



Integrated Upland Monitoring in Black Canyon of the Gunnison National Park and Curecanti National Recreation Area

Annual Report 2010 (Non-Sensitive Version)

Natural Resource Technical Report NPS/NCPN/NRTR—2012/542.N



ON THE COVER

Sagebrush shrubland at Curecanti National Recreation Area. NPS photo.

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February 2012

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

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Please cite this publication as:

Witwicki, D. 2012. Integrated upland monitoring in Black Canyon of the Gunnison National Park and Curecanti National Recreation Area: annual report 2010 (non-sensitive version). Natural Resource Technical Report NPS/NCPN/NRTR—2012/542.N. National Park Service, Fort Collins, Colorado.

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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 monitoring in Black Canyon of the Gunnison National Park (BLCA) and Curecanti National Recreation Area (CURE) during 2010. 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. This report also 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 shrubs, 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 are 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 were monitored for three consecutive years to gain understanding of variability, with 2010 as the third year of pilot monitoring. Assessment of these data guided development of an operational sampling design initiated during the 2011 field season.

In this report, measures were summarized for each vegetation type for 2010. Early monitoring data describe status of vegetation types, and interpretation is limited until additional data are acquired and more rigorously analyzed. A power analysis of the first three years of monitoring data was conducted and is summarized in a separate report.

1 Introduction

Uplands represent the vast majority of land area in national park units of the Northern Colorado Plateau Network (NCPN). These upland areas include rock outcrops, badlands, shrublands, grasslands, woodlands, forests, and subalpine meadows, 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 and nutrient cycling, 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 conditions in riparian areas.

Upland ecosystems of the Colorado Plateau, where the majority of NCPN park units are located, tend to be dominated by shrubs, perennial grasses, and small trees. Although these life forms play an integral role in defining the structure and function of Colorado Plateau ecosystems (Whitford 2002), it is the highly-pinnacled biological soil crusts that make these these dryland systems unique. Biological soil crusts are biotic communities composed of cyanobacteria, algae, micro-fungi, mosses, and lichens that occur on and within the upper few millimeters of the soil surface (Belnap et al. 2003). Their presence stabilizes the soil surface and reduces susceptibility to wind and water erosion (Williams et al. 1995). They also contribute to nutrient cycling by fixing C (Lange 2003) and N (Evans and Lange 2003; Belnap 2002) and affect the availability of nutrients to plants (Harper and Belnap 2001). Biological soil crusts are particularly sensitive to disturbances that affect the soil surface, such as trampling and off-road vehicle use (Rosentreter and Belnap 2003).

In the basins neighboring the Colorado Plateau, where several NCPN park units are located, biological soil crusts also play an important role but are less dramatically pin-

nacled. In the forests, shrublands, and meadows of the mountain regions surrounding the Colorado Plateau, where numerous NCPN park units are located, the role of biological soil crusts is less important because much of the soil surface is covered by vegetation and litter.

Many upland ecosystems of the region are characterized by low resistance and resilience. Even moderate disturbances can affect vegetative composition and structure, and recovery to pre-disturbance conditions can be relatively slow. Natural disturbance regimes of the region include extreme climatic events; fire, insect and disease outbreaks; herbivory; and trampling (Miller 2005). 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 et al. 2011) that persist for many decades or longer. Fire-regime alteration (Whelan 1995) and invasion of exotic plants (Bock et al. 1986) have additionally contributed to these shifts. Increasing recreational use and unauthorized social trailing threatens the integrity of upland systems through soil surface disturbance and resulting increases in soil erosion by water and wind. Additional pressure inside parks may also result from land use in adjacent areas.

Global climate change is expected to change levels and seasonality of dominant precipitation events (Garfin et al. 2010), and we are only beginning to understand the implications for plateau ecosystems (Munson et al. 2011a,b). Additional information on characteristics of Colorado Plateau ecosystems and ecological threats to the region is provided in Miller (2005).

The overall goal of the NCPN integrated upland monitoring program is to determine long-term trends in vegetation, soil stability, and hydrologic function in the context of changes in other ecological drivers, stressors, and processes. Monitoring will increase fundamental understanding of upland systems and provide managers with early warning of undesirable change and information for management decisions. Specific objectives of the integrated upland monitoring protocol are described below.

Determine status and trends in plant communities, including:

- overall species richness
- cover of vegetation by dominant species and life form
- density of shrubs by size class
- basal area and density of tree species
- canopy closure
- fuel volume and litter/duff depth
- frequency of exotic invasive species

Determine status and trends in soil stability, including:

- cover of biological soil crusts by morphological group (cyanobacteria, lichen, moss, and undifferentiated crust)
- cover of other surface features (litter, rock, bare ground, etc.)

- soil aggregate stability
- canopy-gap size (as an indicator of wind erosion potential)

Determine status and trends in hydrologic function, including:

- basal-gap size

Evaluation of upland monitoring data relative to other vital signs will help us to identify drivers and distinguish “natural” from anthropogenic change. Local weather-station data can be used to interpret responses, and remote sensing can be used to determine change in vegetation at larger scales caused by land use or climate change. Historical upland monitoring data sets may be integrated with data collected by the NCPN to allow earlier detection of trends.

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 (*Artemisia tridentata*) shrublands (hereafter referred to as sagebrush), pinyon-juniper (PJ) woodlands, Gambel oak (*Quercus gambelii*)/mixed montane shrublands (hereafter referred to as oak or oak scrub), and aspen (*Populus tremuloides*) forests as high priorities 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 as well as early warning of system degradation. There are particular management concerns regarding sagebrush, the most extensive community type in the park units. Although sagebrush has been grazed over the entire Gunnison Basin historically, it is not currently grazed in parts of Black Canyon of the Gunnison National Park (BLCA) and Curecanti National Recreation Area (CURE), providing a unique opportunity to compare grazed and ungrazed sagebrush communities.

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 >50% and/or isolated by steep slopes were eliminated. Due primarily to costs, areas accessible only by reservoir or river were eliminated from consideration. Accessibility and slope features were generated using the Landscape Accessibility Model (<http://science.nature.nps.gov/im/units/npcn/Tools.cfm>).

Creation of the BLCA/CURE accessibility map involved many challenges not found in other NCPN park units. BLCA contains numerous parcels of private property within its boundary, and boundaries change regularly as parcels owned by the Bureau of Land Management and private individuals are transitioned to National Park Service (NPS) ownership. Only private property with conservation easements and agreeable landowners was considered for the accessibility map. Parcels that were heavily managed (e.g., active hay fields or elk ranching) were eliminated from the accessibility map. Additional discussion with park staff included NPS land in the Blue Creek and Pine Creek areas accessible by crossing private land with agreeable owners or established NPS access easements through private property.

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 the 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. In addition, those surveys provided only limited-range site descriptions instead of more thorough ecological site descriptions. 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 did not entirely match range sites from the soil surveys. Thus, 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 in order to assess (1) the suitability of vegetation map units to delineate target vegetation types and (2) 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. As they seemed to form a continuum across the landscape, however, it was extremely difficult to classify sites in the middle of the range. We attempted to distinguish Mountain Loam and Dry Mountain Loam for the initial effort, but realize that we may eventually have to lump these sites together.

The dominant ecological sites for PJ were Upland Shallow Loam and Upland Stony Loam. These ecological sites are similar and were often mixed on the landscape; therefore, 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, which 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 monitoring plots in this vegetation type. Details and photos of target ecological sites and vegetation types are provided in Table 2-1 and Figure 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; any points within the buffer area 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 51 plots were monitored, including 8 ungrazed Dry Mountain Loam sagebrush, 8 grazed Dry Mountain Loam sagebrush, 7 ungrazed Mountain Loam sagebrush, 8 grazed Mountain Loam sagebrush, 8 PJ, 8 oak scrub, and 4 aspen (see Figures 2-2 and 2-3). Plots were monitored for three consecutive years to gain understanding of variability, and assessment of these data guided the development of an operational survey design initiated in 2011.

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 monitoring procedures recommended by Herrick and colleagues (2005) and standard forest, woodland, and fuels procedures (NPS 2003; Brown 1974). Specific measurements taken at each plot depend on the vegetation type (see the response design column in Table 3-1, next chapter).

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

Ecological sites	Physionomic type	Soil properties	Geological properties	Vegetative properties	Disturbance-mediated alternative states	Potential non-target areas
Big sagebrush (sagebrush)						
Mountain Loam	Shrubland	Deep loams on valleys, benches, and hillslopes	Alluvium, slope alluvium, or glacial deposits	Tall big sagebrush (<i>Artemisia tridentata</i>) with dense cover of grasses; may also include small amounts of mixed montane shrubs	<u>Grazing</u> : decreased perennial grasses, increased big sagebrush. <u>Fire</u> : decreased big sagebrush, increased green rabbitbrush (<i>Chrysothamnus viscidiflorus</i>) and mountain snowberry (<i>Symphoricarpos oreophilus</i>).	Very shallow sandy areas with black sagebrush (<i>Artemisia nova</i>); depressions with basin big sagebrush (<i>A. tridentata</i> ssp. <i>tridentata</i>) and Great Basin wildrye (<i>Elymus cinereus</i>)
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 big sagebrush and snakeweed (<i>Gutierrezia</i> sp.). <u>Fire</u> : decreased big sagebrush.	
Pinyon pine / Utah juniper (PJ)						
Upland / Shallow / Stony Loam	Woodland	Shallow to moderately deep loams and stony loams on ridges and mountain sides	Residuum or colluvium	Pinyon pine (<i>Pinus edulis</i>) and Utah juniper (<i>Juniperus osteosperma</i>) 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 (oak / oak scrub)						
Brushy Loam	Shrubland	Deep loams on uplands and mountain sides	Alluvium, slope alluvium, or glacial deposits	Dominated by Gambel oak (<i>Quercus gambelii</i>), Utah serviceberry (<i>Amelanchier utahensis</i>), mountain snowberry, and mountain big sagebrush (<i>A. tridentata</i> ssp. <i>vaseyana</i>)	<u>Grazing</u> : Decreased perennial grasses, increased woody shrubs. <u>Fire</u> : increased Gambel oak, mountain snowberry, and rabbitbrush (<i>Chrysothamnus</i> sp.), 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 (aspen)						
NA	Forest	Deep loams on mountain sides	Alluvium, glacial till, or colluvium	Dominated by aspen (<i>Populus tremuloides</i>), chokecherry (<i>Prunus virginiana</i>), Saskatoon serviceberry (<i>Amelanchier alnifolia</i>), and mountain snowberry	Ranges from skeleton to climax forest.	Areas with no live aspen

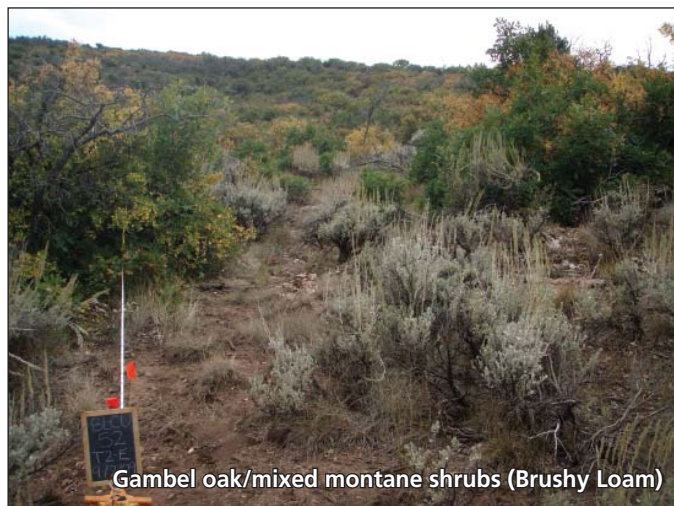


Figure 2-1. Examples of target vegetation (ecological site) types monitored in Black Canyon of the Gunnison NP and Curecanti NRA: Sagebrush (Mountain Loam), Sagebrush (Dry Mountain Loam), Pinyon-juniper (Upland Shallow/Stony Loam), Gambel oak/mixed montane shrubs (Brushy Loam), and Aspen. See Table 2-1 for a description of vegetation types and ecological sites.

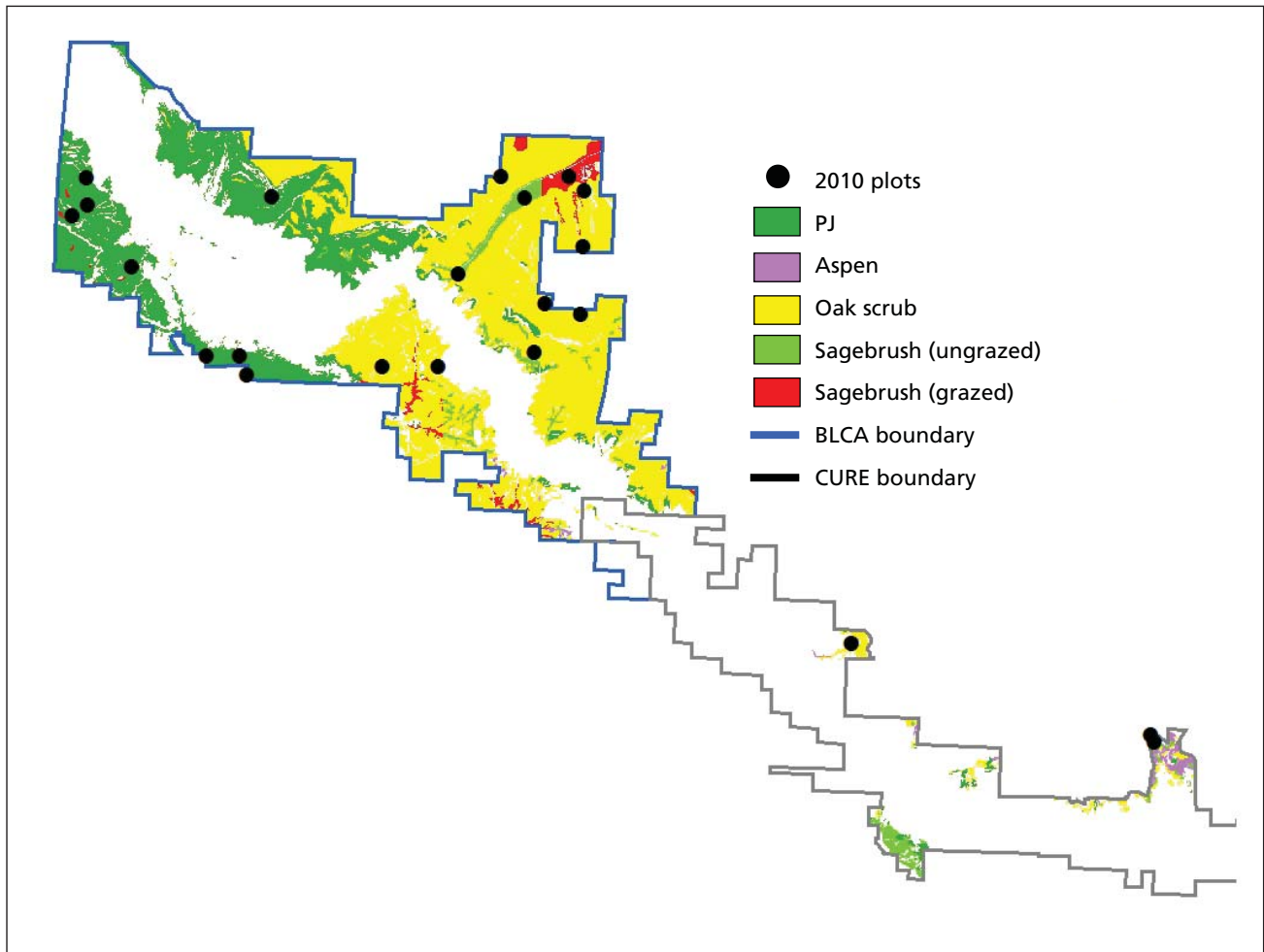


Figure 2-2. Location of monitoring plots in Black Canyon of the Gunnison NP and on the west side of Curecanti NRA, 2010.

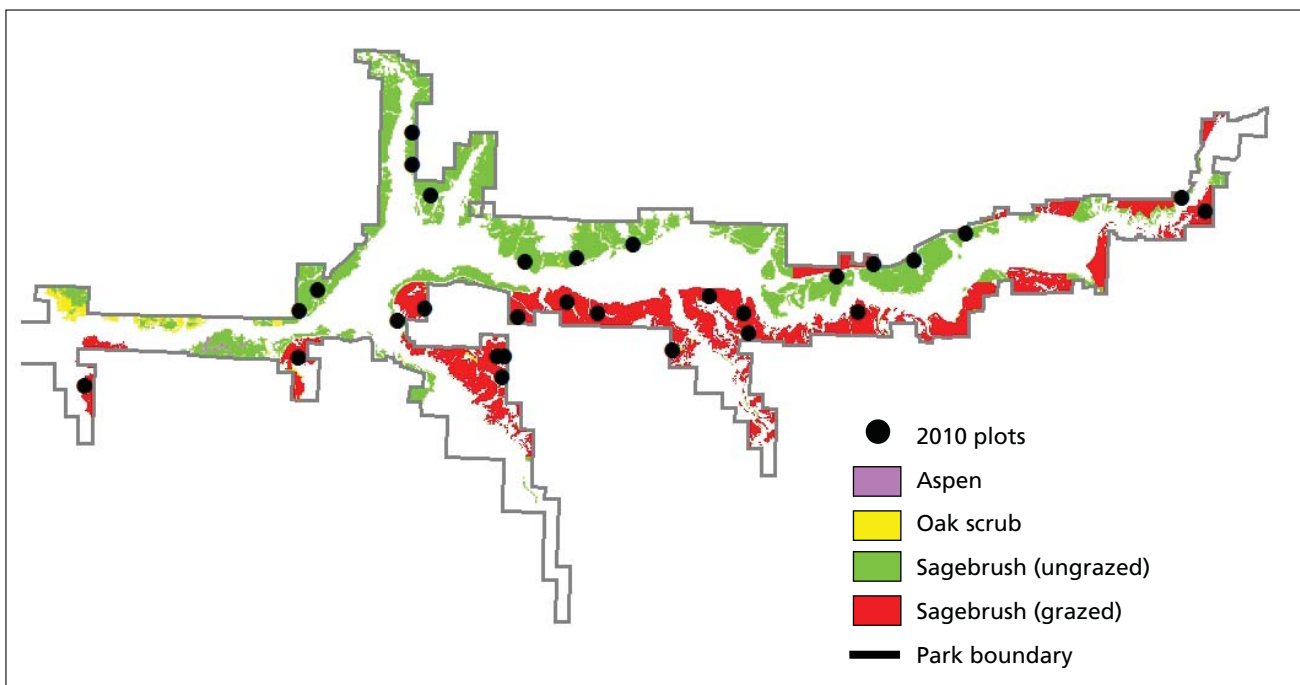


Figure 2-3. Location of monitoring plots on the east side of Curecanti NRA, 2010.

2.2.1.1 Grasslands and shrublands

At each plot, observations are recorded along three parallel, 50-m transects spaced 25 m apart (Figure 2-4). At the origin of each transect, a photo is taken down the length of the transect toward the end point. Photos of biological soil crusts are also taken at a specified point along each transect. A point-intercept method is used to record percent cover of plant species and ground-cover attributes at 0.5-m intervals along each transect. Density of shrubs (by species and height class), tree seedlings (by species), 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 a line-intercept method. Six soil surface samples are taken along each transect to assess soil-aggregate stability. Disturbances observed on and around the site are also recorded.

2.2.1.2 Forests and woodlands

Because vegetation tends to be denser in forests and woodlands, photos are taken at the origin and end of each transect. Using the same methods as for grasslands/shrublands, point-intercept cover of vegetation and surface features, and density of shrubs, tree seedlings, and exotic perennial species are recorded for each transect. Gaps are not recorded in forest or woodland systems, but soil stability measurements may be recorded for woodland ecological sites with potential erosion issues. Disturbances on and off the monitoring plot are also recorded using the same methods as for grasslands/shrublands.

Additional measurements are taken in forest and woodland systems in order to capture the dynamics of stand replacement and gap dynamics (Figure 2-5). Saplings (2.5–15-cm diameter) are identified to species, and density by size class is tallied in a 5-m belt transect centered on Transect 2. All overstory trees (>15-cm diameter) in Quadrant 1 are identified to species, tagged with unique numbers, and measured for diameter. Diameter of trees is typically measured at breast height (dbh). Crown class and health of trees are also recorded at forest plots. Overstory

canopy closure is measured every 10 m along the transects in forest plots. Fuels are measured using Brown's planar method (Brown 1974) along four 15-m transects that extend beyond the plot on two corners. Counts of fine woody fuels and diameters of coarse woody fuels are recorded to derive volumes of each fuel class. Depth of litter and duff are also recorded.

2.2.1.3 Gambel oak/mixed montane shrublands

Gambel oak/mixed montane shrub systems are structurally different from other vegetation types on the Colorado Plateau, and the dense, tall vegetation is not easily sampled using standard upland methods. This vegetation type is sampled using three 20-m transects (Figure 2-6), and photos are taken at the origin and end of each transect. Point-intercept cover is collected at 0.25-m intervals, and fuel measurements are collected along the three transects. Within the 20 × 20-m plot, species and diameter are recorded for all mature trees and exceptionally large individuals of Gambel oak. Density, gaps, and soil stability are not recorded in this vegetation type. Disturbances on and off the monitoring plot are recorded using the same methods as for the other vegetation types.

Cover of shrub species in oak plots was no longer measured using the line-intercept method in 2010. It was determined during methods testing in previous years that this measurement was repetitive of cover measures using the point-intercept method.

2.3 Database

All observations recorded in the field are stored in an NCPN Access database. 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.

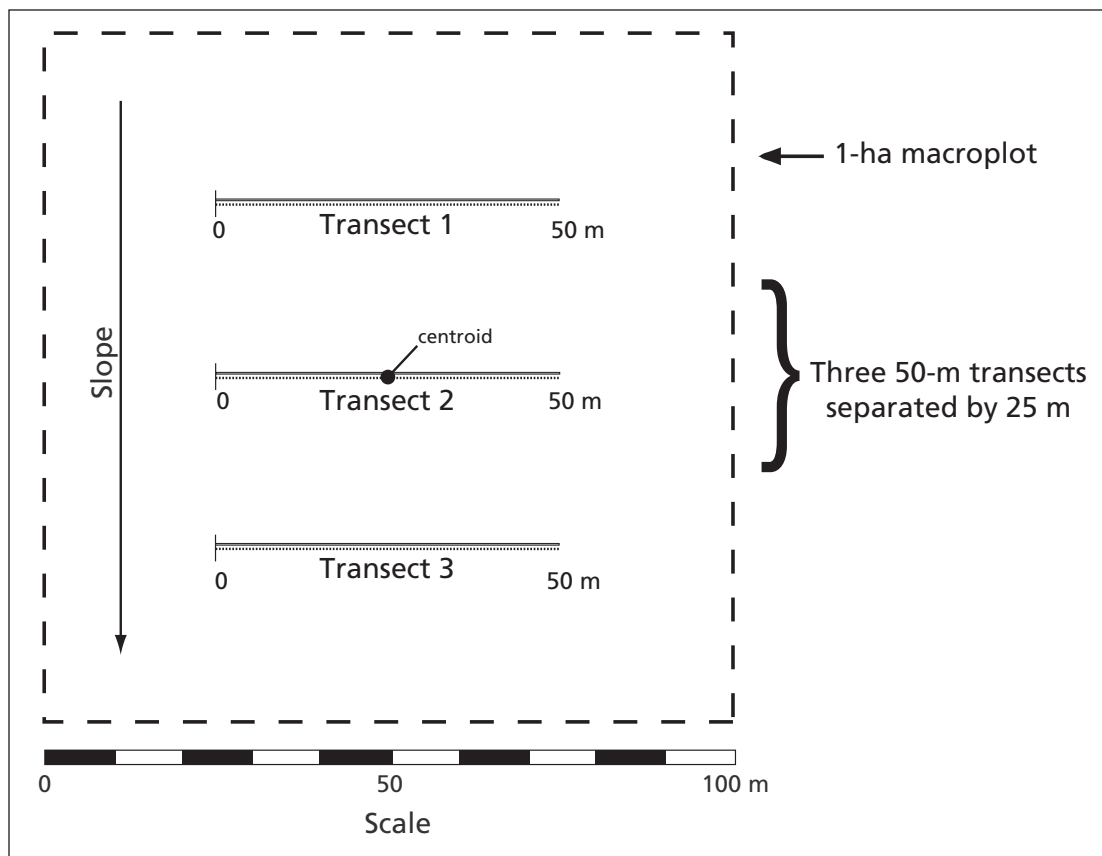


Figure 2-4. Plot layout for upland monitoring of grasslands and shrublands.

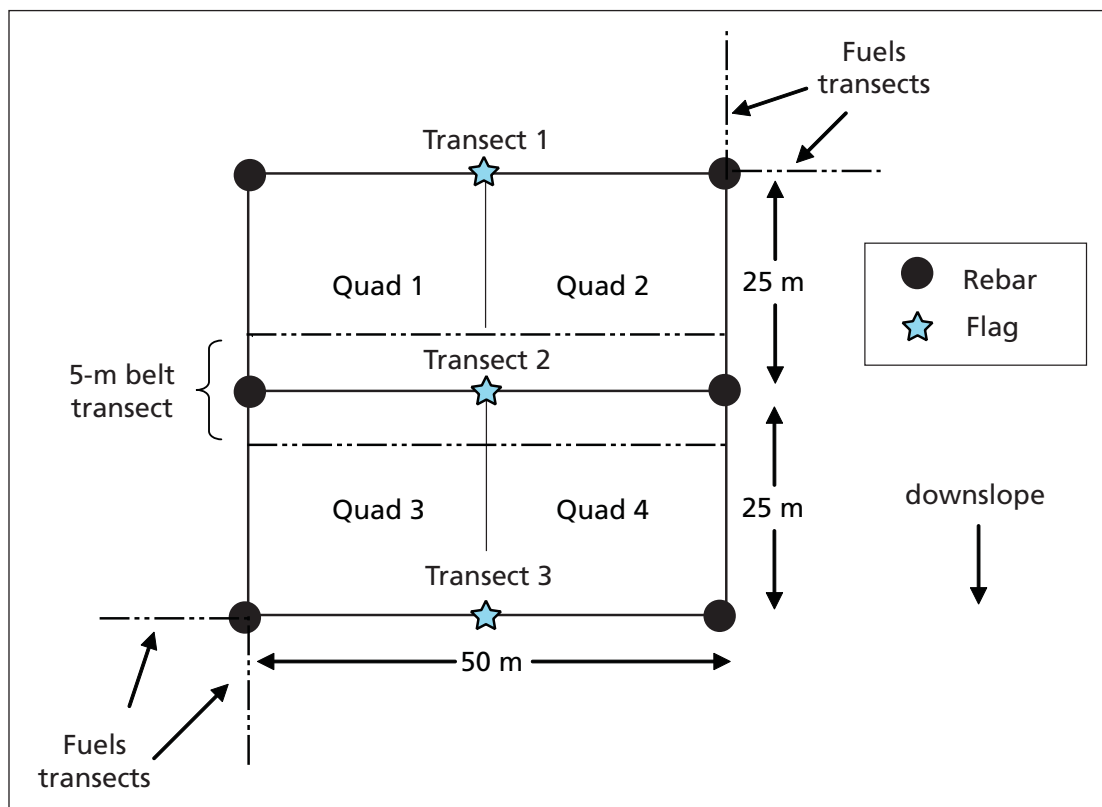


Figure 2-5. Plot layout for upland monitoring of forests and woodlands.

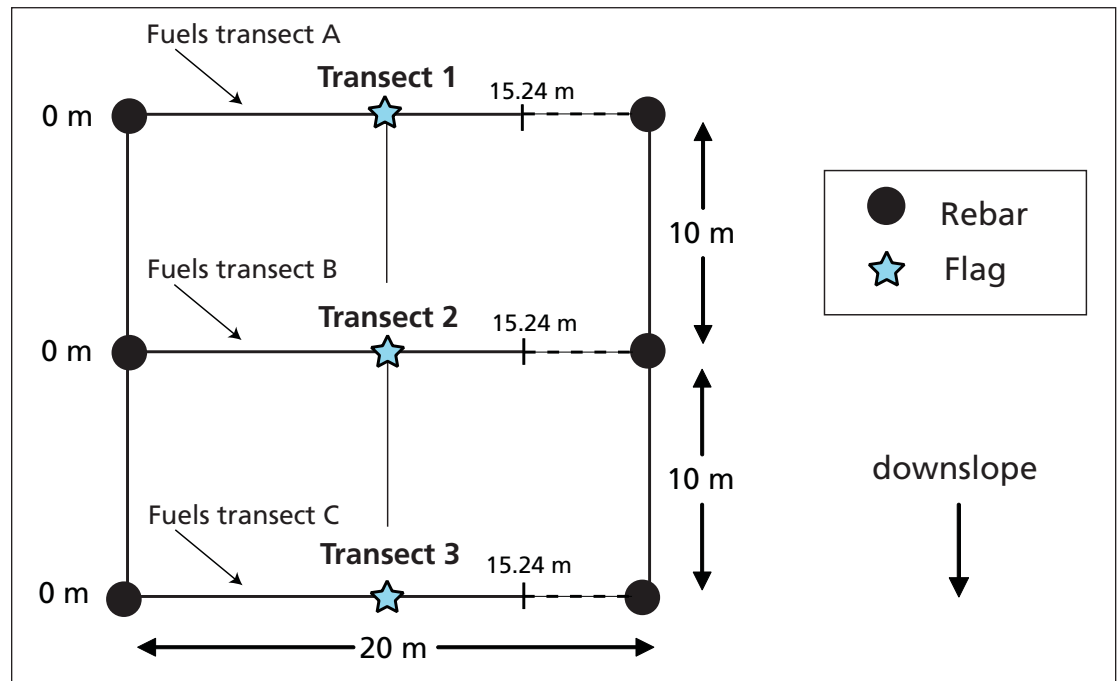


Figure 2-6. Plot layout for upland monitoring of Gambel oak/mixed montane shrublands.

3 Results

3.1 Monitored Plots

In 2010, all 51 previously established plots were revisited in the third year of pilot monitoring (see Figures 2-2 and 2-3). Table 3-1 summarizes plot visits by vegetation, ecological site, grazing status, and year (tables begin on page 13). Each plot was sampled using the suite of measures appropriate for that vegetation type (see response design column in Table 3-1).

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 are complete.

For this annual report, plot-level summaries of the measures listed in Chapter 1 were generated for each monitoring plot, then summarized by vegetation type. 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. Comparisons between years may also be misleading because only a small number of plots were monitored in some vegetation types in 2008 (see Table 3-1). The reader is cautioned not to draw wide-reaching conclusions from this initial set of results.

3.2.1 Species richness

A total of 157 species were detected in BLCA and CURE in 2010. Species richness by life form for all vegetation types is reported in Table 3-2. Recorded species were compared to the NPSpecies database to determine first-time observations in BLCA and CURE. Three new species were detected in 2010. Pinyon dwarf-mistletoe (*Arceuthobium divaricatum*) was detected in BLCA, and tower larkspur (*Delphinium glaucum*) and western valerian (*Valeriana occidentalis*) were detected in CURE. All new species detected were native, and a voucher was created for each species. In addition, vouchers were created for Bigelow's aster (*Machaeranthera bigelovii*) in BLCA, and egg milkvetch (*Astragalus*

oophorus), false hellebore (*Veratrum californicum*), Columbia needlegrass (*Stipa nelsonii*), and Gray's lousewort (*Pedicularis procera*) in CURE.

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 2010.

3.2.2 Overstory canopy closure and cover by life form and dominant species

Overstory canopy closure and percent cover of live and total vegetation by life form for all vegetation types are shown in Table 3-3. 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.

Live and total percent cover of dominant species for all vegetation types are shown in Table 3-4. 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 is included in an electronic appendix that accompanies this report (blca10_species.xls and cure10_species.xls).

3.2.3 Shrub density

Density of shrub species for all vegetation types except oak is shown in Table 3-5. All sagebrush plots had a high density of big sagebrush, and Mountain Loam plots also had a high density of green rabbitbrush (*Chrysothamnus viscidiflorus*). In general, PJ plots had low shrub density. The highest densities of chokecherry (*Prunus virginiana*), Woods' rose (*Rosa woodsii*), Saskatoon serviceberry (*Amelanchier alnifolia*), and mountain snowberry (*Symphoricarpos oreophilus*) were in aspen plots.

3.2.4 Tree density

Density of live seedlings, saplings, and overstory trees for PJ, oak, and aspen is shown in Table 3-6. Density and dbh for all overstory trees >15 cm dbh for these same vegetation

types are shown in Table 3-7. 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 each live tree in the canopy were recorded for aspen plots. The following crown classes are used by NCPN (Figure 3-1):

Dominant. Trees have crowns extending above the general level of the main canopy of adjacent trees and receive full light from above and partly from the sides.

Codominant. Trees have crowns forming the general level of the main canopy of adjacent trees and receive full light from above and comparatively little from the sides.

Intermediate. Trees have crowns extending 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.

Overtopped/Suppressed. Trees have crowns 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 and density of

all exotic perennial species for all vegetation types is shown in Table 3-8. When exotic species were detected, cover was summarized for all plots in the vegetation type.

In 2010, 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 44% cover in aspen plots). Both Kentucky bluegrass and common dandelion (*Taraxacum officinale*) were found at all aspen plots. Cover of cheatgrass (*Bromus tectorum*) was as high as 20% at some PJ plots. Cover and density of exotics was relatively low in sagebrush, except for Kentucky bluegrass in Mountain Loam plots.

In 2010, NCPN upland sampling methods did not include an invasive species walk; therefore, lack of detection does not mean that other exotic species were not present in plots. In 2011, methods will be added to include early detection of exotics.

3.2.6 Biological soil crust and surface features

Biological soil crust and surface-feature cover for all vegetation types are shown in Table 3-9. Litter was the dominant surface cover for all vegetation types. Sagebrush and PJ also had substantial amounts of undifferentiated crust and small rock surface cover.

3.2.7 Canopy and basal gaps

Canopy- and basal-gap sizes for all sagebrush sites are shown in Table 3-10. The distribution of gaps by size class for all sagebrush sites is illustrated in Figures 3-2 and 3-3 (see pages 24–25).

3.2.8 Soil aggregate stability

Measures of soil aggregate stability for all sagebrush sites and PJ are reported in Table 3-11. 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 dur-

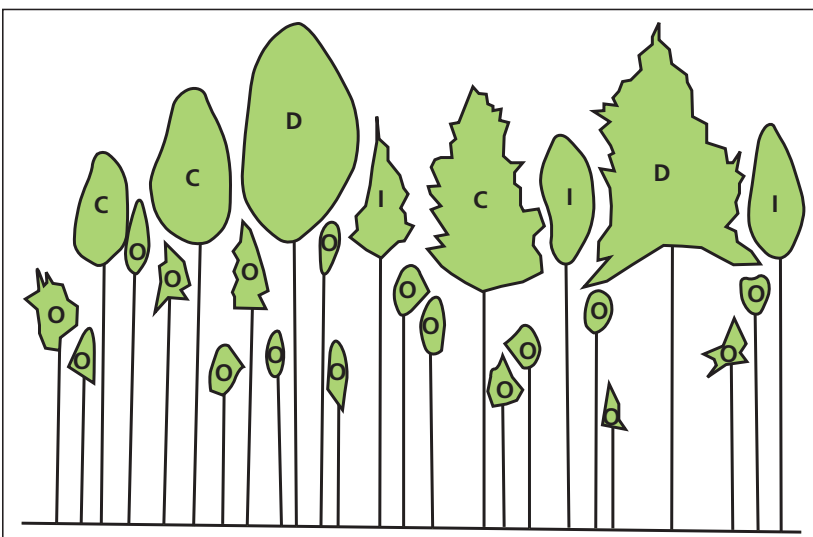


Figure 3-1. The relative positions of trees using four classes for crown classification. D =Dominant, C = Codominant, I = Intermediate, and O = Suppressed/Overtopped.

ing rainstorms. The numbers are affected by soil texture, so 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.

3.2.9 Fuels

Fuel volumes and depth of litter and duff for all vegetation types except sagebrush are reported in Table 3-12. Fuels ranged from very low in oak to high in aspen. Fuels in PJ varied greatly among plots.

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, 2008–2010.

Dominant vegetation	Response design	Ecological site*	Grazing status	Number of plots		
				2008 (August– September)	2009 (July– September)	2010 (August– September)
Sagebrush	Grassland/ shrubland	Dry Mountain Loam	Ungrazed	8	8	8
			Grazed	8	8	8
		Mountain Loam	Ungrazed	7	7	7
			Grazed	7	8	8
PJ	Woodland	Upland Shallow/ Stony Loam	NA	1	8	8
Oak	Oak	Brushy Loam	NA	4	8	8
Aspen	Forest	NA	NA	1	4	4
Total				36	51	51

* See Table 2-1 for description of ecological sites and vegetation types.

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, 2010.

Vegetation type	Number of species detected					
	Total	Tree	Shrub	Perennial grass	Annual grass	Forb/Herb
Sagebrush– Dry Mountain Loam, ungrazed	14.3 (9–22)	0.4 (0–1)	5.8 (3–9)	5.3 (2–8)	0.3 (0–1)	2.6 (2–6)
Sagebrush– Dry Mountain Loam, grazed	15.4 (11–23)	0	8.3 (2–14)	4.5 (2–7)	0	2.6 (0–4)
Sagebrush– Mountain Loam, ungrazed	21.1 (17–36)	0.3 (0–1)	9.1 (7–12)	5.4 (2–8)	0	6.1 (1–18)
Sagebrush– Mountain Loam, grazed	16.5 (13–22)	0	7.4 (5–10)	5.0 (4–6)	0.3 (0–1)	3.9 (2–8)
PJ	9.1 (5–14)	2.0 (2–2)	3.6 (1–7)	1.8 (0–4)	0.4 (0–1)	1.4 (0–4)
Oak	14.8 (11–20)	0.1 (0–1)	5.0 (3–6)	4.0 (3–5)	0	5.5 (2–9)
Aspen	32.8 (23–41)	1.3 (1–2)	6.8 (5–9)	8.0 (7–10)	0	16.8 (5–23)

Table 3-3. Mean (range) overstory canopy closure, and percent cover of vegetation by life form for each vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2010.

Overstory canopy closure	Total*		Tree		Shrub		Perennial grass		Annual grass		Forb/Herb	
	Live	Total	Live	Total	Live	Total	Live	Total	Live	Total	Live	Total
Sagebrush- Dry Mountain Loam, ungrazed												
NA	35.9 (21.7-49.3)	48.5 (29.3-62.7)	0.7 (0-3.7)	0.8 (0-4.3)	23.5 (15.0-43.3)	32.3 (21.0-55.7)	13.1 (4.0-27.3)	18.4 (4.7-37.0)	0 (0-0.7)	0.1 (0-0.7)	2.5 (0.7-4.3)	2.7 (0.7-5.3)
Sagebrush- Dry Mountain Loam, grazed												
NA	36.0 (31.3-40.3)	45.9 (38.7-54.0)	0	0	25.0 (13.7-36.7)	33.2 (20.3-47.0)	9.7 (5.0-13.7)	14.0 (7.0-24.3)	0	0	4.2 (0-7.0)	4.7 (0-8.3)
Sagebrush- Mountain Loam, ungrazed												
NA	44.1 (34.7-55.7)	57.0 (48.7-76.0)	0.8 (0-4.0)	1.0 (0-5.7)	24.7 (13.3-35.3)	33.7 (20.7-40.3)	19.8 (5.7-30.3)	27.9 (9.0-46.7)	0	0	5.1 (0.3-14.0)	5.8 (0.3-16.0)
Sagebrush- Mountain Loam, grazed												
NA	43.9 (34.0-54.3)	59.2 (51.3-76.7)	0	0	24.1 (11.3-33.3)	35.1 (21.7-46.0)	20.0 (9.7-30.0)	29.9 (18.0-46.7)	0	0.1 (0-0.7)	5.9 (2.0-9.3)	7.0 (2.0-12.0)
PJ												
NA	27.2 (19.3-37.7)	36.5 (28.3-43.3)	20.7 (6.7-28.7)	24.9 (10.0-35.7)	4.1 (0.7-10.0)	4.7 (0.7-11.0)	2.0 (0-8.0)	3.8 (0-14.7)	0.3 (0-1.0)	4.7 (0-20.3)	0.9 (0-3.7)	1.3 (0-6.0)
Oak												
NA	61.3 (50.8-72.5)	71.4 (64.2-84.2)	0.6 (0-4.6)	0.6 (0-4.6)	44.2 (37.5-59.6)	50.1 (42.1-68.3)	17.8 (7.9-32.9)	27.4 (16.7-42.9)	0	0	7.5 (0.8-14.6)	9.1 (1.3-16.3)
Aspen												
57.6 (46.6-72.3)	69.3 (42.0-88.7)	75.7 (47.3-94.3)	1.2 (0.7-2.7)	1.5 (0.7-3.0)	24.9 (9.0-56.7)	27.2 (9.3-62.0)	40.8 (29.3-48.0)	51.1 (35.7-59.0)	0	0	32.0 (10.0-48.0)	34.6 (10.7-50.3)

*Total vegetation cover at all canopy heights for sagebrush, PJ, and oak; total understory cover for aspen.

Table 3-4. Mean (range) percent cover of dominant species by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2010.

Scientific name	Common name	Life form	Duration	Nativity	No. of plots with species present*	Percent cover**	
						Live	Total
Sagebrush– Dry Mountain Loam, ungrazed							
<i>Artemisia tridentata</i>	big sagebrush	Shrub	Perennial	Native	8	18.0 (11.3–32.7)	25.2 (15.7–40.3)
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	Shrub	Perennial	Native	8	1.5 (0–4.3)	1.9 (0.3–5.7)
<i>Elymus elymoides</i>	squirreltail	Graminoid	Perennial	Native	6	0.6 (0–1.7)	0.8 (0–1.7)
<i>Koeleria macrantha</i>	junegrass	Graminoid	Perennial	Native	4	0.6 (0–2.7)	0.8 (0–4.0)
<i>Poa fendleriana</i>	muttongrass	Graminoid	Perennial	Native	7	6.5 (0–23.0)	8.5 (0–30.7)
<i>Stipa comata</i>	needle and thread	Graminoid	Perennial	Native	5	1.6 (0–7.0)	2.4 (0–11.0)
<i>Stipa hymenoides</i>	Indian ricegrass	Graminoid	Perennial	Native	5	0.3 (0–0.7)	0.5 (0–2.0)
<i>Stipa lettermanii</i>	Letterman's needlegrass	Graminoid	Perennial	Native	5	0.9 (0–2.3)	1.3 (0–4.0)
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Shrub	Perennial	Native	1	0.04 (0–0.3)	0.04 (0–0.3)
Sagebrush– Dry Mountain Loam, grazed							
<i>Artemisia tridentata</i>	big sagebrush	Shrub	Perennial	Native	8	17.3 (7.0–25.3)	24.7 (9.0–35.0)
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	Shrub	Perennial	Native	5	1.0 (0–4.0)	1.2 (0–4.7)
<i>Elymus elymoides</i>	squirreltail	Graminoid	Perennial	Native	5	0.8 (0–2.0)	0.9 (0–2.7)
<i>Koeleria macrantha</i>	junegrass	Graminoid	Perennial	Native	2	0.1 (0–0.7)	0.2 (0–0.7)
<i>Poa fendleriana</i>	muttongrass	Graminoid	Perennial	Native	8	5.1 (0.3–10.7)	7.3 (0.3–20.3)
<i>Stipa comata</i>	needle and thread	Graminoid	Perennial	Native	5	0.5 (0–2.0)	0.8 (0–3.0)
<i>Stipa hymenoides</i>	Indian ricegrass	Graminoid	Perennial	Native	4	0.2 (0–0.7)	0.3 (0–1.0)
<i>Stipa lettermanii</i>	Letterman's needlegrass	Graminoid	Perennial	Native	5	1.2 (0–3.7)	1.5 (0–4.0)
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Shrub	Perennial	Native	3	0.3 (0–1.7)	0.4 (0–1.7)
Sagebrush– Mountain Loam, ungrazed							
<i>Artemisia tridentata</i>	big sagebrush	Shrub	Perennial	Native	7	13.5 (10.7–19.3)	21.3 (16.0–27.3)
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	Shrub	Perennial	Native	7	2.5 (0–5.7)	3.1 (0.3–7.0)
<i>Elymus elymoides</i>	squirreltail	Graminoid	Perennial	Native	5	1.7 (0–4.7)	2.8 (0–8.7)
<i>Koeleria macrantha</i>	junegrass	Graminoid	Perennial	Native	3	0.8 (0–4.3)	0.8 (0–4.7)
<i>Poa fendleriana</i>	muttongrass	Graminoid	Perennial	Native	7	8.8 (2.7–20.3)	12.2 (3.0–29.3)
<i>Stipa comata</i>	needle and thread	Graminoid	Perennial	Native	3	0.7 (0–4.0)	0.9 (0–4.7)
<i>Stipa hymenoides</i>	Indian ricegrass	Graminoid	Perennial	Native	2	0.2 (0–1.0)	0.2 (0–1.3)
<i>Stipa lettermanii</i>	Letterman's needlegrass	Graminoid	Perennial	Native	7	3.8 (1.0–7.7)	5.9 (2.0–12.7)
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Shrub	Perennial	Native	4	0.7 (0–3.7)	0.8 (0–4.3)
Sagebrush– Mountain Loam, grazed							
<i>Artemisia tridentata</i>	big sagebrush	Shrub	Perennial	Native	8	14.6 (4.7–24.3)	24.5 (13.0–42.0)
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	Shrub	Perennial	Native	8	3.2 (0.7–9.0)	3.8 (0.7–9.7)

Table 3-4. Mean (range) percent cover of dominant species by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2010, cont.

Scientific name	Common name	Life form	Duration	Nativity	No. of plots with species present*	Percent cover**	
						Live	Total
Sagebrush– Mountain Loam, grazed, cont.							
<i>Elymus elymoides</i>	squirreltail	Graminoid	Perennial	Native	5	0.7 (0–2.7)	1.0 (0–4.7)
<i>Koeleria macrantha</i>	junegrass	Graminoid	Perennial	Native	4	0.6 (0–2.7)	0.8 (0–3.3)
<i>Poa fendleriana</i>	muttongrass	Graminoid	Perennial	Native	8	11.1 (0.3–20.7)	16.6 (0.3–27.0)
<i>Stipa comata</i>	needle and thread	Graminoid	Perennial	Native	5	1.3 (0–7.3)	2.1 (0–12.7)
<i>Stipa hymenoides</i>	Indian ricegrass	Graminoid	Perennial	Native	4	0.3 (0–1.0)	0.4 (0–1.3)
<i>Stipa lettermanii</i>	Letterman's needlegrass	Graminoid	Perennial	Native	8	3.7 (0.7–8.0)	5.8 (0.7–16.7)
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Shrub	Perennial	Native	4	0.6 (0–2.7)	0.8 (0–3.0)
PJ							
<i>Cercocarpus montanus</i>	alder-leaf mountain mahogany	Shrub	Perennial	Native	4	1.6 (0–6.0)	1.8 (0–7.0)
<i>Ephedra viridis</i>	Mormon tea	Shrub	Perennial	Native	5	0.6 (0–1.7)	0.7 (0–1.7)
<i>Juniperus osteosperma</i>	Utah juniper	Tree	Perennial	Native	8	12.6 (5.3–25.0)	15.4 (7.7–32.0)
<i>Pinus edulis</i>	two-needle pinyon	Tree	Perennial	Native	7	8.3 (0–23.3)	10.0 (0–26.3)
Oak							
<i>Amelanchier utahensis</i>	Utah serviceberry	Shrub	Perennial	Native	8	21.6 (8.3–50.8)	25.6 (9.6–61.3)
<i>Artemisia tridentata</i>	big sagebrush	Shrub	Perennial	Native	8	5.7 (0.8–16.7)	7.7 (1.3–19.2)
<i>Poa fendleriana</i>	muttongrass	Graminoid	Perennial	Native	7	7.1 (0–15.4)	12.2 (0–26.7)
<i>Quercus gambelii</i>	Gambel oak	Shrub	Perennial	Native	7	14.6 (0–31.3)	15.5 (0–33.8)
<i>Stipa lettermanii</i>	Letterman's needlegrass	Graminoid	Perennial	Native	7	1.5 (0–3.8)	2.1 (0–5.0)
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Shrub	Perennial	Native	8	6.6 (0.4–21.3)	7.7 (0.4–23.3)
Aspen							
<i>Achillea millefolium</i>	common yarrow	Forb	Perennial	Native	3	6.2 (0–13.3)	6.3 (0–13.3)
<i>Bromus carinatus</i>	mountain brome	Graminoid	Perennial	Native	3	1.4 (0–3.3)	1.5 (0–3.3)
<i>Bromus ciliatus</i>	fringed brome	Graminoid	Perennial	Native	2	1.8 (0–5.3)	2.1 (0–5.7)
<i>Carex geyeri</i>	elk sedge	Graminoid	Perennial	Native	1	5.3 (0–21.3)	6.2 (0–24.7)
<i>Elymus glaucus</i>	blue wildrye	Graminoid	Perennial	Native	4	4.5 (0.7–10.3)	5.1 (0.7–11.3)
<i>Geranium richardsonii</i>	Richardson's crane's-bill	Forb	Perennial	Native	3	0.4 (0–0.7)	0.4 (0–0.7)
<i>Populus tremuloides</i>	quaking aspen	Tree	Perennial	Native	4	1.2 (0.7–2.7)	1.5 (0.7–3.0)
<i>Rosa woodsii</i>	Woods' rose	Shrub	Perennial	Native	3	0.5 (0–1.0)	0.5 (0–1.0)
<i>Symphoricarpos oreophilus</i>	mountain snowberry	Shrub	Perennial	Native	4	16.9 (5.3–32.0)	18.8 (5.3–35.7)
<i>Vicia americana</i>	American vetch	Forb	Perennial	Native	3	9.7 (0–15.7)	11.3 (0–18.3)

* In 2010, a total of 8 plots were monitored in each vegetation type, except ungrazed Mountain Loam sagebrush (7 plots) and aspen (4 plots).

** Cover at all canopy heights for sagebrush, PJ, and oak; understory cover (<2 m) for aspen.

Table 3-5. Density of shrub species per hectare by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2010.

Scientific name	Common name	No. of plots with species present*	Density (number of shrubs/ha)		
			Mean	Minimum	Maximum
Sagebrush– Dry Mountain Loam, ungrazed					
<i>Amelanchier utahensis</i>	Utah serviceberry	1	8	0	67
<i>Artemisia frigida</i>	fringed sagebrush	4	775	0	2,800
<i>Artemisia nova</i>	black sagebrush	1	325	0	2,600
<i>Artemisia tridentata</i>	big sagebrush	8	10,833	3,867	20,400
<i>Chrysothamnus depressus</i>	dwarf rabbitbrush	5	3,925	0	23,933
<i>Chrysothamnus nauseosus</i>	rubber rabbitbrush	1	1,142	0	9,133
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	8	6,033	600	27,267
<i>Eriogonum lonchophyllum</i>	spearleaf buckwheat	1	17	0	133
<i>Juniperus scopulorum</i>	Rocky Mountain juniper	2	58	0	400
<i>Krascheninnikovia lanata</i>	winterfat	3	742	0	5,800
<i>Leptodactylon pungens</i>	prickly-phlox	2	625	0	4,800
<i>Prunus virginiana</i>	chokecherry	1	158	0	1,267
<i>Purshia tridentata</i>	antelope bitterbrush	1	150	0	1,200
<i>Quercus gambelii</i>	Gambel oak	2	142	0	1,000
<i>Symphoricarpos oreophilus</i>	mountain snowberry	3	75	0	333
<i>Tetradymia canescens</i>	spineless horsebrush	4	325	0	2,067
Sagebrush– Dry Mountain Loam, grazed					
<i>Amelanchier utahensis</i>	Utah serviceberry	5	342	0	1,200
<i>Artemisia frigida</i>	fringed sagebrush	5	725	0	3,000
<i>Artemisia nova</i>	black sagebrush	2	1,608	0	12,667
<i>Artemisia tridentata</i>	big sagebrush	8	12,008	7,867	19,933
<i>Cercocarpus montanus</i>	alder-leaf mountain mahogany	1	600	0	4,800
<i>Chrysothamnus depressus</i>	dwarf rabbitbrush	4	4,067	0	30,600
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	8	2,942	67	9,400
<i>Eriogonum lonchophyllum</i>	spearleaf buckwheat	3	383	0	2,867
<i>Krascheninnikovia lanata</i>	winterfat	4	192	0	667
<i>Leptodactylon pungens</i>	prickly-phlox	1	17	0	133
<i>Purshia tridentata</i>	antelope bitterbrush	3	283	0	2,133
<i>Quercus gambelii</i>	Gambel oak	2	92	0	600
<i>Rhus trilobata</i>	skunkbush sumac	1	8	0	67
<i>Symphoricarpos oreophilus</i>	mountain snowberry	7	1,258	0	3,267
<i>Tetradymia canescens</i>	spineless horsebrush	5	567	0	3,667
Sagebrush– Mountain Loam, ungrazed					
<i>Amelanchier utahensis</i>	Utah serviceberry	6	314	0	2,200
<i>Artemisia frigida</i>	fringed sagebrush	3	162	0	1,133
<i>Artemisia tridentata</i>	big sagebrush	7	8,943	7,133	62,600
<i>Ceanothus fendleri</i>	Fendler's mountain-lilac	1	171	0	1,200
<i>Cercocarpus montanus</i>	alder-leaf mountain mahogany	1	48	0	333
<i>Chrysothamnus depressus</i>	dwarf rabbitbrush	4	1,295	0	9,067
<i>Chrysothamnus parryi</i>	Parry's rabbitbrush	3	743	0	5,200
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	7	9,229	733	64,600
<i>Eriogonum lonchophyllum</i>	spearleaf buckwheat	2	276	0	1,933
<i>Juniperus scopulorum</i>	Rocky Mountain juniper	2	57	0	400
<i>Krascheninnikovia lanata</i>	winterfat	1	10	0	67
<i>Leptodactylon pungens</i>	prickly-phlox	2	48	0	333

Table 3-5. Density of shrub species per hectare by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2010.

Scientific name	Common name	No. of plots with species present*	Density (number of shrubs/ha)		
			Mean	Minimum	Maximum
Sagebrush– Mountain Loam, ungrazed, cont.					
<i>Peraphyllum ramosissimum</i>	squaw-apple	1	29	0	200
<i>Prunus virginiana</i>	chokecherry	2	267	0	1,867
<i>Purshia tridentata</i>	antelope bitterbrush	4	1,095	0	7,667
<i>Symphoricarpos oreophilus</i>	mountain snowberry	7	1,371	67	9,600
<i>Tetradymia canescens</i>	spineless horsebrush	3	152	0	1,067
Sagebrush– Mountain Loam, grazed					
<i>Amelanchier utahensis</i>	Utah serviceberry	5	633	0	5,067
<i>Artemisia frigida</i>	fringed sagebrush	3	650	0	5,200
<i>Artemisia nova</i>	black sagebrush	2	1,208	0	9,667
<i>Artemisia tridentata</i>	big sagebrush	8	8,358	4,200	66,867
<i>Cercocarpus montanus</i>	alder-leaf mountain mahogany	2	242	0	1,933
<i>Chrysothamnus depressus</i>	dwarf rabbitbrush	6	2,683	0	21,467
<i>Chrysothamnus parryi</i>	Parry's rabbitbrush	2	117	0	933
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	8	7,350	533	58,800
<i>Leptodactylon pungens</i>	prickly-phlox	2	200	0	1,600
<i>Purshia tridentata</i>	antelope bitterbrush	3	275	0	2,200
<i>Rosa woodsii</i>	Woods' rose	1	42	0	333
<i>Symphoricarpos oreophilus</i>	mountain snowberry	5	1,442	0	11,533
<i>Tetradymia canescens</i>	spineless horsebrush	4	83	0	667
PJ					
<i>Amelanchier utahensis</i>	Utah serviceberry	4	33	0	67
<i>Artemisia tridentata</i>	big sagebrush	2	25	0	133
<i>Brickellia microphylla</i>	littleleaf brickellbush	1	50	0	400
<i>Cercocarpus montanus</i>	alder-leaf mountain mahogany	5	417	0	1,467
<i>Ephedra viridis</i>	green ephedra	6	383	0	1,000
<i>Eriogonum microthecum</i>	slender wild buckwheat	1	150	0	1,200
<i>Glossopetalon spinescens</i>	spiny greasebush	1	33	0	267
<i>Mahonia fremontii</i>	Fremont's mahonia	1	50	0	400
<i>Purshia tridentata</i>	antelope bitterbrush	1	8	0	67
<i>Symphoricarpos oreophilus</i>	mountain snowberry	1	8	0	67
Aspen					
<i>Amelanchier alnifolia</i>	Saskatoon serviceberry	3	600	0	1,600
<i>Amelanchier utahensis</i>	Utah serviceberry	2	333	0	1,067
<i>Artemisia tridentata</i>	big sagebrush	1	17	0	67
<i>Chrysothamnus parryi</i>	Parry's rabbitbrush	1	33	0	133
<i>Chrysothamnus viscidiflorus</i>	green rabbitbrush	1	67	0	267
<i>Juniperus communis</i>	common juniper	1	17	0	67
<i>Prunus virginiana</i>	chokecherry	3	900	0	2,400
<i>Ribes inerme</i>	whitestem gooseberry	1	17	0	67
<i>Rosa woodsii</i>	Woods' rose	4	850	67	2,533
<i>Salix scouleriana</i>	Scouler's willow	1	17	0	67
<i>Symphoricarpos oreophilus</i>	mountain snowberry	3	2,733	0	4,867

* In 2010, a total of 8 plots were monitored in each vegetation type, except ungrazed Mountain Loam sagebrush (7 plots) and aspen (4 plots).

Table 3-6. Mean (range) density of live seedlings, saplings, and overstory trees by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2010.

Vegetation type	Scientific name	Common name	No. of plots with species detected*	Density of live trees by dbh class (no. of trees/ha)				
				Seeding (<2.5 cm)	Sapling			Tree (>15 cm**)
PJ	<i>Juniperus osteosperma</i>	Utah juniper	8	342 (133–867)	80 (0–280)	60 (0–160)	40 (0–200)	162 (32–288)
	<i>Pinus edulis</i>	two-needle pinyon	8	508 (67–2,133)	80 (0–160)	65 (0–160)	35 (0–120)	42 (0–176)
Oak	<i>Pseudotsuga menziesii</i>	Douglas-fir	1	NA	NA	NA	NA	2 (0–16)
	<i>Quercus gambelii</i>	Gambel oak	1	NA	NA	NA	NA	+
Aspen	<i>Juniperus scopulorum</i>	Rocky Mountain juniper	1	0	0 (0–40)	10 (0–40)	20 (0–80)	0
	<i>Populus tremuloides</i>	quaking aspen	4	817 (200–1,600)	70 (0–120)	300 (0–480)	120 (0–200)	260 (144–448)

*A total of 8 PJ, 8 oak, and 4 aspen plots were monitored in 2010.

** This category also includes Gambel oak >10 cm dbh.

+ In 2010, Gambel oak with >10 cm dbh were not measured, although they existed in one of the oak plots that was monitored.

Table 3-7. 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, 2010.

Vegetation type	Scientific name	Common name	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	184 (32-288)	24 (16-36)	NA	NA	NA	NA	NA	NA	NA	NA	11 (0-28)
	<i>Pinus edulis</i>	two-needle pinyon	46 (0-176)	20 (15-24)	NA	NA	NA	NA	NA	NA	NA	NA	29 (0-100)
	<i>Pseudotsuga menzies</i>	Douglas-fir	2 (0-16)	23 (23-23)	NA	NA	NA	NA	NA	NA	NA	NA	0
Oak	<i>Quercus gambelii</i>	Gambel oak	+	+	NA	NA	NA	NA	NA	NA	NA	NA	+
	<i>Juniperus scopulorum</i>	Rocky Mountain juniper	0	-	-	-	-	-	-	-	-	-	-
Aspen	<i>Populus tremuloides</i>	quaking aspen	424 (352-560)	21 (19-24)	0	14 (4-23)	38 (15-58)	6 (0-15)	39 (22-59)	16 (5-30)	4 (0-9)	0	40 (22-67)

+ In 2010, Gambel oak with >10 cm dbh were not measured, although they existed in one of the oak plots that was monitored.

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 3-8. Mean (range) cover and density of exotic plant species detected in Black Canyon of the Gunnison NP and Curecanti NRA, 2010.

Scientific name	Common name	Life form	Duration	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	1	0	0	8 (0–67)
<i>Bromus inermis</i>	smooth brome	Graminoid	Perennial	1	0	0	25 (0–200)
<i>Bromus tectorum</i>	cheatgrass	Graminoid	Annual	2	0	0.1 (0–0.7)	NA
Sagebrush– Dry Mountain Loam, grazed							
<i>Agropyron cristatum</i>	crested wheatgrass	Graminoid	Perennial	1	0.04 (0–0.3)	0.04 (0–0.3)	8 (0–67)
<i>Bromus inermis</i>	smooth brome	Graminoid	Perennial	1	0	0	17 (0–133)
Sagebrush– Mountain Loam, ungrazed							
<i>Agropyron cristatum</i>	crested wheatgrass	Graminoid	Perennial	1	0	0.05 (0–0.3)	10 (0–67)
<i>Bromus inermis</i>	smooth brome	Graminoid	Perennial	2	0.1 (0–0.7)	0.1 (0–0.7)	19 (0–67)
<i>Carduus nutans</i>	musk thistle	Forb	Perennial	1	0	0	38 (0–267)
<i>Elymus hispidus</i>	intermediate wheatgrass	Graminoid	Perennial	1	0.1 (0–0.7)	0.1 (0–0.7)	114 (0–800)
<i>Melilotus officinalis</i>	yellow sweet-clover	Forb	Biennial	2	0.1 (0–0.7)	0.1 (0–0.7)	162 (0–1,000)
<i>Poa pratensis</i>	Kentucky bluegrass	Graminoid	Perennial	3	3.2 (0–10.3)	4.4 (0–13.7)	19143 (0–11,667)
<i>Polygonum aviculare</i>	yard knotweed	Forb	Annual	1	0.05 (0–0.3)	0.05 (0–0.3)	NA
<i>Taraxacum officinale</i>	common dandelion	Forb	Perennial	3	0.3 (0–1.3)	0.3 (0–1.3)	990 (0–5,000)
<i>Tragopogon dubius</i>	yellow salsify	Forb	Biennial	1	0.05 (0–0.3)	0.05 (0–0.3)	19 (0–133)
Sagebrush– Mountain Loam, grazed							
<i>Bromus tectorum</i>	cheatgrass	Graminoid	Annual	2	0	0.1 (0–0.7)	NA
<i>Poa pratensis</i>	Kentucky bluegrass	Graminoid	Perennial	2	1.8 (0–9.3)	2.7 (0–16.3)	350 (0–2,800)
<i>Taraxacum officinale</i>	common dandelion	Forb	Perennial	2	0.04 (0–0.3)	0.04 (0–0.3)	300 (0–2,333)
PJ							
<i>Alyssum alyssoides</i>	pale madwort	Forb	Annual	1	0	0.1 (0–0.7)	NA
<i>Bromus tectorum</i>	cheatgrass	Graminoid	Annual	3	0.3 (0–1.0)	4.7 (0–20.3)	NA
<i>Sisymbrium altissimum</i>	tumble mustard	Forb	Annual	1	0.04 (0–0.3)	0.04 (0–0.3)	NA

Table 3-8. Mean (range) cover and density of exotic plant species detected in Black Canyon of the Gunnison NP and Curecanti NRA, 2010, cont.

Scientific name	Common name	Life form	Duration	No. of plots with exotic species detected*	Percent cover**		Density (number of exotic perennials/ha)
					Live	Total	
Oak							
<i>Poa pratensis</i>	Kentucky bluegrass	Graminoid	Perennial	6	7.6 (0–22.1)	10.9 (0–30.4)	NA
<i>Taraxacum officinale</i>	common dandelion	Forb	Perennial	1	0.2 (0–1.3)	0.2 (0–1.7)	NA
Aspen							
<i>Bromus inermis</i>	smooth brome	Graminoid	Perennial	1	0	0.1 (0–0.3)	67 (0–267)
<i>Carduus nutans</i>	musk thistle	Forb	Perennial	2	0.1 (0–0.3)	0.1 (0–0.3)	33 (0–67)
<i>Cirsium arvense</i>	Canada thistle	Forb	Perennial	1	0.3 (0–1.3)	0.3 (0–1.3)	1,150 (0–4,600)
<i>Poa pratensis</i>	Kentucky bluegrass	Graminoid	Perennial	4	18.0 (2.0–32.3)	25.4 (2.3–44.3)	60367 (133–133,333)
<i>Rumex crispex</i>	curly dock	Forb	Perennial	1	0.1 (0–0.3)	0.2 (0–0.7)	0
<i>Taraxacum officinale</i>	common dandelion	Forb	Perennial	4	5.6 (0–10.7)	5.8 (0–11.0)	52,650 (6,267–120,000)

* In 2010, a total of 8 plots were monitored in each vegetation type, except ungrazed Mountain Loam sagebrush (7 plots) and aspen (4 plots).

** Mean and range are based on all plots within a vegetation type where an exotic species was detected.

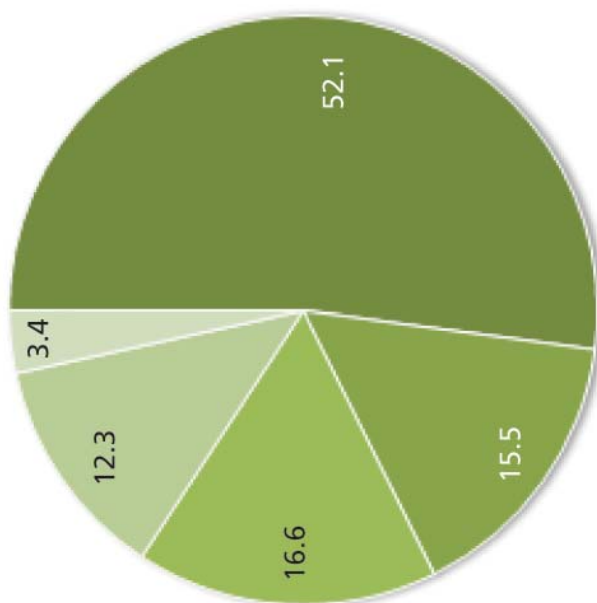
Table 3-9. Mean (range) percent cover of surface features by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2010.

Crust, undifferentiated	Cyanobacteria	Lichen	Moss	Bare soil	Litter	Woody debris	Small rock	Large rock	Bedrock
Sagebrush– Dry Mountain Loam, ungrazed									
24.9 (11.7–58.7)	0	0.2 (0–1.3)	1.8 (0–8.7)	2.8 (0–14.0)	35.7 (15.3–63.7)	0.3 (0–1.7)	18.0 (1.0–41.3)	8.4 (0–19.0)	0
Sagebrush– Dry Mountain Loam, grazed									
17.5 (8.3–36.7)	0	1.0 (0–5.3)	1.3 (0–4.0)	1.7 (0–6.0)	36.0 (23.0–48.0)	0.04 (0–0.3)	24.7 (13.3–33.3)	7.8 (0–15.7)	0
Sagebrush– Mountain Loam, ungrazed									
16.3 (8.0–30.3)	0	0.1 (0–0.3)	1.1 (0–5.3)	0.2 (0–0.7)	56.7 (43.0–75.0)	0.3 (0–1.0)	10.9 (0–22.3)	3.1 (0–11.0)	0.05 (0–0.3)
Sagebrush– Mountain Loam, grazed									
15.4 (4.0–41.3)	0	0.5 (0–1.7)	0.8 (0–2.7)	1.3 (0–2.7)	58.6 (35.7–79.7)	0.3 (0–1.0)	10.8 (0–34.3)	2.8 (0–10.0)	0.3 (0–1.0)
PJ									
14.0 (2.0–31.3)	0.2 (0–0.7)	0.2 (0–0.7)	1.4 (0–4.7)	1.5 (0.7–2.3)	54.0 (28.3–76.0)	1.8 (0.3–4.7)	14.1 (8.0–21.0)	7.5 (0.3–15.0)	3.1 (0–12.3)
Oak									
7.7 (2.9–11.3)	0	0.1 (0–0.4)	0.2 (0–0.4)	0.7 (0–1.7)	79.1 (68.3–92.9)	0.4 (0–2.1)	3.5 (0.4–8.3)	2.1 (0–6.3)	0
Aspen									
0	0	0	0	3.0 (2.3–3.7)	77.9 (69.3–84.0)	7.5 (4.0–12.0)	0.1 (0–0.3)	2.0 (0–5.0)	0

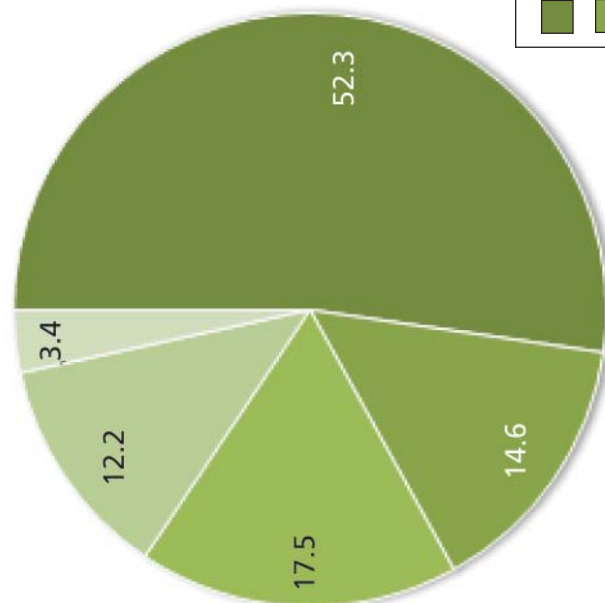
Table 3-10. Mean (range) canopy- and basal-gap size by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2010.

Vegetation type	Canopy gap (cm)	Basal gap (cm)
Sagebrush– Dry Mountain Loam, ungrazed	59 (49–74)	97 (77–136)
Sagebrush– Dry Mountain Loam, grazed	63 (46–80)	101 (52–175)
Sagebrush– Mountain Loam, ungrazed	51 (38–73)	76 (47–119)
Sagebrush– Mountain Loam, grazed	53 (41–81)	74 (51–114)

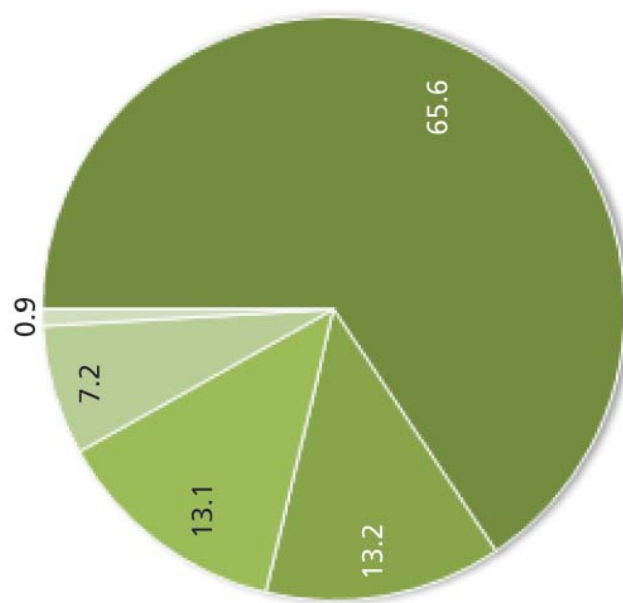
A) Ungrazed Dry Mountain Loam



B) Grazed Dry Mountain Loam



C) Ungrazed Mountain Loam



D) Grazed Mountain Loam

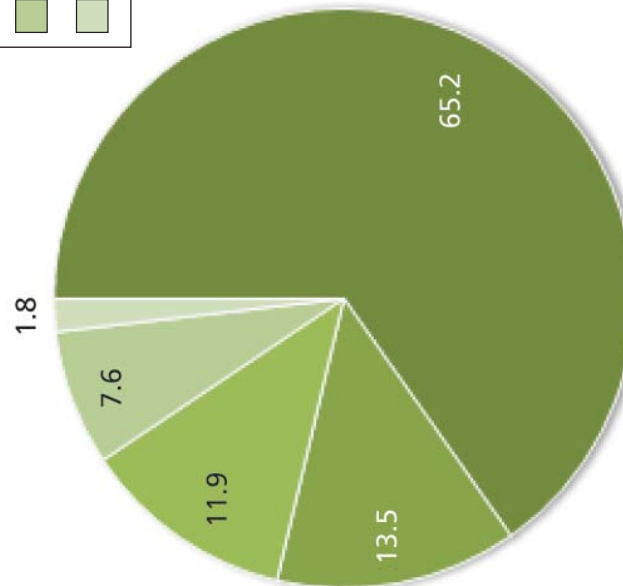
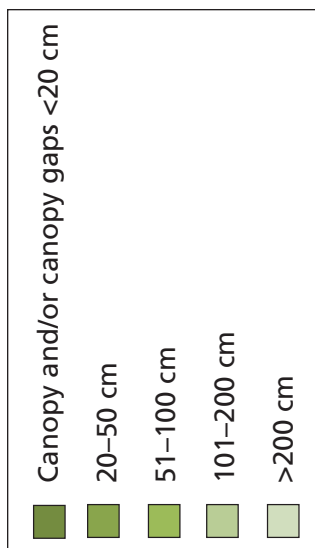
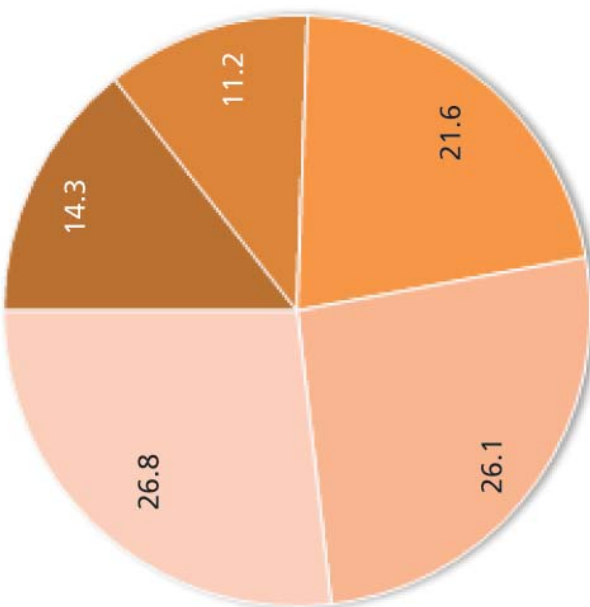


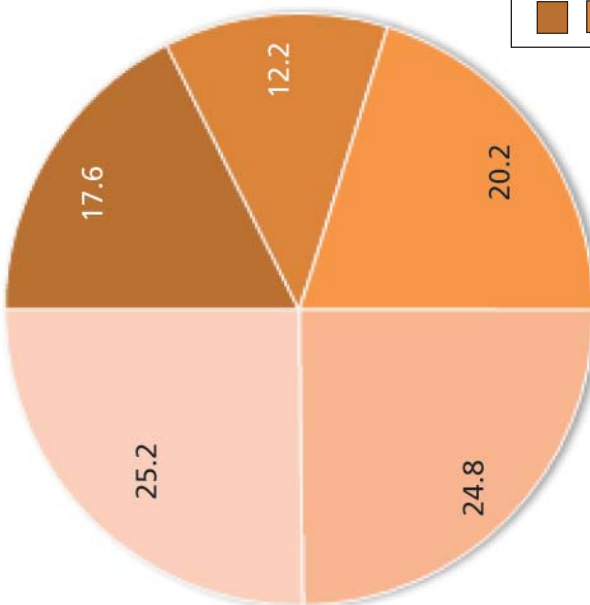
Figure 3-2. Distribution of canopy gaps for (A) ungrazed Dry Mountain Loam, (B) grazed Dry Mountain Loam, (C) ungrazed Mountain Loam, and (D) grazed Mountain Loam sagebrush sites in Black Canyon of the Gunnison NP and Curecanti NRA, 2010.



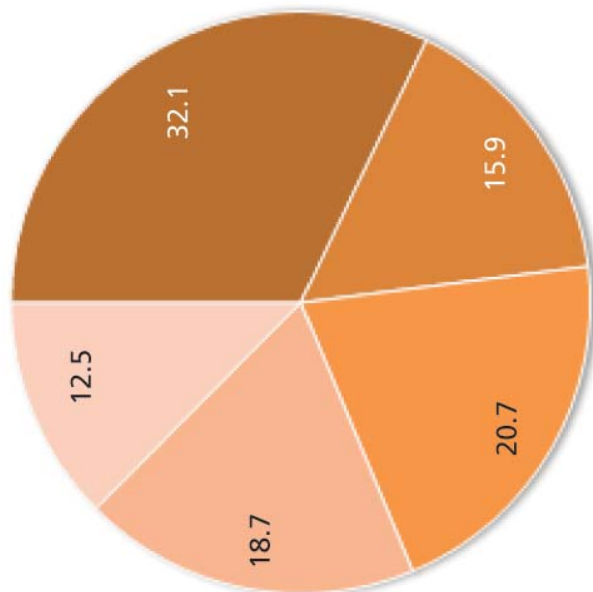
A) Ungrazed Dry Mountain Loam



B) Grazed Dry Mountain Loam



C) Ungrazed Mountain Loam



D) Grazed Mountain Loam

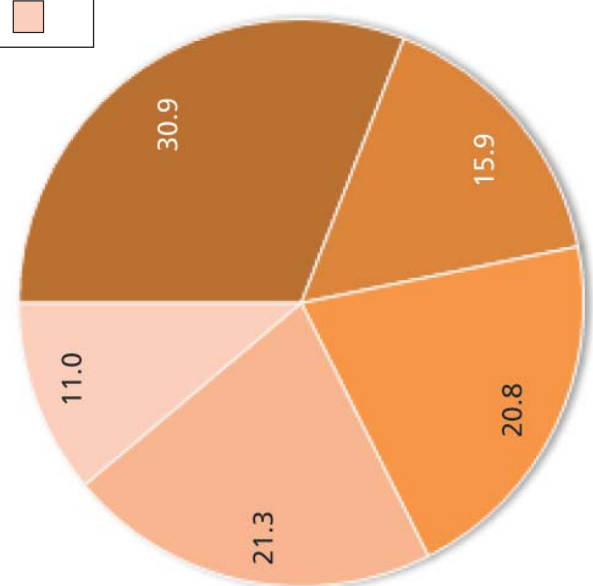


Figure 3-3. Distribution of basal gaps for (A) ungrazed Dry Mountain Loam, (B) grazed Dry Mountain Loam, (C) ungrazed Mountain Loam, and (D) grazed Mountain Loam sagebrush sites in Black Canyon of the Gunnison NP and Curecanti NRA, 2010.

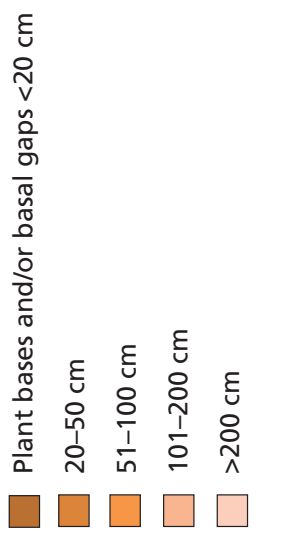


Table 3-11. Mean (range) soil-aggregate stability measures by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2010.

Vegetation type	Total	Protected*	Unprotected*
Sagebrush– Dry Mountain Loam, ungrazed	2.4 (2.2–2.7)	2.5 (1.9–3.0)	2.2 (1.5–3.0)
Sagebrush– Dry Mountain Loam, grazed	2.5 (1.8–3.6)	2.7 (1.8–4.0)	2.3 (1.7–3.4)
Sagebrush– Mountain Loam, ungrazed	3.7 (2.3–5.0)	3.8 (2.3–5.2)	3.6 (2.0–6.0)
Sagebrush– Mountain Loam, grazed	3.1 (2.5–5.1)	3.1 (2.1–5.1)	2.9 (2.4–4.5)
PJ	3.8 (2.4–4.7)	3.7 (2.0–5.3)	3.9 (2.6–4.6)

*Protected are samples collected under vegetation; unprotected are samples collected in the open. Numbers range from 1 (least stable) to 6 (most stable).

Table 3-12. Mean (range) fuel volume and depth of litter and duff by vegetation type, Black Canyon of the Gunnison NP and Curecanti NRA, 2010.

Vegetation type	Fuel volume (tons/acre)						Depth (cm)	
	Total	1-hr	10-hr	100-hr	1000-hr		Litter	Duff
					Sound	Rotten		
PJ	8.4 (0.1–50.3)	0.1 (0.02–0.3)	0.6 (0.1–1.7)	0.8 (0–3.2)	3.2 (0–20.7)	3.8 (0–27.7)	0.6 (0.3–1.5)	0.6 (0–1.9)
Oak	1.0 (0.1–2.1)	0.1 (0.01–0.4)	0.6 (0.1–1.3)	0.3 (0–1.1)	0	0	1.4 (0.8–2.3)	1.1 (0.3–3.2)
Aspen	16.2 (9.0–27.6)	0.14 (0.06–0.31)	1.2 (0.3–2.8)	4.5 (0–13.8)	7.0 (2.2–10.1)	3.5 (1.4–8.5)	1.6 (1.3–2.0)	2.2 (1.3–4.6)

4 Discussion

In general, data from 2010 were similar to data from previous years. In spring 2011, two-to-three years of monitoring data were analyzed for estimates of variance (unpublished report; available from NCPN upon request). Variance, which serves as the basis for determining our ability to detect a minimum trend, was used to evaluate the number of plots needed, as well as potential revisit designs. Recommendations for an opera-

tional survey design were presented to BLCA and CURE resource staff for discussion and approval. In the 2011 field season, plots will be established and monitored according to the full operational monitoring design. 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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The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 144/112736, 616/112736, February 2012

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