–1.6)	1.3 (1.0–1.5)	2.5 (1.7–3.3)	2.7 (1.4–3.5)	2.4 (1.8–3.7)
Sagebrush-Mountain Loam, ungrazed	1.7 (1.2–2.3)	1.6 (1.0–2.4)	1.7 (1.1–2.2)	3.3 (2.2–4.6)	3.4 (2.3–4.6)	3.1 (2.0–4.5)
Sagebrush-Mountain Loam, grazed	1.5 (1.0–2.3)	1.4 (1.0–2.8)	1.6 (1.0–3.3)	3.1 (1.9–4.8)	3.3 (2.1–5.5)	3.1 (1.7–6.0)
PJ	3.2	4.0	3.2	3.4 (1.7–4.3)	3.4 (2.0–4.4)	3.5 (1.6–4.7)

Numbers range from 1 (least stable) to 6 (most stable).

Protected are samples collected under vegetation; unprotected are samples collected in the open.

Table 3-13. Fuel volume and depth of litter and duff by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2008 and 2009.

Year	Fuel volume (tons/acre)						Depth (cm)	
	Total	1-hr	10-hr	100-hr	1000-hr		Litter	Duff
					Sound	Rotten		
PJ								
2009	9.2 (0.1–50.6)	0.1 (0.01–0.5)	0.6 (0–1.8)	0.6 (0–2.4)	7.7 (0–48.0)	0.2 (0–1.3)	0.7 (0.3–1.8)	0.3 (0–0.6)
2008	0.9	0.1	0.3	0.5	0	0	0.4	0
Oak								
2009	1.2 (0.1–2.7)	0.04 (0–0.2)	0.5 (0.1–2.0)	0.4 (0–2.1)	0.1 (0–0.6)	0.04 (0–0.3)	1.5 (1.0–2.4)	0.4 (0–0.8)
2008	1.7 (0.5–2.6)	0.09 (0.03–0.17)	0.7 (0.4–1.1)	1.0 (0–1.4)	0	0	1.7 (1.1–2.5)	0.9 (0.3–1.4)
Aspen								
2009	16.2 (12.8–19.8)	0.05 (0.02–0.09)	0.5 (0.1–0.9)	1.6 (0.8–2.4)	11.3 (9.5–16.2)	2.8 (0.9–5.9)	1.5 (0.7–2.6)	1.3 (0.4–2.7)
2008	18.1	0.1	0.4	0.3	14.3	3.0	2.1	0.3

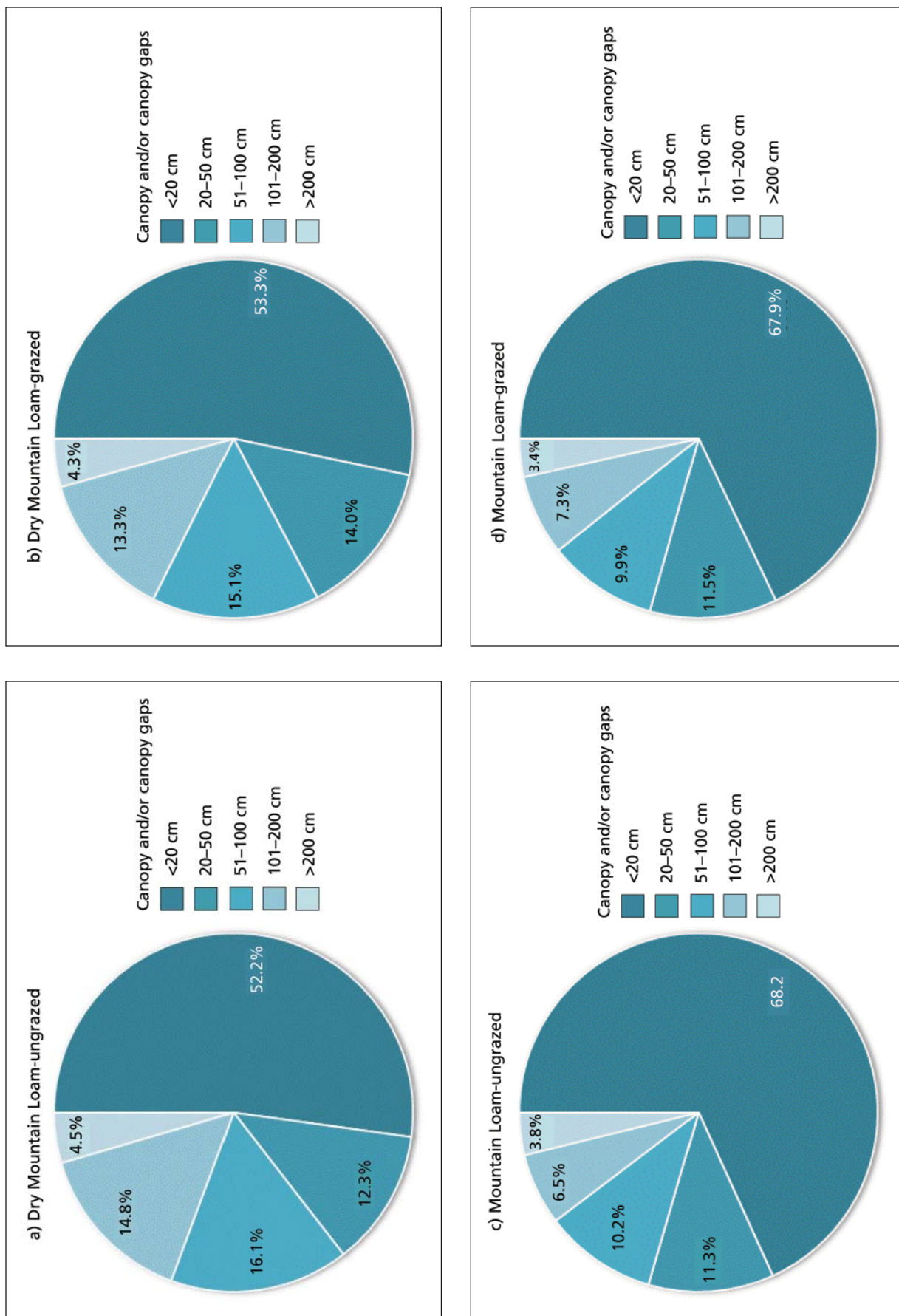


Figure 3-2. Distribution of canopy gaps for a) ungrazed Dry Mountain Loam, b) grazed Dry Mountain Loam, c) ungrazed Mountain Loam, and d) grazed Mountain Loam sagebrush sites in Black Canyon of the Gunnison NP and Curecanti NRA, 2008.

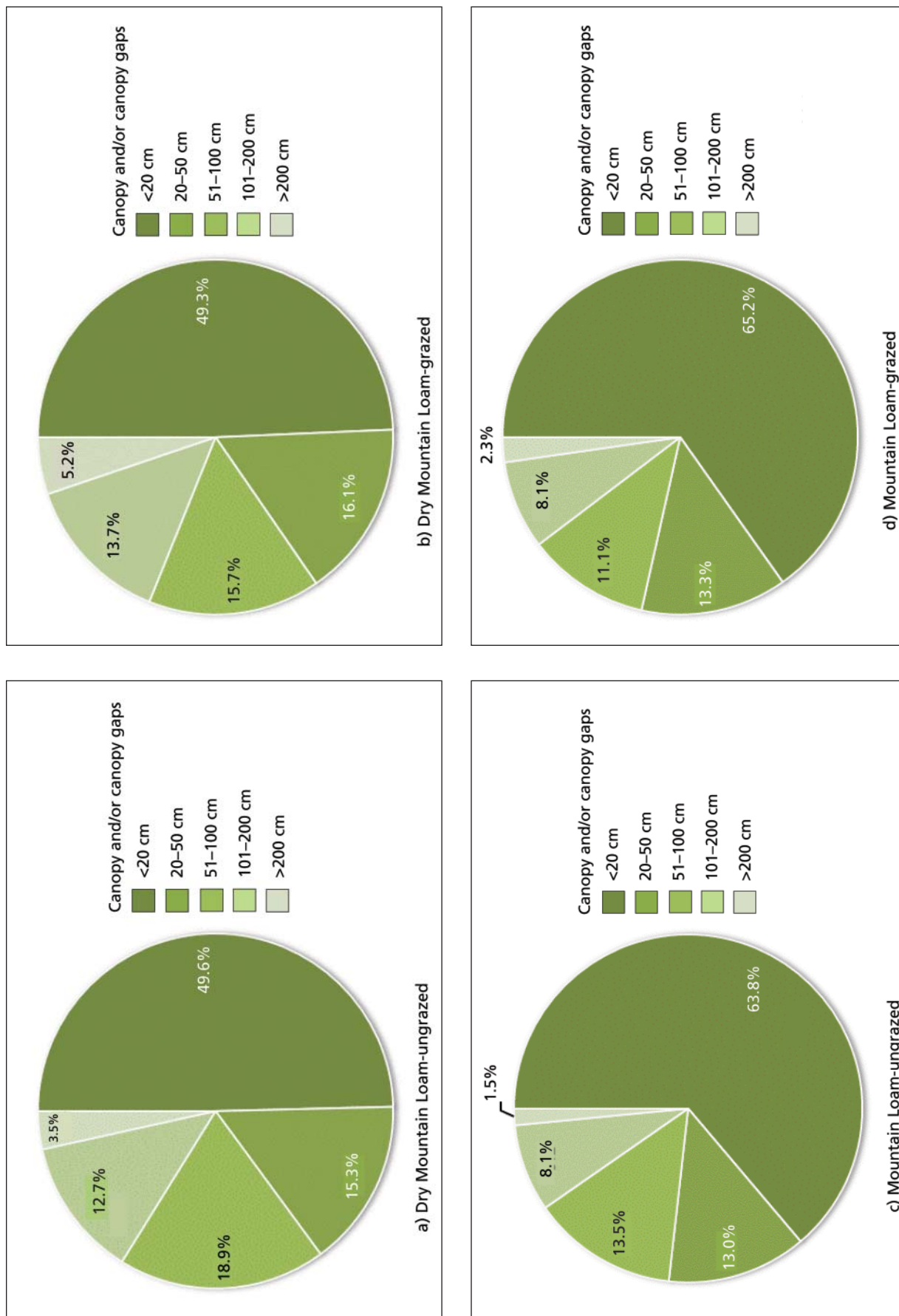


Figure 3-3. Distribution of canopy gaps for a) ungrazed Dry Mountain Loam, b) grazed Dry Mountain Loam, c) ungrazed Mountain Loam, and d) grazed Mountain Loam sagebrush sites in Black Canyon of the Gunnison NP and Curecanti NRA, 2009.

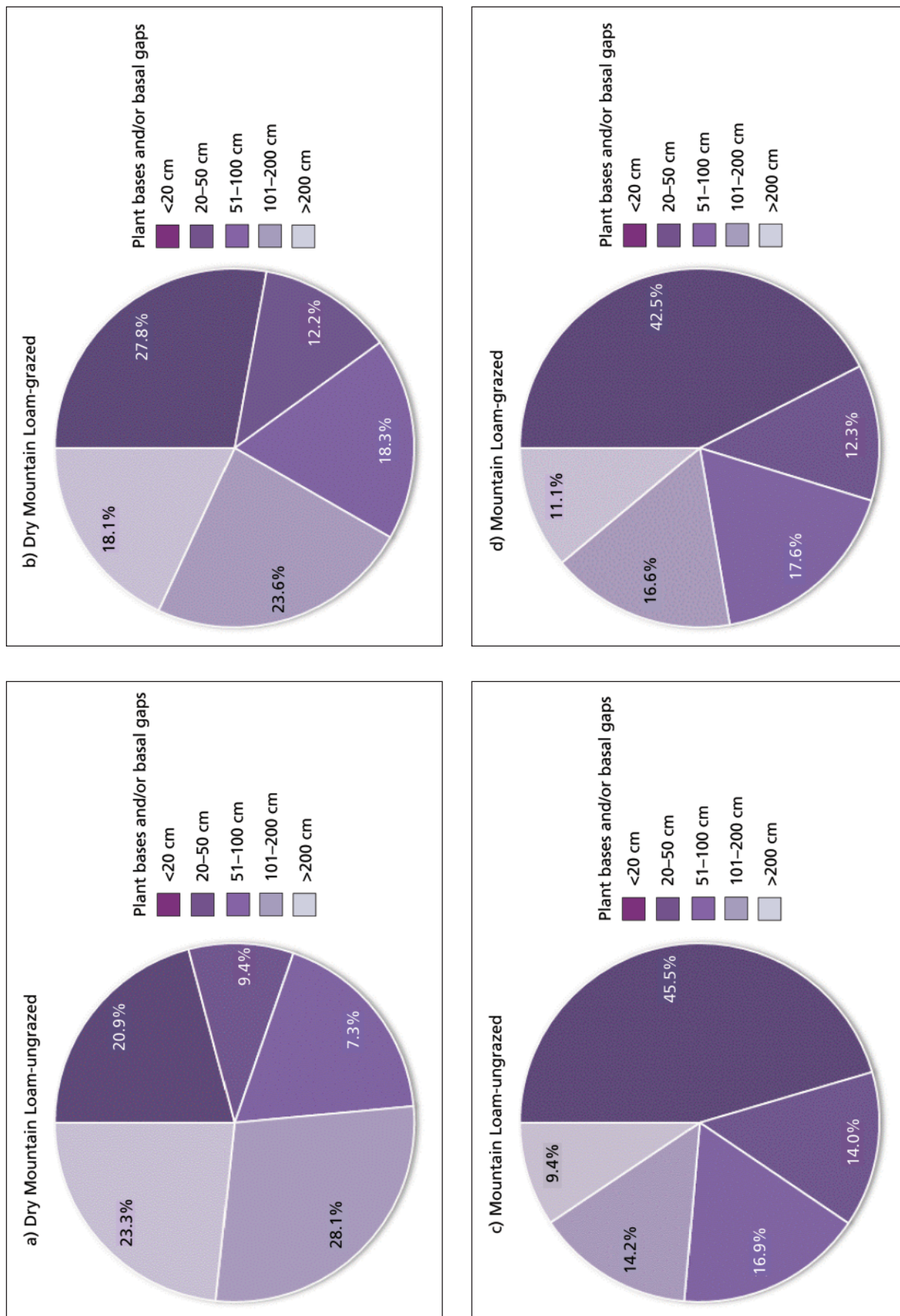


Figure 3-4. Distribution of basal gaps for a) ungrazed Dry Mountain Loam, b) grazed Dry Mountain Loam, c) ungrazed Mountain Loam, and d) grazed Mountain Loam sagebrush sites in Black Canyon of the Gunnison NP and Curecanti NRA, 2008.

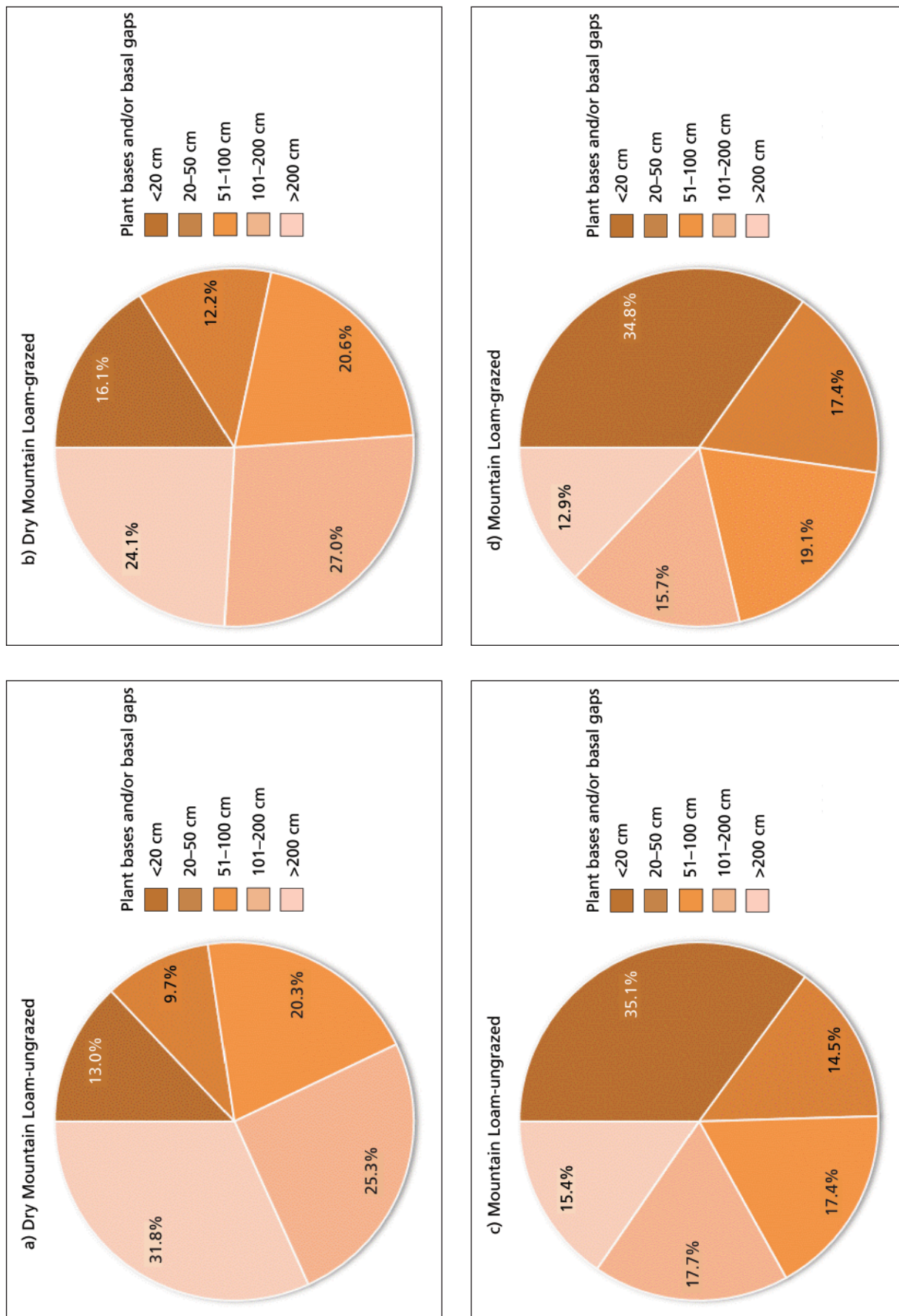


Figure 3-5. Distribution of basal gaps for a) ungrazed Dry Mountain Loam, b) grazed Dry Mountain Loam, c) ungrazed Mountain Loam, and d) grazed Mountain Loam sagebrush sites in Black Canyon of the Gunnison NP and Curecanti NRA, 2009.

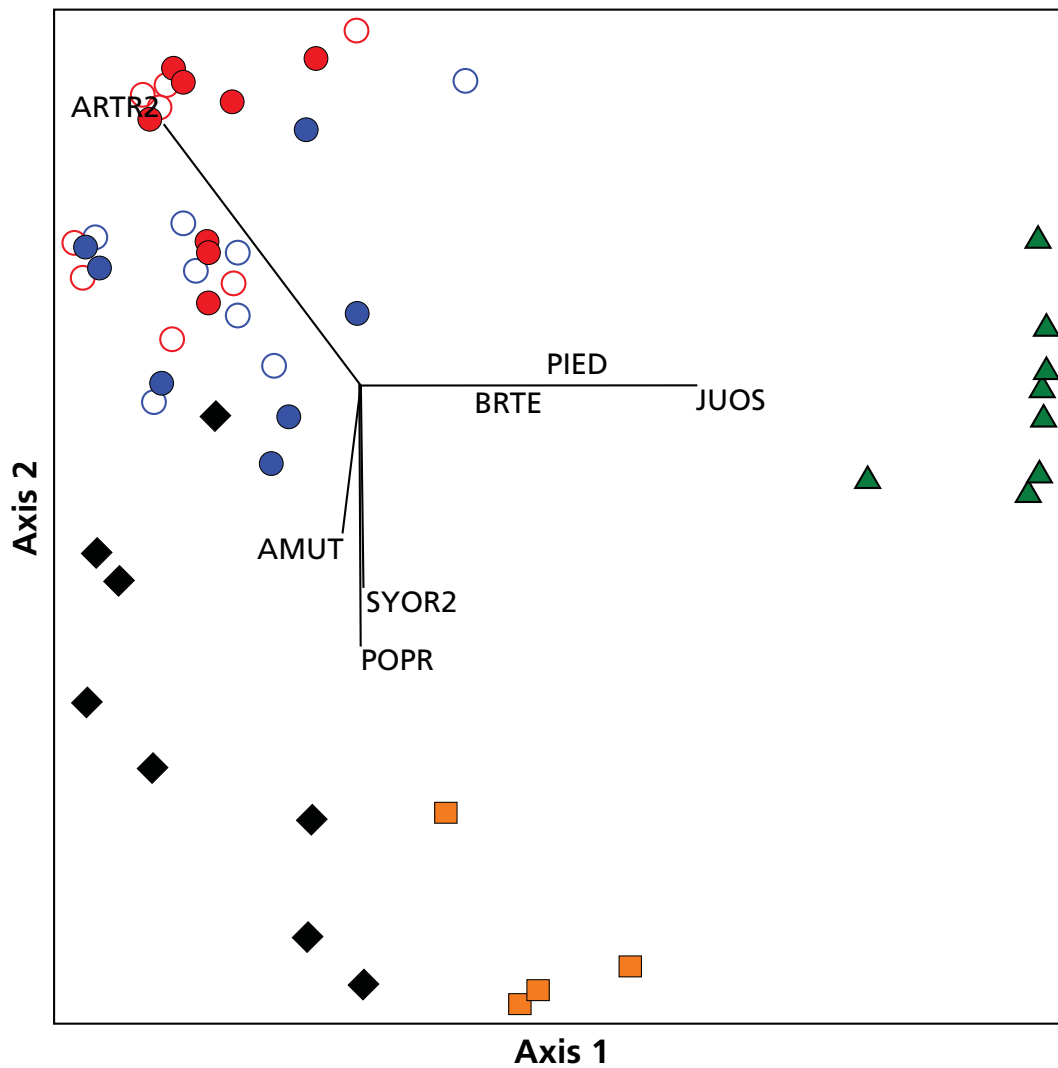


Figure 3-6. Non-metric multidimensional scaling (NMS) ordination of plots from the seven vegetation types monitored in Black Canyon of the Gunnison National Park and Curecanti National Recreation Area, 2009.

- Sagebrush-Dry Mountain Loam, ungrazed
- Sagebrush-Dry Mountain Loam, grazed
- Sagebrush-Mountain Loam, ungrazed
- Sagebrush-Mountain Loam, grazed
- ▲ PJ
- ◆ Oak
- Aspen

Species codes

- AMUT = *Amelanchier utahensis* (Utah serviceberry)
- ARTR2 = *Artemisia tridentata* (big sagebrush)
- BRTE = *Bromus tectorum* (cheatgrass)
- JUOS = *Juniperus osteosperma* (Utah juniper)
- POPR = *Poa pratensis* (Kentucky bluegrass)
- PIED = *Pinus edulis* (two-needle pinyon pine)
- SYOR2 = *Symphoricarpos oreophilus* (snowberry)

4 Discussion

One goal of monitoring sagebrush at BLCA and CURE is to compare grazed and ungrazed areas in the park units. Our initial sampling detected little difference between grazed and ungrazed sagebrush for most measurements. The only clear contrast was that grazed sagebrush had a much higher cover of bare soil than ungrazed sagebrush in 2008. Although the sampling dates and precipitation amounts were similar between years, this difference was not detected in 2009. Higher cover of bare soil occurred primarily in the Iola, Pine Creek, and Sapinero Mesa allotments. One potential explanation is that we detected higher use of these allotments in 2008 than in 2009.

Differences between Mountain Loam and Dry Mountain Loam sagebrush provided a much more dramatic contrast. Mountain Loam sites were generally higher in elevation or more north-facing, while Dry Mountain Loam sites were generally lower in elevation or more south-facing. Mountain Loam sagebrush had smaller canopy and basal gaps and a higher cover of perennial grasses. Dry Mountain Loam sagebrush, with lower plant cover, larger gaps, and a higher surface cover of soil and biological soil crust, has a higher risk of soil erosion.

Soil stability was higher for all vegetation types in 2009 than in 2008, due to differences in sampling methods between the years. Soil stability samples were incorrectly collected under litter in 2008, which decreased the overall rating for sites during that field season. Methods were clarified after the 2008 field season, and all future measures refer only to exposed soil and crust. Cover of exposed soil and crust is relatively low at sites in BLCA and CURE, and overall, the risk of soil erosion is much lower than for most grasslands and shrublands in the greater Colorado Plateau area.

In 2008 and 2009, shrub cover was measured using both the point-intercept method and the line-intercept method in oak plots. Although a couple of species with low cover were detected by the line-intercept method but missed by the point-intercept method, total shrub cover for each species was similar for both methods. In future sampling, NCPN will only use the point-intercept method to measure cover in oak.

In 2010, NCPN crews will revisit the 51 established plots. In winter 2011, 2–3 years of monitoring data will be analyzed for estimates of variance. Variance serves as the basis for determining the ability to detect a minimum trend and is used to evaluate the number of plots needed and potential revisit designs. Recommendations for an operational survey design will be presented to BLCA and CURE resource staff for discussion and approval in spring 2011. After five full years of monitoring, data will be analyzed for status and trends. Continued discussion with park resource staff will occur to ensure that park expectations and needs are satisfied by NCPN integrated upland monitoring.

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Appendix A. Supplemental Information

Table A. Physical attributes of upland monitoring plots by vegetation type, Black Canyon of the Gunnison National Park and Curecanti National Recreation Area, 2008 and 2009.

Plot ID	Park unit	Elevation (m)	Percent slope	Azimuth (degrees)	Year visited	
					2008	2009
Sagebrush-Dry Mountain Loam, ungrazed						
241	CURE	2,285	4	36	X	X
243	CURE	2,352	25	40	X	X
248	CURE	2,381	19	150	X	X
250	CURE	2,310	3	130	X	X
252	CURE	2,298	38	268	X	X
253	CURE	2,304	35	156	X	X
255	CURE	2,296	16	118	X	X
275	CURE	2,328	7	218	X	X
Sagebrush-Dry Mountain Loam, grazed						
242	CURE	2,319	28	278	X	X
247	CURE	2,335	20	240	X	X
249	CURE	2,339	13	300	X	X
256	CURE	2,335	5	78	X	X
260	CURE	2,449	30	240	X	X
264	CURE	2,331	15	280	X	X
265	CURE	2,306	8	78	X	X
270	CURE	2,559	45	80	X	X
Sagebrush-Mountain Loam, ungrazed						
254	CURE	2,339	8	260	X	X
263	CURE	2,310	20	8	X	X
271	CURE	2,414	7	300	X	X
272	BLCA	2,304	1	130	X	X
273	CURE	2,350	27	106	X	X
290	BLCA	2,354	7	255	X	X
295	CURE	2,349	12	340	X	X
Sagebrush-Mountain Loam, grazed						
251	CURE	2,401	12	286	X	X
278	CURE	2,373	8	306	X	X
279	CURE	2,416	35	360	X	X
283	BLCA	2,357	2	290	X	X
288	CURE	2,381	9	315	X	X
293	CURE	2,525	13	159		X
294	CURE	2,630	20	255	X	X
296	CURE	2,397	27	330	X	X

Table A. Physical attributes and UTM coordinates (NAD83 Zone 13N) of upland monitoring plots by vegetation type, Black Canyon of the Gunnison National Park and Curecanti National Recreation Area, 2008 and 2009, cont.

Plot ID	Park unit	Elevation (m)	Percent slope	Azimuth (degrees)	Year visited	
					2008	2009
PJ						
141	BLCA	2,073	15	180	X	X
142	BLCA	2,103	16	146		X
143	BLCA	2,129	10	70		X
144	BLCA	2,419	27	100		X
148	BLCA	2,243	21	150		X
150	BLCA	2,047	26	194		X
151	BLCA	2,193	32	74		X
153	BLCA	2,029	23	260		X
Oak						
41	BLCA	2,437	0	0	X	X
42	BLCA	2,483	10	352	X	X
43	BLCA	2,503	6	266	X	X
44	BLCA	2,391	19	358	X	X
47	BLCA	2,574	8	10		X
49	BLCA	2,584	2	0		X
51	BLCA	2,454	4	205		X
52	BLCA	2,469	18	6		X
Aspen						
5	CURE	2,644	12	30	X	X
8	CURE	2,641	24	270		X
9	CURE	2,644	26	12		X
10	CURE	2,571	4	282		X
nontarget						
282	CURE	2,281	13	313	X	X

See Table 2-1 for description of vegetation types.

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