Cedar Breaks National Monument
Survey Design and Site Selection Report

Defining the Upland Resources for Monitoring

Discussion with CEBR staff identified high-elevation meadows, spruce-fir forests, and aspen stands as the highest priority for long-term monitoring. Management issues of concern included expansion and contraction of vegetation types, recovery of spruce-fir forests from beetle kill, sudden aspen decline (SAD), and the spread of smooth brome invasion. Currently, the area above the rim in CEBR is dominated by a mixture of meadows and spruce-fir forest. Although there are large patches of forest in many areas, there are also islands and fingers of forest interspersed throughout the meadows. How climate change will favor certain community types and reposition their distribution across the landscape is of interest to resource management. Spruce-fir forests, especially Engelmann spruce within the forests, have been heavily attacked by bark beetles, creating a high percentage of dead trees throughout these forests. Tracking recovery of these forests is high priority to management due to extent of the affected area. Although aspen stands make up a relatively small part of high elevation vegetation in CEBR, they are of particular concern due to the threat of SAD. Smooth brome is an invasive exotic perennial grass that exists along roadsides and has expanded into other areas of the monument. Although CEBR actively treats some areas to remove this species, there is concern that it is displacing native grasses and forbs in the meadows.

The park expressed interest in monitoring white fir and Ponderosa pine in Ashdown Gorge as a secondary priority. There is little data from this area of the monument and a need for more monitoring and research. There is also concern that white fir may move up in elevation with increasing temperatures, and CEBR is interested in documenting these vegetation changes. A sampling design for the Ashdown Gorge area was created in case of future expansion of upland monitoring.

CEBR also identified a few species and management issues that were high priority for the park, but not suitable for long-term monitoring with NCPN sampling methods. There are cushion plants on the rim near the campground, and CEBR would like to monitor the amount of trampling in this area and how this affects rare plants. In the northern part of the park, there is a small area of Arizona willow that may be affected by snowmobile use in the winter months. Bristlecone pine grows on dry windswept ridges, and is unique because it lives longer than most species. These issues could be more appropriately addressed by a smaller monitoring or research project.

Accessibility

An accessibility map was created for CEBR based on road and trail access (Figure 1). Steep slopes ($\geq$ 50%) and areas isolated due to steep slopes (e.g. mesa tops) were considered inaccessible. For CEBR, the breaks provided a natural barrier between the high elevation rim area of the monument and the lower elevation Ashdown Gorge area.

Accessibility in CEBR was derived using the NCPN Landscape Accessibility Model.

Delineating the Target Population

Defining the target population typically involves determining the ecological sites that correspond to the resource of interest. Since no ecological sites exist for CEBR, alternative methods were used to define the target population and create a sampling frame.

Defining Target Vegetation Communities

Inspection of the draft NCPN vegetation map for CEBR (as of 10/1/08) and field visits to the park unit determined the vegetation associations corresponding to the target communities for monitoring (Table 1).

Defining Target Soils and Ecological Sites

NCPN typically creates a sampling frame based on ecological sites and their associated soil map units. Dixie National Forest mapped soils for CEBR but does not have associated ecological sites (USDA USFS unpublished). Instead, broad categories of vegetation are associated with each soil map unit. Comparing the soil map to the vegetation map showed that the priority vegetation types were not well distinguished by soil map units. Therefore, ecological sites and soil map units were not incorporated into the survey design for CEBR.

An alternative idea was stratification of the meadows was based on geology since the Brian Head formation in the north part of the monument seems to have a different plant community than the Claron formation to the south. Comparison of the soil and geology maps showed inconsistencies, and we could not determine which data layer was more accurate. Therefore, this stratification approach was not used.

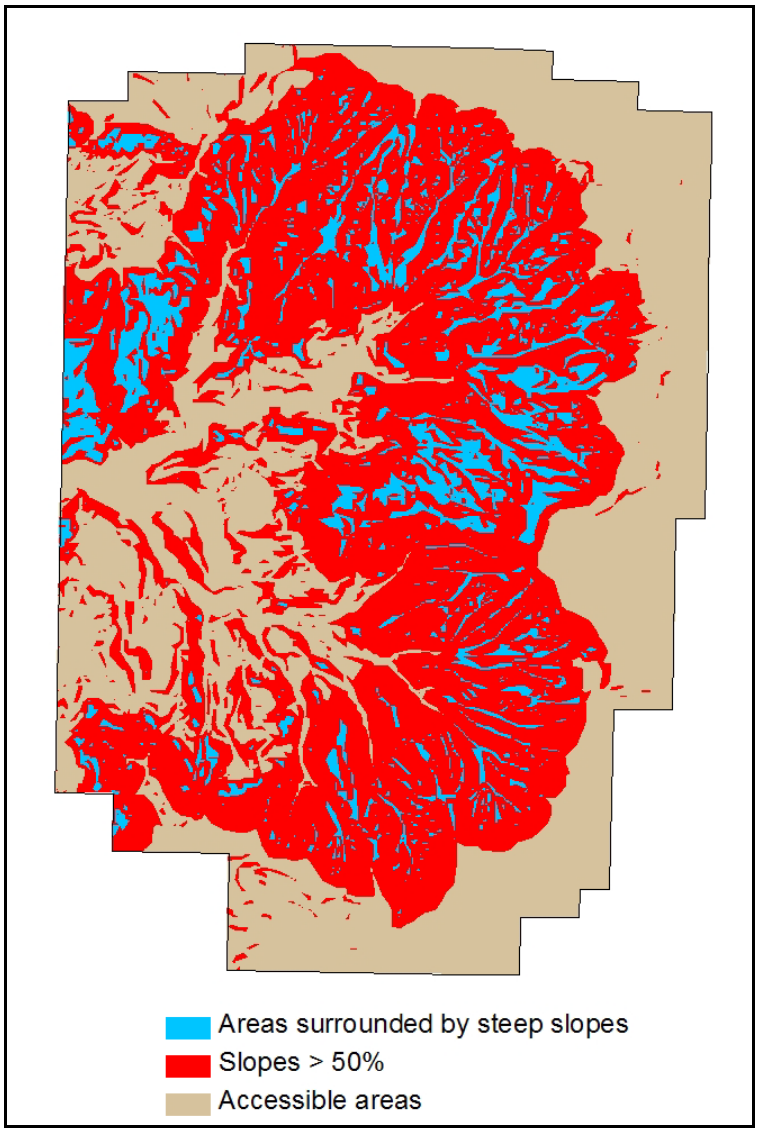

Figure 1. Accessible areas of Cedar Breaks National Monument.

Table 1. Accessible area (ha) of vegetation types in Cedar Breaks National Monument.

Vegetation type	Map unit #	Vegetation map unit name	Area (ha)
Subalpine meadow			
	34	Dry Meadow Mixed Herbaceous Vegetation Mosaic	83.3
	35	Perennial Disturbed Grassland Complex	82.5
	36	Carex spp.- Juncus spp. Wet Meadow Herbaceous Vegetation Mosaic	23.5
		Total subalpine meadow	189.3
Spruce-fir			
	5	Abies lasiocarpa - Picea engelmannii Forest Complex	342.5
Aspen			
	19	Populus tremuloides Forest Complex	57.4
Ponderosa pine			
	10	Pinus ponderosa - (Pseudotsuga menziesii) Woodland Complex	128.7
White Fir			
	3	Abies concolor / Arctostaphylos patula Forest	34.5
	4	Abies concolor Forest Alliance	69.2
		Total white fir	103.7
		Total target vegetation	**821.7**
Bristlecone pine			
	18	Pinus longaeva Woodland Alliance	12.1
Non-target subalpine vegetation			
	27	Ericameria (Chrysothamnus) spp. Shrubland Complex	0.7
	28	Salix spp. Temporarily Flooded Shrubland Complex	2.2
	29	Mixed Desert Shrubland Complex	8.7
	30	Bottomland Shrubland Complex	12.8
	31	Mixed Mountain Shrubland Complex	10.9
	33	Dasiphora fruticosa ssp. floribunda Shrubland	1.1
		Total non-target subalpine vegetation	36.3
Non-target vegetation in Ashdown Gorge			
	8	Picea pungens Forest Alliance	14.9
	14	Pinus edulis. - Juniperus spp. Woodland Complex	9.8
	21	Cercocarpus ledifolius Woodland Alliance	3.0
	22	Temporarily Flooded Wash Complex	32.4
	26	Arctostaphylos patula Shrubland Alliance	14.4
		Total non-target vegetation below breaks	74.5
Other non-target			
	37	Red Claron Formation	39.0
	38	White Claron Formation	14.2
	39	Unvegetated surface (e.g., scree, sparse vegetation)	0.1
	40	Park Infrastructure	20.6
		Grand Total	**1018.6**

Basis for Sampling Frame

Due to issues with the soil survey and the relatively small area of the monument, we decided to use a much simpler mapping process for CEBR. Stratification of the sampling frame was minimized, using the natural barrier of the breaks to distinguish high and low elevation. Within the accessible area of the monument, all target vegetation types (subalpine meadow, spruce-fir, aspen, Ponderosa pine, and white fir represented by vegetation map units 3, 4, 5, 10, 19, 34, 35, and 36) were included in the sampling frame. This represented 81% of the accessible area of the monument with 548 ha on the rim and 260 ha in Ashdown Gorge. There were 13 ha that fell within the breaks in the NW part of the park that were excluded from the sampling frame (Figure 2). This area was excluded because it was similar to both the above the rim area or the Ashdown Gorge area, but did not fit well in either one. Since the sampling frame included most of the park, little field time was spent assessing the accuracy of sampling frame. It was assumed that most monitoring plots would land in target vegetation types.

Before site selection, the sampling frame was buffered by 25 m to prevent plots from crossing roads, trails, the park boundary, non-target vegetation, or inaccessible areas.

Monitoring Site Selection

Monitoring sites were selected using R-GRTS (Stevens and Olsen 2004). An area frame was used, consisting of an ArcGIS shape file with unique coding for areas above and below the rim. Twenty-eight plots were selected on the rim and 9 plots were selected in Ashdown Gorge. Forty-two extra points were selected to account for errors in the sampling frame and the possibility of future plot additions. Combining all target vegetation types in the sampling frame allows plots to fall near the boundary of different vegetation types so that expansion and contraction of communities can be monitored.

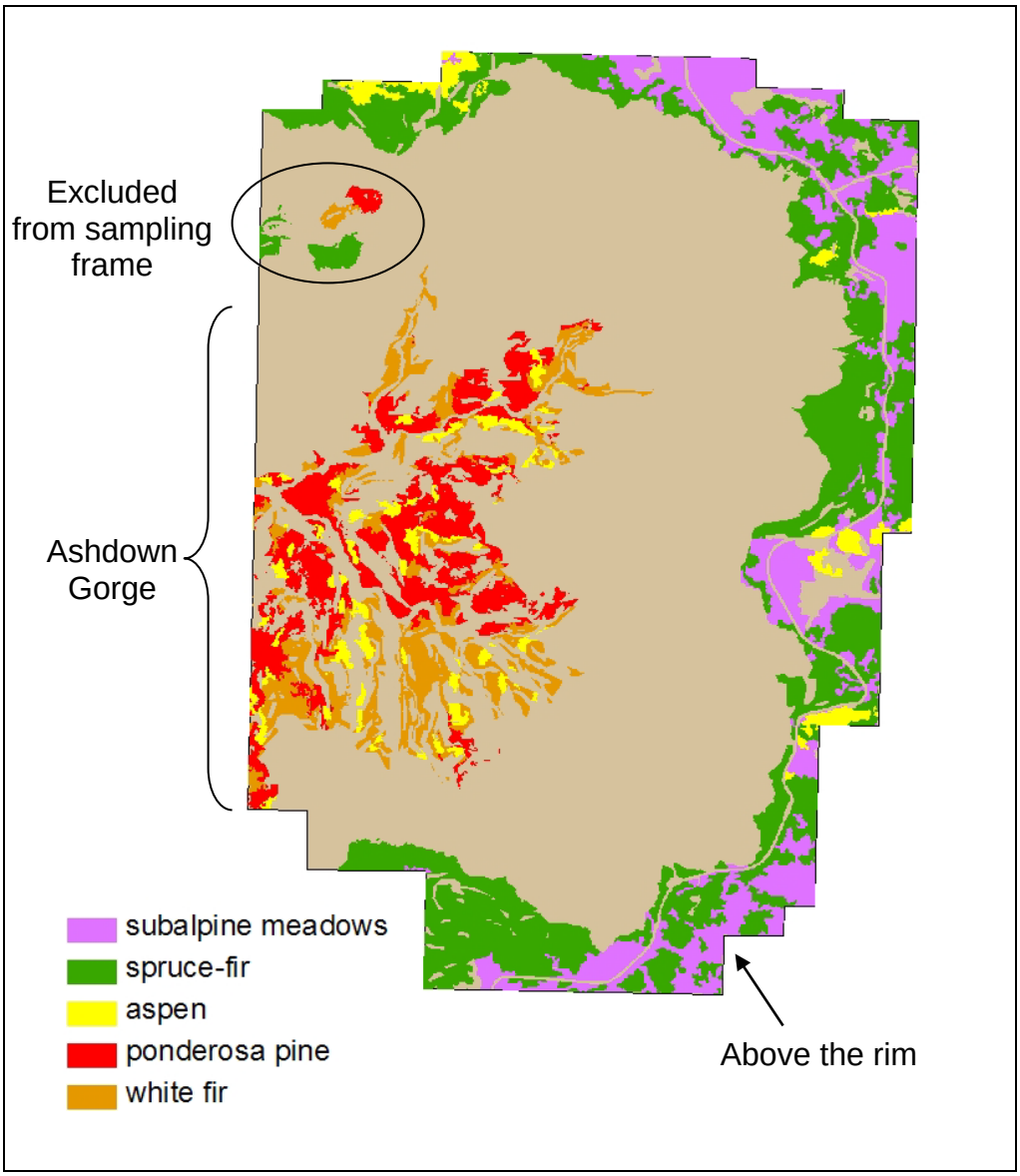

Figure 2. Sampling frame for Cedar Breaks National Monument.

Tracking Monitoring Sites

A sequential list of the first 79 selected locations is stored in a shape file (CEBR_upland_master). The list indicates acceptance or rejection of locations, reasons for rejection, date of plot establishment, and other important tracking information. Attributes of this shape file are described in Table 2.

Table 2. Attributes of CEBR_upland_master.shp for tracking upland monitoring locations in Cedar Breaks National Monument.

Field	Description
Veg_Type	Vegetation type for upland sampling methods (forest)
EcoType	Predicted vegetation type based on sampling frame (forest-meadow)
MasterStrat	Indicates groups for analyzing data (forest-meadow)
PlotID	The plot number, based on the siteID produced by GRTS
panel	Panel that plot is associated with in the revisit design (1-7, panel=0 for rejected plots)
PanelYear	Year(s) that panel is sampled (1-7)
EvalStatus	Ultimate status of a plot (estab = established; NotEval = not visited; accept = visited and deemed to be acceptable as a monitoring site; reject = rejected)
S_Action	Status of plot determined in the field and recorded on GPS (accept or reject)
EvalReason	Describes why a site was accepted or rejected
Estab_Date	Month, day, and year of plot establishment
Soil_MU	Soil map unit from Dixie National Forest Soil Survey associated with the monitoring plot
xcoord	UTM E (NAD83, Zone 12)
ycoord	UTM N (NAD83, Zone 12)
Hike_km	Hiking distance to plot in kilometers
AreaDescr	General area of the park where the plot is located
Comments	Miscellaneous
siteID	GRTS-assigned ordered unique identifier
stratum	GRTS attribute not used for selection of these sites (None)
mdcaty	Code for stratification of the sampling frame used by GRTS (1 = above the rim and 2 = Ashdown Gorge)
wgt	1/selection probability for each point

Survey Design

After further discussion with CEBR, we decided to limit upland monitoring to the area on the rim. Points selected in the Ashdown Gorge area will be saved in case of future expansion of upland monitoring. We also decided that there was no need for pilot monitoring in CEBR because the number of monitoring plots is more limited by affordable effort than variability of vegetation.

Plots are sampled following a rotating-panel design (Figure 3) that samples 8 plots each year and a total of 28 plots over 7 years. Plots are sampled 2 years in a row (in order to detect year-to-year differences due to temperature, precipitation, etc.) and rested for 5 years. Every 7 years, the sampling scheme repeats itself. The number of plots in each vegetation type should approximately represent the area of each vegetation type in the sampling frame.

	Year									
panel	1	2	3	4	5	6	7	8	9	10
1	4	4						4	4	
2		4	4						4	4
3			4	4						4
4				4	4					
5					4	4				
6						4	4			
7	4						4	4		

Figure 3. Number of plots sampled each year based on 7-year rotating panel revisit design for long-term upland monitoring at Cedar Breaks National Monument.

Benefits of this sampling design:

1) Provides inference to all target vegetation types on the rim.
2) Minimizes travel costs and maximizes the number of plots that NCPN can sample by only sampling on the rim.
3) Allows NCPN to sample plots with a mix of target vegetation types to investigate the expansion/contraction question.
4) Provides data on condition of spruce-fir forests on the rim, including information on beetle kill.
5) Provides data on presence and cover of smooth brome on the rim.

Limitations of this sampling design:

1) Provides minimal data on aspen stands in the park.

Response Design

The response design for CEBR is based on NCPN upland monitoring protocols for forests and subalpine meadows. Table 3 outlines specific methods used.

Table 3. Response design for vegetation monitored in Cedar Breaks National Monument.

Method	Forest/Subalpine meadow
Transects	3 – 50 m transects
Plot establishment	Rebar at transect ends, plot side slopes, optional witness trees
Photos	Transect origin and end
Point-intercept	X
Gap intercept	
Soil stability	
1-m belt transect (shrub and seeding density, exotic frequency)	X
1-m belt transect (richness)	X
5-m belt transect (sapling density)	X
Tree census	X
Spherical densiometer	X
Fuels	X
Site Impact	X

Modifications After Year 1

Points were visited ahead of the monitoring crew in order to filter out rejected sites. It was quickly discovered that the 25 m buffer used on the sampling frame was not large enough for a small park unit that is highly dissected by roads and trails. Over a third of the points were rejected because they were too close to a road, trail, cliff, or the monument boundary. It took 1½ days to accept enough plots for the first year of monitoring, much longer than expected.

Due to the unexpected high rejection rate, we needed to select additional monitoring plots. After consulting the national Inventory and Monitoring quantitative ecologist, it

was determined that the 7 plots established in 2009 would remain in the sampling design and a new GRTS run would be used for the remaining plots. We were not able to force GRTS to replicate the original draw with additional points because we did not have the random seed from original run.

This time the sampling frame was buffered by 65 m to account for the length of the fuels transects. In addition, the sampling frame was carefully reviewed to make sure all roads, trails, and perennial streams were buffered by 65 m.
In the additional GRTS run, we selected the remaining 21 plots and 30 oversample points. To prevent overlapping PlotID's between the two GRTS runs, PlotID's from the second GRTS run were assigned using siteID + 100. To make sure that plots do not overlap, points will be rejected if the centroid is less than 150 m from an established plot.

Literature Cited

Stevens, D. L. and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

USDA USFS. Unpublished. Soil Survey Report for Dixie National Forest - Parts of Garfield, Washington, Iron, Kane and Wayne Counties.