Chapter 5. Methods Used for Field Data and Analysis

Ecological Classification Used

For the basic unit of the classification, we used the *Ecological Type* (ET), synonymous with *Ecological Site* as defined by the Society for Range Management (Artz and others 1983). We designed names of Ecological Types in three parts: the plant association, a soil characteristic, and a landform or other diagnostic characteristic. The third part is an optional, additional descriptor of landform, geology, or climate, where needed to distinguish one Ecological Type from another. We separated the three parts by a long dash (–).

Climax Plant Communities

We classified potential natural communities using the standard vegetation classification methods of Daubenmire (1952, 1968, 1970, and 1978) and Daubenmire and Daubenmire (1968). In this system, the basic classification unit is the plant association, a climax plant community, "that state of a community that is attained when population structures of all of its species fluctuate rather than exhibit unidirectional change … It is the potential vegetation determined primarily by climate and soil in the absence of man's influence that serves as the basis for this classification" (Daubenmire 1978: 46, 313).

Soil Classification

We used the soil classifications done as parts of the five existing soil resource inventories as a primary basis for Ecological Type classification. Two of these soil surveys have been published, and the other three are in various states of completion:

1. Soil Survey of the Gunnison Area (Hunter and Spears 1975). Covers non-National Forest lands (private and public) in the UGB, except the public lands above Lake City.
2. Soil Survey of the Taylor River Area (Fox and others 1965-1977). Covers National Forest lands in the northeast part of the UGB, in the Taylor River and parts of adjacent watersheds, from Waunita Pass to Crested Butte.
3. Soil Survey of the Cochetopa Area. Mapped and described, not published yet. National Forest lands in the southeast part of the UGB, in the Cochetopa Creek, Cebolla Creek, and parts of adjacent drainages, from Waunita Pass to Lake City.
4. Soil Survey of the Grand Mesa-West Elk Area. Mapped and described, but not published yet. National Forest lands in the northwest part of the UGB, extending out of the UGB to the west and north.
5. Soil Survey of the Ouray Area. Mapped and partially described, not published yet. National Forest lands in the southwest part of the UGB, north and west of Lake City, including the public lands above Lake City.

The soil taxa and characteristics used in Ecological Type classification and description are contained in one or more of the five soil surveys for the UGB. We described soil taxa and characteristics using standard terminology (Soil Survey Staff 1951, 1973, 1996) and following the National Cooperative Soil Survey where applicable.

Field Methods

Selection of Sites to be Sampled

We interviewed resource management personnel actively working in the area, and surveyed current and ongoing inventories, in an effort to determine

- Location and estimated type of all reported and suspected sites with relict vegetation
- Unmanaged or little-used areas that need investigation
- Location of other studies that may need correlation or better vegetation data (for example, reference soil pedon locations)
- Locations of areas and types of major resource management concern
- Areas (range allotments, watersheds, dam sites, etc.) where managers and public groups recognize a need for better ecological information
- Locations where inventory data are stored.

At the same time, we interviewed resource managers to discover what data needed to be collected for development of management implications, potentials, and responses.

Location of Samples

In the field, we inspected each site selected for sampling to confirm whether it was appropriate for sampling. If so, we sampled at least one plant community within the site. We chose a point for a vegetation transect, using the following criteria, listed in priority order.

a. Choose the sample location on the ground after inspecting the whole polygon.
b. Choose the sample location so as to best represent (in one sample if possible) the average conditions in the site.

c. Choose the sample location to best represent the anticipated Ecological Type. Will this sample complement other samples made of the ET, so as to lead to a good description of the ET's characteristics, limitations, distinguishing factors, and variation within it?
d. Transects in riparian areas should avoid crossing live water or an active channel if possible. Place the first sample on the most stable and least-slope-angle landform within the area, and contain the transect within that landform if possible.
e. Keep the whole sample (both transect and plot) within the best-developed vegetation community in the site.
f. The transect should be 30 m long if possible.

We chose one end of the transect as the starting point (usually the lowest-elevation end, or else the end from which the oblique photograph showed the most). We marked the starting point permanently on the ground (usually using 3/8 in or ½ in re-bar, a few using short fence posts), and on an quadrangle map or aerial photograph.

If the homogeneous subsite (patch) to be sampled was not large enough to allow a transect of 30 m length, we shortened the transect to only include homogeneous vegetation, soils, and landforms, down to a minimum length of 15 m.

We took at least two photographs at each sample location, one looking in the direction of the transect line showing the starting-point marker and the tape, and another showing one of the microplots along the transect from above. We took both photographs prior to sampling either the transect or the plot.

Vegetation Sampling Methods

We used a transect method, because of a transect's advantages over a large plot for cover estimates (Bauer 1943, Hatton and others 1986, Mitchell and others 1988). The vegetation sampling methods that we chose represent the best available methods that will ensure consistency with other studies, resource management usability, and sufficiency to meet the goals of this project.

We placed ten 0.1-m² (20 × 50 cm) microplots (Fig. 5-1) centered on equidistant points along the tape (Fig. 5-2), avoiding the beginning and end points.

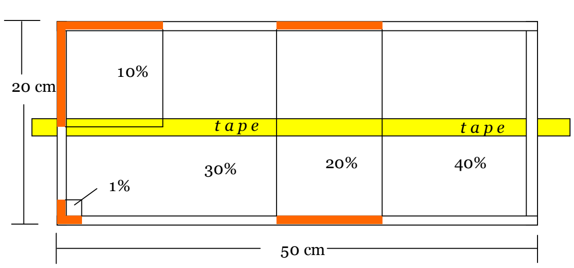

Fig. 5-1. 20 x 50 cm (0.1 m²) microplot marked in 10% classes.

Table 5-1. Cover classes used with the microplot frame in Fig. 5-1.

Code	Range	Midpoint
T	0–1 %	0.5 %
0	1–10 %	5.5 %
1	10–20 %	15.0 %
2	20–30 %	25.0 %
3	30–40 %	35.0 %
4	40–50 %	45.0 %
5	50–60 %	55.0 %
6	60–70 %	65.0 %
7	70–80 %	75.0 %
8	80–90 %	85.0 %
9	90–99 %	94.5 %
X	99–100 %	99.5 %

Within each microplot along the transect, we estimated canopy cover by plant species in 10% cover-classes (Table 5-1), and afterwards averaged over the transect. We used Weber (1987) and Weber and Wittmann (1992) for identification of plant species. At the same time, we estimated cover on each microplot by ground cover category. Also, we estimated cover on each microplot for each natural layer that occurred on that site (at the end of the transect, minimum-average-maximum heights were estimated for each of those layers).

For shrubs, we additionally estimated canopy cover by species using the line-intercept method along the transect line (Parker and Savage 1944, Heady and others 1959, Hanley 1978). We estimated lengths of intercept to the nearest 1 cm.

For tall shrubs and trees >3 m tall, the microplot was held horizontally at arm's length above the microplot center marks on the transect, and canopy cover estimated by species as before (Bunnell and Vales 1990).

Canopy cover has many advantages over other attributes such as frequency or weight (also see Daubenmire 1959, Taylor 1986).

> "Coverage data ... provide a sound basis from which the percentage composition of the vegetation can be calculated, because they take into account the fact that plants vary as to size. In addition, coverage can be expressed as the actual amount of the ground surface covered, an important ecological character. It is coverage rather than frequency or other quantitative [measures] ... that determines dominance and gives character to a community" (Bauer 1943).

Composition measures, such as composition by weight or relative canopy cover, have been discouraged by workers in many fields (Anderson 1986, Sholes 1988, Jackson 1997).

At sites that have tree cover, we laid out a 375 m² rectangular macroplot (15 × 25 m, ± 0.1 ac), using the first 25 m of the transect as the long axis. Within each macroplot, we tallied individual tree plants present in the macroplot by species and diameter class. In sites where trees were present, we used Standard Specifications for Stand Exam

(USDA Forest Service 1990) to choose trees for sampling for growth. We chose at least one tree for each tree species having a mature component on the macroplot. For each selected growth tree, we measured height, diameter at breast height (dbh), age, and radial growth for each decade of the tree's life.

In 1994 and 1995, we took production measurements of herbaceous and shrub vegetation at a few sites. At each of these sites, we measured current year's production of herbaceous plants and shrubs. We clipped current year's production on every other microplot (microplots 2, 4, 6, 8, and 10) – the same microplots that had been used for canopy cover estimates (total area clipped = 0.5 m^2). Clippings were bagged by species (graminoids and shrubs) or species group (palatable forbs, other forbs) and air-dried before weighing.

At each transect (1994 and after), we estimated hiding cover using the method of Griffith and Youtie (1988), slightly modified. With the observer at the midpoint (15 m mark) of the transect, we placed a cover pole at four points 15 m away from the observer: at the zero and 30 m marks on the transect, and at two points 15 m from the midpoint and perpendicular to it. This method gives four replications of one cover pole reading for the site. The cover pole we used was the one prescribed in Griffith and Youtie (1988): A two-meter vertical rod, marked off into four 0.5-m sectors; each of these sectors is painted in five bands 0.1 m wide. A band is considered obstructed if more than ½ of the band is not visible to the observer. This pole is visible in many of the photographs, since we also used it for scale in the photographs.

Soil Sampling Methods

For each vegetation transect, we located and dug a soil pit within the macroplot, preferably within the major landform and vegetation that the transect represented. We described the soil pedon by horizon, including depth and thickness, texture, presence of mottles, color of soil crushed (both moist and dry), presence of carbonates. We dug the pit as deep as it was possible to get with a tile spade and soil auger with a 5-ft handle.

In the field or shortly thereafter, we made a tentative assignment of each soil at least as far as the soil great group level. Some time later, we keyed the soil out to great group, and we made appropriate adjustments made to the tentative field assignment. We used the keys and descriptions in Soil Survey Staff (1975-1996) and the descriptions in the five soil surveys in the UBG. We found that it was usually straightforward, if time-consuming, to key soils out in this way.

At the end of 1995, a total of 978 plots had been sampled with enough vegetation and soil information to use for analysis.

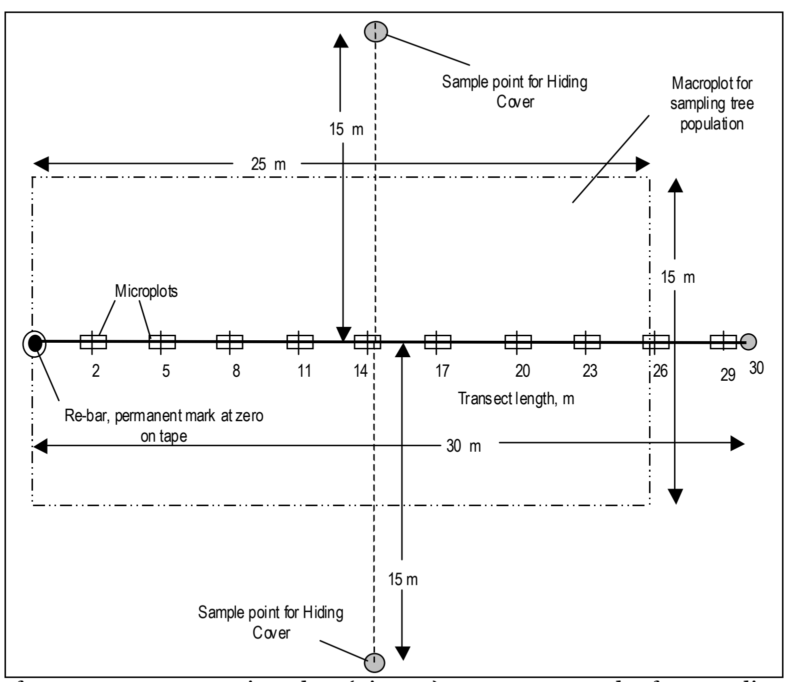

Fig. 5-2. Layout of 30 m transect, ten microplots (Fig. 5-1), 15 × 25 macroplot for sampling tree population, and sample points for sampling hiding cover.

Table 5-2. Quantities Sampled, Measured, or Recorded at Each Site.			
Quantity	**Concept, Method**	**Stratum**	**Units (to nearest)**
Canopy cover by species	Daubenmire (1959)	By microplot	Cover class
Canopy cover by species (shrub species)	Daubenmire (1959), Kinsinger and others 1960, Hanley 1978	By transect	Centimeters (1 cm)
Canopy cover for ground cover	Daubenmire (1959)	By microplot	Cover class
Canopy cover by layer	Daubenmire (1959)	By layer	Cover class
Layer heights (Minimum, Average, Maximum)	Estimate	By layer	Meters (0.1 m)
Tree height	Clinometer	One tree/species	Feet (1 ft)
Tree diameter (breast height)	Diameter-tape	One tree/species	Inches (0.1 in)
Number of trees	Count	By size class	Integer count
Tree growth by decade	Increment borer, Ruler	One tree/species	Millimeters (1 mm)
Tree age	Increment borer, count	One tree/species	Years (1 yr)
Depth of soil horizons (top and bottom)	Measuring tape	By horizon	Centimeters (1 cm)
Soil color (dry and moist), crushed	Munsell Color Charts	By horizon	Munsell Class
Mottle presence	Observation	By horizon	Abundance Class
Mottle color(s)	Munsell Color Charts	By horizon	Munsell Class(es)
Texture of mineral fraction	Soil Survey Handbook, Feel	By horizon	Texture Class
Percent organic matter	Feel	By horizon	Percent (5%)
Texture of organic fraction	Feel, observation	By horizon	Texture Class
Coarse Fraction (O, G, C, & S)	Sieve, estimate by weight	By horizon	Percent (5%)
Textural comp. of mineral fraction (S, SI, C)	Feel, estimate	By horizon	Percent (1-5%)
Geologic Formation and Lithology	Observation, identification	By horizon	Geology Map Class
Landform	Observation, identification	Whole site	Landform Class
Elevation	USGS Quadrangle Map	Sample Point	Feet (10 ft)
Aspect	Compass (uncorrected)	Sample Point	Degrees azimuth (1°)
Slope	Clinometer	Sample Point	Percent (1%)
Transect Direction	Compass (uncorrected)	Sample Point	Degrees azimuth (1°)
Transect Length	Tape measure	Sample Point	Meters (1 m)
Sample Point Location	GLO Survey	Sample Point	Quarter-Quarter Section
Sample Point Location	USGS Quadrangle Map	Sample Point	mm in 2 dimensions from SE corner of map

Data Storage and Analysis

For data storage and retrieval, we used a relational, object-based system: Paradox® Version 7 (Borland, 1996). For the last year, we used Paradox® Version 8 (Corel 1998). For statistical calculations, we used Statistix® (Analytical Software 1996).

We have deposited electronic copies of the raw data with the three cooperators in this project, listed on the title page, in appropriate formats.

We subjected vegetation cover and selected environmental data at each sample location to ordination, that is, reducing those data to a four-dimensional plot. We selected a detrended correspondence analysis method for analysis of the data: Decorana (Hill 1979).

For the initial ordination, we used 779 samples of the total 978 available; samples thought to be mixed were omitted from this step, as well as earlier seral stages of riparian areas and serviceberry shrublands. We noted clusters that appeared in the plot. We removed clusters that appeared to be clearly separate from the rest, and then ordinated the remaining data set again. This process was repeated (about 150 times) until all the 779 samples were grouped into tentative clusters. Thereafter, we added the samples excluded earlier to these clusters.

We assembled a complete correlation table, relating all plant species used in the classification, summary vegetation characteristics, ground cover categories, and selected soil and site characteristics. Also, we made a complete association table of each species in each sample. We used the correlation tables and association tables to assist in the final classification.

For final classification, we sorted the 978 samples into the clusters that emerged from the ordinations. At each step, we made new association tables and summary calculations for each of the new clusters. We prepared a paper report for each sample, and sorted these into the clusters and examined. In some cases, we then needed to design new clusters, and we made new association tables for the new clusters. We repeated this process until the clusters were relatively homogeneous in potential vegetation, soil, and landform. We started with over 250 clusters, which were boiled down to the 166 clusters finally used. We described some of the clusters as *Ecological Types*, and some lesser ones as *Phases*. We defined Ecological Types where there were major differences in potential

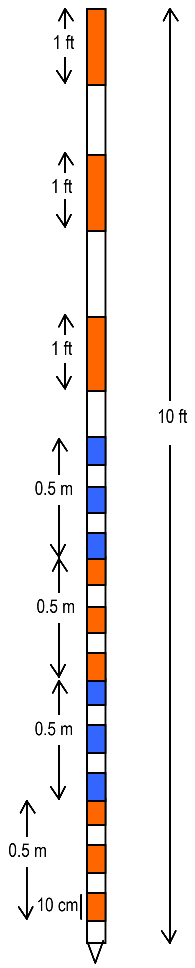

Fig. 5-3. The cover pole shown in photographs.

vegetation dominance, soil characteristics, landform, climate, or water. In contrast, we made phase distinctions where the differences were recognizable but reflected in minor or indefinite changes in potential vegetation, soils, landform, climate, or water.

Then we added other samples that didn't have soils or landform descriptions, and made new vegetation association tables of 1,666 samples. From these association tables, we grouped samples into *Community Types* based on several factors:

- Plant species dominance, as reflected by canopy cover values, for indicator plant species
- Total live cover and total cover by graminoids, shrubs, or other appropriate category (for example, total cover of willows)

For hiding cover, each sample using the method of Griffith and Youtie resulted in 16 integers (0–5), for the four replications and the four 0.5 m sectors of the pole (Fig. 5-3). We summarized these data were summarized by calculating a percentage obstruction for each of the four sectors, and then total obstruction for the whole 2 m pole.

Grouping into Community Types was a difficult and time-consuming process. Especially difficult was the often contradictory tasks of keeping relative homogeneity within Community Types and maintaining an acceptable number of samples per Community Type (4 to 5).

Initially, we described Community Types within phases of Ecological Types. After review by scientists and resource managers, we decided to eliminate the phase level in the classification. So the final classification appears here as 97 Ecological Types, divided into 377 Community Types.

For the descriptions, we made further calculations and analyses. We calculated basal area of tree stands using the following equation, where A_b is basal area (ft²/ac), and d is the total diameter (in/ac) at breast height of all trees > 5 in.

$$A_b = \frac{\pi d^2}{576}$$

We calculated average permeability for each soil sampled, using the formulas shown in the Glossary.

We air-dried the bags from the production samples, and then weighed them with and without the plant materials. We calculated productivity for each species and species class on a lb/ac/yr basis.

We calculated live cover as a simple sum of cover for all live species (except mosses and lichens) in four categories: shrubs, graminoids, forbs, and total (for non-tree species). We calculated several diversity measures; the one we used in the descriptions is TLC/S, total live cover divided by number of live species.

A view in my front yard, illustrating canopy cover classes. The broader-leaf grass is quackgrass (*Elytrigia repens*), a pest that I have nonetheless learned to live with, not having much choice, cover class 7 (70-80% cover). The green, narrow-leaf grass on the right is good old Kentucky bluegrass (*Poa pratensis*), cover class 6 (60-70% cover). The fine-leaf grass in the bottom left corner is some exotic fescue, cover class 3 (30-40% cover).