Plant Cover Estimation: A Contiguous Daubenmire Frame

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Plant cover is one of the most measured characteristics of vegetation. Cover is used to describe plant communities by individual species, to describe plant-environmental interactions within these communities, to monitor effects of changes on plant species within these communities, and to assess restoration or reclamation success of disturbed plant communities. Cover values have been widely used to calculate synthetic variables such as diversity indices and plant community coefficients. Individual plant species cover has been used to develop models for prediction of individual species biomass.

History of Cover Classes

The use of cover to describe vegetation communities originated in Europe during the first third of the 20th Century. During this period, plant ecologists used rating scales for plant species abundance in small areas of larger vegetation communities. Terms such as dominant, abundant, frequent, and rare were qualitative assessments of species occurrences.

These terms were considered sufficient to describe vegetation. Each term had to be accompanied by a definition supplied by the ecologist and as a result, comparisons of vegetation composition from place to place were difficult because terms were not consistent among observers.

A widely used cover-abundance scale developed by Braun-Blanquet during the 1920s was considered to be absolute because the scale was related to a fixed size of area as determined by the ecologist. Five scales were assigned numbers from 1 to 5 where 1 = less than 5% cover, 2 = 5–25% cover, 3 = 25–50% cover, 4 = 50–75% cover, and 5 = greater than 75% cover. The lower scale of 1 was often given an additional symbol to indicate level of abundance.

The noted USA plant ecologist, R. F. Daubenmire, modified the foregoing cover-abundance scale by division of the > 75% into two scales of 5 = 75–95% and 6 = 95–100% (Daubenmire 1959). He also used a 20 cm x 50 cm plot to estimate cover according to these scales. It is important to note that all historical cover measurements, including the method of Daubenmire, were originally obtained to describe plant communities, not to compare these communities.

Cover Definition

In spite of historical documentation stating otherwise, Daubenmire has been widely cited for his development of the cover class method. However he stated that plant cover is an approximation of the area over which a plant exerts its influence on other parts of the plant community.

In contrast to those before him, he insisted that cover is not an estimate of the shaded area on the ground and that plants may be present, but only the plant's area of influence may be measured. This definition led to the approximating polygons of plant canopies that occurred within his plot rather than on larger areas used by European ecologists. Because of the difficulty in measuring a plant's area of influence, other investigators soon interpreted the measurement Daubenmire made, with a given plot size and shape, to be synonymous with an estimation of cover rather than a plant's area of influence.

In turn, several definitions of plant cover followed, but most can be summarized as the percentage of ground covered by live vegetation material within a given reference area such as a plot.

Further Modifications

As noted above, Daubenmire derived the markings for his famous plot from the cover classes developed and used by European ecologists to describe areas of vegetation. They used cover scales for individual plant species occurring within an area called a releve' which was the bounded area of interest. Daubenmire insisted that he did not develop a "plot," but rather he developed "a canopy coverage method" using a marked plot.

His desire was that students of plant ecology be informed of the difference between the plot and the method. Perhaps, he also recognized that the description of his method in the famous 1959 publication had become so corrupted through "modifications," among vegetation ecologists, that his efforts might be hopeless to insist that we either use his method as it was published or not use his name. So, he personally expressed to the senior author of this paper that at least students of vegetation ecology should be taught that his "canopy coverage method" was just that, a method not a partitioned plot.

Particular definitions for plant cover have been and continue to be used according to the interests and needs of the ecologist who plans and conducts the vegetation study. The specific Daubenmire method itself continues to be ignored by all but a few field investigators.

Taking only the cover scale part of the Daubenmire method has resulted in a host of modifications to both the method and the frame. Changes have included range in cover class intervals, size of frames, shape of frames, and frame placements along transect lines. Cover classes range from the use of equal classes, such as those used by some of the federal land management agencies, to the use by field researchers of a small 0.1% increment class at lower cover values. Still others have used unequal classes at both the lower and upper cover values and retain equal cover class ranges in between. Some of these modifications essentially returned classes to the original cover-abundance scale of Braun-Blanquet.

The modern use of class intervals have complicated modifications made by Daubenmire to the original methods of the European ecologists. Changes in markings have been applied to various plot sizes and shapes. Circles, rectangles, and squares with varying area are used to obtain plant cover measurements.

Still, these plot descriptions in the literature are referred to as a "modified Daubenmire plot." It would be more appropriate to refer to one's modification as "another modification of the Braun-Blanquet method using the Daubenmire, 20 cm x 50 cm, frame" if the exact frame size and shape is used. It is not appropriate to refer to use of different size and/or shape changes to the original "Daubenmire plot" as a "modified Daubenmire plot or method." Changes in markings of a 20 cm x 50 cm plot should be clearly stated as a modification of Daubenmire's markings.

Visual vs Direct Measures

There is much disagreement in the literature over "estimates" versus "measurements." Recording cover obtained by visually guessing is referred to as "estimates" by some plant ecologists while others insist that a "measurement" of cover is obtained from these "estimates" as plot size approaches such a small area that it becomes a point. In any case, numerical values representing cover contain errors which in turn lead to inaccurate (statistically) measurements. To reduce possible confusion, we suggest that all numerical values of vegetation cover be referred to as "measurements" in keeping with the definition of a measure.

Observers may be deceived into believing that visual measurements are not as "accurate" as those obtained from pins, singly or in groups, that are placed along a line. These pin-methods are stated by some ecologists to be a "direct" or "accurate" method to obtain an estimate of plant cover. Yet, errors occur because of pin diameter size, length of pin, area of a pin point, and so forth.

Additionally, decisions must be made by the observer as to whether or not the point of the pin makes contact with any portion of a plant as the pin is lowered at a pre-selected angle through vegetation from a pre-selected position above the vegetation. The use of a laser beam to detect a contact does not eliminate other sources of variation, such as effects of air currents, plant water content, shading, and position of the equipment.

Some field studies comparing various pieces of equipment (points vs. plots) have been contradicted by results of other studies using the same type of equipment in a different vegetation type. Then a general problem seems to arise as to what is being measured and what is the subsequent use of this measure for plant cover. All types of equipment have in common the measurement of plant cover of an area or volume of space occupied by plants. Whether cover is obtained using plots, lines, point frames or single points, equipment affects the resulting cover measurement.

Accuracy vs Precision

It is difficult to ensure that no bias will enter, undetected, into measurement of plant cover obtained from any equipment, method of measurement, or from any observer. Because this is true, then it is proper to refer to the precision of a measurement rather than its accuracy.

Cochran (1977, p. 16) states: "Accuracy refers to the size of deviations from the true mean (mu), whereas precision refers to the size of deviations from the mean (m) obtained by repeated application of the sampling procedure." Then accuracy is never known in field studies.

Measurements can be very precise and not at all accurate because the process of measuring cover can be repeated by various observers using the same cover class intervals. Therefore, repeatable results are not equivalent to accuracy when obtaining cover measurements because the true average remains unknown.

Still many articles report results of cover sampling exercises wherein various equipment, measurement methods, and sampling designs were compared in terms of precision and accuracy when in fact accuracy was not determined. On the other hand, reporting precision or relative precision (relative to the average) may be useful in comparative studies of cover methods.

A Field Trial

A frame was constructed to contain five contiguous plots that Daubenmire described for use in his method. The goal was to reduce most sources of error in visual estimates of plant cover obtained from plots. A trial evaluation of the frame was conducted on reclaimed land of The Pittsburg & Midway Coal Mining Company's York Canyon Mine Complex near Raton, New Mexico.

Currently, vegetation on the reclaimed area consists of grass or grass/shrub plant communities. Requirements of the New Mexico Energy, Minerals, and Natural Resources Department, Mining and Minerals Division state that amounts of total live plant cover and total cover (includes plant cover, litter, and surface rocks) are sufficient for phase II consideration of partial bond release. Phase III requires additional demonstrations that cover criteria must be met on that reclaimed area.

We refer to our arrangement of individual Daubenmire method plots as the Extended Daubenmire Method which seemed appropriate because it incorporates the marked plot used by Daubenmire. Five of these 20 cm by 50 cm plots were placed in a contiguous series within a larger frame (50 cm x 101.2 cm) (Figure 1). The 1.2 cm added to a meter length frame account for the cross bars used in the extended frame. This single large frame was constructed to secure the boundary defi-

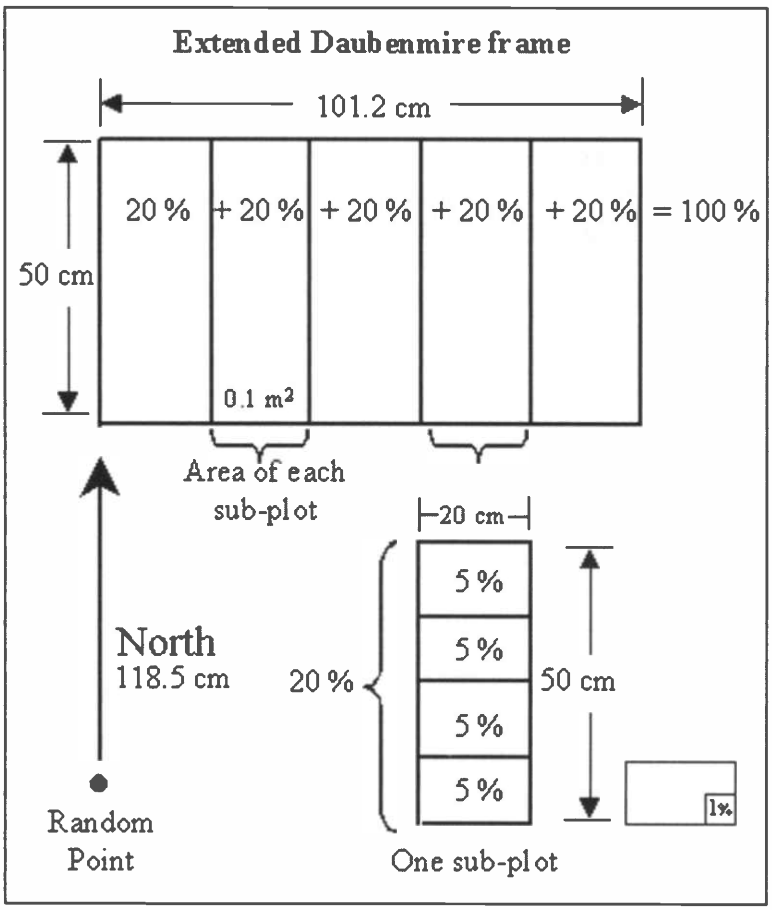

Figure 1. *Schematic diagram of the extended Daubenmire Method frame.*

Table 1. Example of cover data by species and categories using the extended Daubenmire method.

Date:11/23/00	Sample Point: 26					
Cover type	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Total
Total cover	17	14	18	19	15	83
Bare ground	3	6	2	1	5	17
Litter	9	6	12	8	10	45
Rock	0	1	0	1	0	2
Bocu	3	1	1	0	2	7
Scsc	1	0	2	7	1	11
Pasm	4	6	3	3	2	18
Total live plant	8	7	6	11	5	36

nitions for each of the 5 contiguous, smaller plots. The dimensions and markings of the extended frame are in accordance with the 5- Daubenmire method plots, each of which retains its individuality in data recording.

Each 0.1 m^2 plot area, as originally marked by Daubenmire, is reduced by a factor of 5 and represents 20% of the area of the extended frame (0.5 m^2). The 5% area of the Daubenmire method plot becomes 1% while the original 25% area of the Daubenmire method plot represents 5% of the extended Daubenmire method frame. Then each individual plot within the extended frame represents only 20% of the total measurement area (50 cm x 100 cm). This arrangement of individual plots results in the original 5% area becoming a 1% area within each original plot (Fig.1). This 1% area allows measurements to be more precisely made in 1% increments of an individual species' cover, total live plant cover, and litter plus rock cover.

The summation of cover measurements for plant species over all 5 plots at each sample point provides a cover estimate at each sample point. An example of a placement of one extended frame is given in Figure 2. An abbreviated example of data recording is presented in Table 1. Sample locations were obtained by randomly selecting 30 points from two-dimensional grid lines placed on a map of the reclaimed area.

The extended Daubenmire method frame was placed approximately 1.18 m north of each grid location with the longest axis facing an East-West direction. Two steel pins were used to hold the extended frame in place. Percentage cover was visually measured within each Daubenmire plot to the nearest 1% for each plant species, litter + rock, and total live plant cover. Percentage bare ground was also independently measured for each plot and used as a check for measurements of total ground cover (100 - % total ground cover = % bare ground).

Data were summarized to obtain averages for the 30 extended frames. Again, the extension of Daubenmire's method was to obtain more precise visual measurements of cover by increasing the size of a 1% area relative to the original plot size used by Daubenmire.

Evaluation

The use of the extended Daubenmire method only included the measurement of ground cover as defined by the majority of field ecologists. We suggest that the users of the extended frame consider the following:

- The extended method should lead to increased repeatability for one or more observers and provide a more reliable measure of cover to the nearest 1% as required by some state and federal agencies involved in reclamation of surface mined-land.
- It was tempting to use fractions of less than 1% for cover measurements because of the large 1% area displayed within the individual plots of the extended frame. We recommend that all cover data be recorded to the nearest 1% to preserve the reason for using the extended Daubenmire method frame in the first place. Recall that a major concern in using the Daubenmire method plot to measure plant cover is the lack of precision resulting from a single observer or among several observers working in the same vegetation type. Use of the

Figure 2. ***In the field illustration of the Daubenmire method plot arranged within the painted frame that designates area percentages. Each cross bar is removable for easy placement of the frame.***

nearest 1% measure provided by the extended frame, rather than fractions thereof, should increase precision.

- Recognize that the data collected from the extended frame should not be used to compare results with other plot sizes and shapes or with other categories for cover. For example, to multiply the first plot in the extended frame by a factor of 5 to convert all plot data into original Daubenmire Method plot data for comparisons may result in biased estimates of cover measurements.

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