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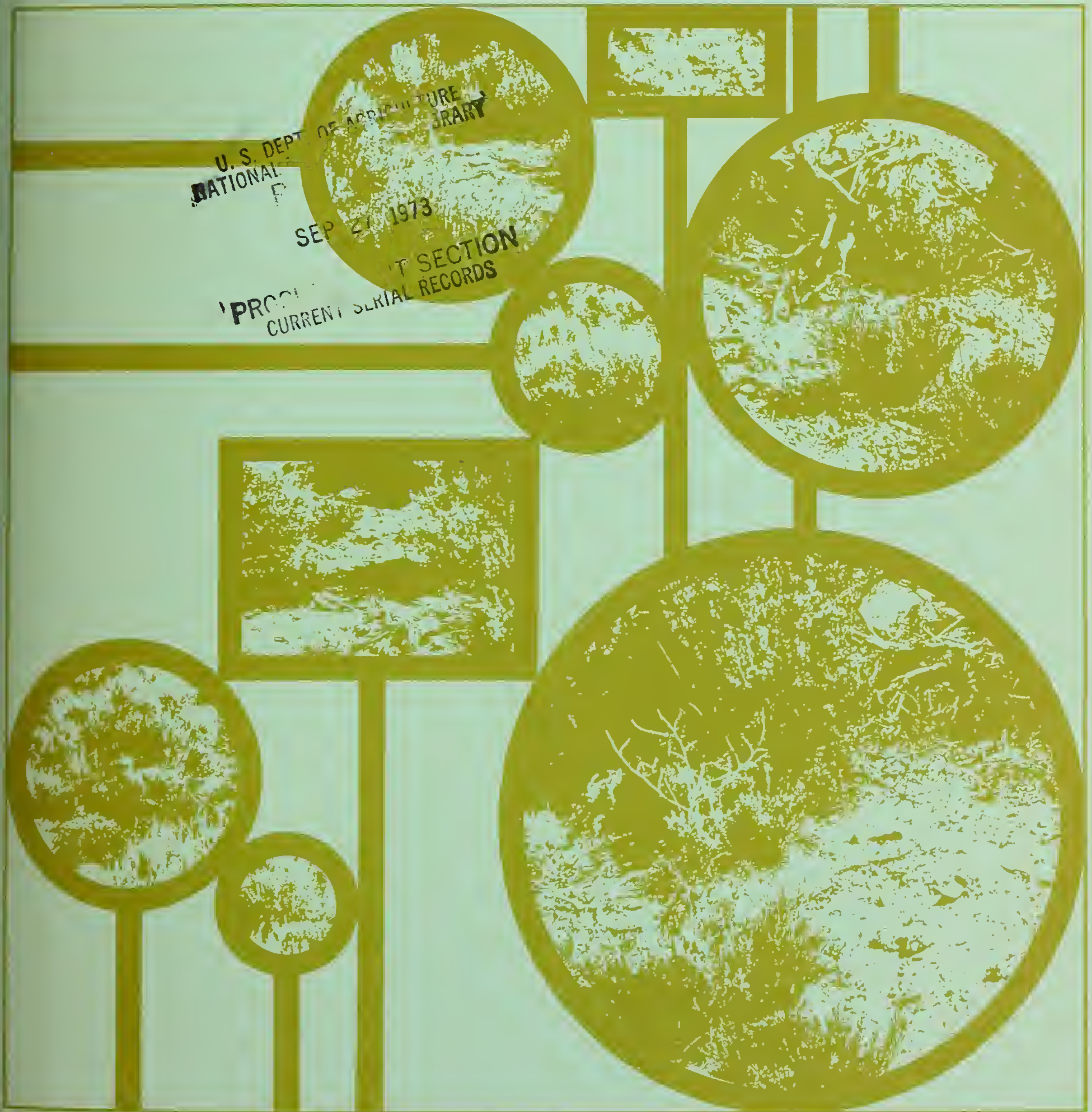
Estimating Understory Plant Cover With Rated Microplots

by Meredith J. Morris



Abstract

Plant cover measurements are used to detect changes caused by grazing, fire, and other factors. Tests on both high and low production sites of 17 areas in the West indicate that trained range personnel rate small plots similarly in respect to the area occupied by aerial and basal plant cover. Plots used ranged from 1/8 square inch to 8 square inches. Equal area rectangles and circles were used. All are well suited for rating plant cover, although the smaller sizes tended to be slightly more precise.

Oxford: 268.5. **Keywords:** Range measurements, range surveys, plant cover.

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by

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Estimating Understory Plant Cover With Rated Microplots

Meredith J. Morris

For some time, land managers on National Forest and other publicly owned rangelands have expressed a need for an indicator of how influences such as livestock grazing, big game use, recreation, and other environmental factors are affecting the range. In my opinion, plant cover—percent area occupied by shrubs, forbs, and grasses—is the best single measure of these impacts upon understory vegetation. Several studies by other people and some preliminary work of my own have shown that rating or scoring the area occupied by plants inside small plots, or "microplots," might be used to estimate plant cover, both aerial and basal. If, in fact, cover could be estimated accurately and efficiently from rated microplots, then this technique should be considered for general use and for possible incorporation into the "3-Step Method" for measuring trend in range condition (Parker 1951). The plant cover index, as derived in the 3-Step Method, is synonomous with the frequency (of occurrence) figure long used by plant ecologists. The plot used in the 3-Step Method is much smaller than what is generally used by ecologists, however.

Frequency is partially dependent upon plant cover, so the two measures will be correlated. The degree of correlation will depend upon many factors, however. Hence, the value of frequency as an index to plant cover will vary from one set of conditions to another.

Previous Work

Although several authors pointed out that plant density or cover indexes were larger than estimates of plant cover obtained by methods such as points or line intercept, they did not give reasons for the difference. Hutchings and Holmgren (1959) discussed the relation between plant density index (frequency of aerial and basal cover) and actual plant cover, as well as the effects of plot size, number and size of plants, plant dispersion, and plant shape on the index. The overestimate of cover, or bias, obtained by use of the loop as discussed by Hutchings and Holmgren (1959) is actually identical to the bias discussed by Goodall (1952) in relation to the overestimation of cover with pins when the points of the pins have greater than zero dimension.

The idea of using rated plots for estimating plant cover is not new. The use of a very small plot, or "microplot," has been limited, however. Hutchings and Holmgren (1959) summarized the results of a test on synthetic plant populations composed of 29/32-inch-diameter circles with concentric 3/8-inch-diameter circles of different colors randomly located on a strip of paper 2 feet wide and 60 feet long. Several observers sampled these synthetic populations with a 13/16-inch-diameter loop at 1-foot intervals along randomly located 50-foot line transects. The loops were rated to the nearest one-tenth of area occupied. A large number of samples showed that the rated loops provided close estimates of the actual area occupied by the artificial populations of 3/8-inch and 29/32-inch circles. Estimates were 1.2 and 1.1 times greater than the actual for the two populations, respectively. Some of the differences between the actual and observed values could be attributed to sampling error, however, as the rated loop estimates were quite variable in these particular populations.

Cook and Box (1961) compared rated 3/4-inch loops with point-frame and single point readings for crown canopy and basal area along 100-foot transects in a mountain brush type in northern Utah. For the loop, a measurement was not recorded unless one-half or more of the loop was filled; this constitutes a 2-point scale. Only first contacts were recorded in aerial cover for all three methods. They found that the rated loop overestimated aerial cover for shrubby species and underestimated it for grasses. Estimates of aerial cover for forbs and basal area for all groups were essentially the same by all three methods.

Winkworth, Perry, and Rossetti (1962) compared estimates from three sizes and shapes of rated plots with those obtained from points and line intercepts in an arid tussock grassland in central Australia. The small plots used for rating or scoring were a circle of 1.9 cm (0.75 inch) diameter, and rectangles measuring 2 cm by 5 cm and 4 cm by 10 cm. Presence or absence of aerial cover in the circular plot was scored according to whether cover was greater or less than 50 percent. The rectangular plots were scored in 10 percent cover classes from 0 to 100. A comparison of means and variances showed that, while the line intercept method was in doubt, for all practical purposes the five methods gave similar and equally reliable estimates. The point method and the rated circular plot were more rapid than the others.

In July 1962, a preliminary test of rated microplots was conducted in the Fairfield District of the Sawtooth National Forest in

Idaho. A meadow site and a bunchgrass site were sampled with 25 randomly located points each. Four rectangles and four circles of varying size, fully described later in this report, were rated to the nearest one-tenth of area occupied by shrub, forb, and grass species for both aerial cover and basal area. Litter, rock, bare soil, erosion pavement, and mosses on the soil surface were also rated. The same items rated on the microplots were also recorded using a 10-point frame at the same sample points.

Although the data were not completely analyzed, summaries showed no apparent differences in the ratings from the different microplots. The point frame and the larger microplots detected more species, however. It was also noticed that some of the microplots were easier to score than others.

Since the use of rated microplots seemed to be feasible from the results of the preliminary test, a large-scale study was designed with the following objectives:

1. To determine the effect of selected microplot sizes and shapes on ratings of cover or percent area occupied by plants.
2. To estimate the optimum microplot on the basis of a minimized variance-cost function.
3. To compare cover estimates derived from rated microplots and pins in a point frame.

Procedures

Study Areas and Sampling Layout

The study was designed to sample the major range types at 17 locations in the western United States. These locations were selected within National Forests and Experimental

Table 1.--Vegetation types, locations on Ranger Districts (RD) of National Forests (NF) and Experimental Forests and Ranges, and sampling dates

Vegetation type	Location	Sampling date
Mountain grassland	Helena NF - Townsend RD, Townsend, Montana	June 1963
Mountain bunchgrass-Thurber fescue	Black Mesa Exp. Range, Crawford, Colorado	July 1964
Pacific bunchgrass	Sawtooth NF - Twin Falls RD, Twin Falls, Idaho	June 1963
Sod-forming grama	Sitgreaves NF - Pinedale RD, Snowflake, Arizona	October 1963
Mixed gramas	Santa Rita Exp. Range, Amado, Arizona	October 1963
Mountain meadow	Beaverhead NF - Jackson RD, Jackson, Montana	July 1964
Mountain meadow	Tahoe NF - Sierraville RD, Sierraville, California	August 1964
Upland herb-aspen	U.S. Sheep Station Exp. Range, Dubois, Idaho	August 1964
Sagebrush-grass	U.S. Sheep Station Exp. Range, Dubois, Idaho	June 1964
Chaparral	Prescott NF - Granite RD, Prescott, Arizona	April 1964
Mixed shrub	Roosevelt NF - Redfeather RD, Redfeather Lakes, Colorado	September 1964
Sagebrush-bitterbrush	Tahoe NF - Truckee RD, Truckee, California	August 1964
Pine-bunchgrass	Manitou Exp. Forest, Woodland Park, Colorado	August 1963
Pine-bunchgrass	Ochoco NF - Big Summit RD, Pineville, Oregon	June 1964
Pine-pinegrass	Starkey Exp. Range, LaGrande, Oregon	August 1963
Aspen-weed	Routt NF - Bears Ears RD, Craig, Colorado	July 1963
Annual grass	San Joaquin Exp. Range, Coarsegold, California	May 1964

Areas to represent most of the major range forage types of the National Forests.

The range types and locations sampled and sampling dates are shown in table 1. At each location we selected two contrasting test sites, one containing an abundance of vegetation and a similar site containing a sparse amount (fig. 1). The amount and homogeneity of the vegetation on the two sites were the criteria for selection as test areas.

The size of the sampling area varied from about 1/2 acre minimum to about 5 acres maximum. Fifty random sample points were marked on each site (high and low), making a total of 100 sample points for each location. Each sample point was located by means of compass

Figure 1.—Two contrasting test sites in the ponderosa pine-bunchgrass type, Manitou Experimental Forest, Colorado:

A low-production site

A high-production site

bearings and pacing, and marked with an angle iron stake with 3/4-inch flanges driven into the ground to provide a fixed locus for the microplots and point frame. All stakes were oriented so that the open side of the "V" faced north. The maximum height of the stakes aboveground was about 5 1/2 feet; measurements were taken only from the 4-foot level to the ground surface.

About 3 feet south of each metal stake, a surveyor's wooden stake was driven into the ground. Each wooden stake was numbered and tagged for permanent identification so that remeasurements could be made at a future time to measure vegetative or site changes.

Microplot Ratings

Two microplot shapes (circles and rectangles) with four sizes per shape were tested (fig. 2). The circle has the least perimeter of any geometric figure for a fixed area. The rectangle was arbitrarily designed with the length being twice the width. Each pair of shapes enclosed an equal area, so that microplot shapes could be directly compared. The areas in square inches and the dimensions in inches for each microplot size and shape were:

Rectangle	Area	Circle (diameter)
1/4 x 1/2	0.125	0.3989
1/2 x 1	.500	.7979
1 x 2	2.000	1.5958
2 x 4	8.000	3.1915

Aerial or crown cover and basal area by species for shrubs, forbs, grasses, and soil surface items were rated at each sample point. Items rated were defined as follows:

1. **Aerial cover.**—The vertical projection by species of all live plant parts from the 4-foot level to the ground surface.
2. **Basal area.**—The area occupied by live plant parts at the ground surface, or the area defined by live root crown. The basal area of plants with basal rosettes was understood to be the area defined by live root crowns only; the rest of the live parts were considered aerial cover.
3. **Litter.**—Dead organic material lying on the soil surface from previous years' growth. Dead centers of plants were also considered as litter if the parts were in contact with the ground surface. Animal droppings were considered as litter.

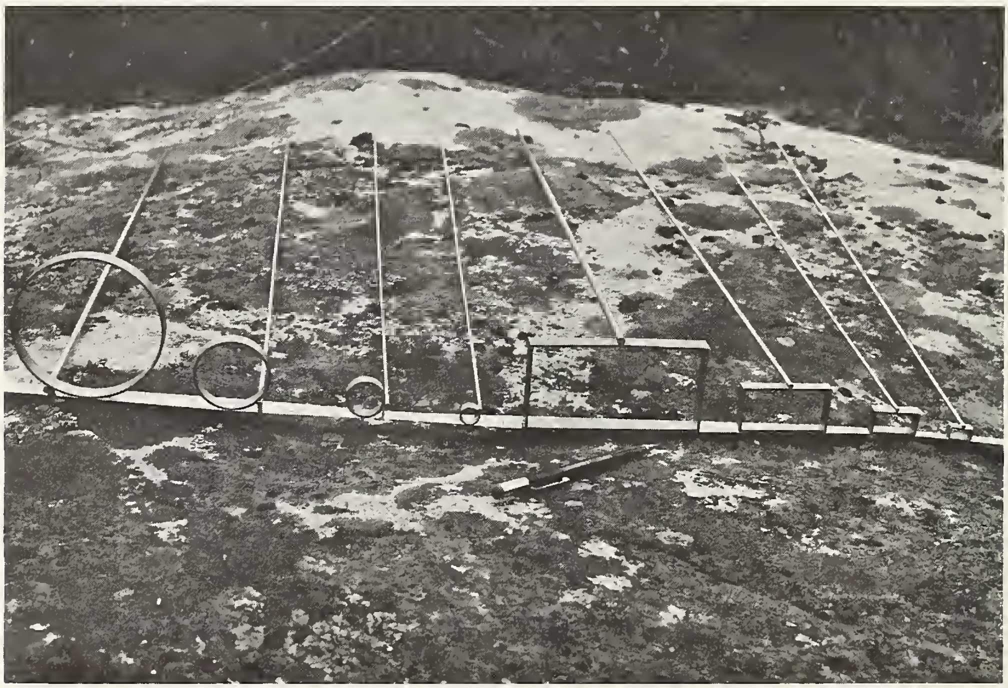

Figure 2.—Set of eight frames used in microplot study. The largest rectangle is 2 by 4 inches.

4. **Moss and lichens.**—Area covered by moss and lichens growing on the soil surface.
5. **Bare soil.**—All exposed mineral soil and rock particles up to 1/8 inch diameter, and well-dispersed rock particles up to 3/4 inch diameter that did not provide a continuous cover.
6. **Erosion pavement.**—Particles of rock from 1/8 to 3/4 inch in diameter forming a continuous cover on the soil surface. Individual rock particles from 1/8 to 3/4 inch in diameter that did not form a continuous cover were classified as bare soil.
7. **Rock.**—Stones larger than 3/4 inch in diameter at the soil surface.

Two teams of two men each worked at each site. One man on each team made the readings for all eight of the microplots at all the sample points in the site; the other man did all the recording. Therefore, two complete sets of readings were taken at each site. Forms were designed for field use that would allow data to be transferred directly to punch cards.

Sliding metal arms, which clamped securely to the angle iron stake at a desired height, were used to position the microplot frames in the same place (fig. 3). The eight microplots were rated, in random order, by each observer on each team to the nearest one-tenth (1/10 = score of 1; 10/10 = score of 10) of area occupied, for each of the items that occurred in that microplot. Only one randomly selected microplot frame at a time was used by each team until all the readings had been made at all 50 sample points in the site. Within each microplot, ratings of basal area and soil surface items could have only a maximum total of 10; the aerial cover ratings did not have any combined maximum value.

Figure 3.—Sliding metal arm used to position microplot frames in the same place.

Point-Frame Readings

After the ratings had been completed in a site by each of the two observers for all eight microplot frames, point readings from the 4-foot level to the ground were taken by means of a circular point frame containing 10 vertical pins. The point frame was designed so that the 10 pins were equally spaced on a circle with a circumference equal to that of the largest circular microplot (fig. 4). All hits by species on live aerial parts of plants and hits on basal area by species and soil surface items were recorded. Only one set of point readings was made on each site.

Time records were kept for each of the microplots and the point-frame readings (that is, for each set of 50 observations). When an observer started rating one of the microplots at the first sample point in a site, the recorder on the team started a stopwatch. At the completion of the last reading, the watch was stopped and the total elapsed time recorded. The watch was stopped during any interruptions. The time involved in taking the point readings was measured in a similar manner.

Data Analyses

Microplot and point-frame data were analyzed in the following steps: (1) Identifying and informative material such as plant species names were edited and coded numerically; (2) measurement and coded data were punched on cards; (3) computer programs were written and checked; and (4) detailed variance analyses were computed.

Figure 4.— Specially designed point frame used in microplot study.

Analyses of variance were made on the aerial cover data with plot shape, plot size, observers, sites, and locations being the main effects. A plant species thus had to be present on both sites within two or more locations. A maximum of seven locations could be used in the combined analysis because of storage limitations in the computer. The analyses were repeated for basal area ratings of each plant species and ratings of ground surface items. A mixed components-of-variance model was assumed in this study, with microplot shape, microplot size, and site being fixed effects and observer and location being random effects. The components of variance in this mixed model are shown in table 2. Note that the main effects, A, B, and D, and the interactions, AB, AD, BD, and ABD, have no error terms for making significance tests (*F* test). In these cases, approximate tests were used (Cochran 1951, Satterthwaite 1946).

Point-frame readings of aerial cover and basal area of plant species and ground surface items were summarized by observer, site, and location, and compared directly with the largest circular microplot ratings in analyses of variance. Methods (points versus ratings of two observers) and sites were assumed to be fixed effects, and locations a random effect. The components-of-variance model for this analysis is shown in table 3.

Results and Discussion

Microplot Ratings

If the "best" microplot or plots were determined for each plant species or soil surface item, each cover type, each site, and each location, it would be difficult to select the one optimum microplot for management purposes. Therefore, the microplot ratings were analyzed for a particular plant species or soil surface item and cover type occurring at two or more locations. Note in table 2 that individual observer, site, and location differences are evaluated. Grasses, forbs, shrubs, and soil surface items (different forms and shapes) were all represented in the combined location analyses.

Examples of combined location analyses are shown in tables 4 and 5. Table 4 is the analysis of variance for ratings of aerial cover of *Achillea lanulosa* Nutt., or woolly yarrow. The four locations are mountain bunchgrass-Thurber fescue, upland herb-aspen, pine-bunchgrass, and aspen-weed. Note that significant differences were found between locations in the main effects and in the interaction terms, shape-by-observer and site-by-location. Since observer and location effects are confounded (different observers were used at different locations), the significant terms are not important. And, of course, sites and

Table 2.--Components-of-variance model for microplot ratings--combined locations

Shape	A (a=2)	$\sigma^2 + rbd\sigma^2_{ACE}$	$+ rbcd\sigma^2_{AE}$	$+ rbde\sigma^2_{AC}$	$+ rbcde\sigma^2_{A}$
Size	B (b=4)	$\sigma^2 + rad\sigma^2_{BCE}$	$+ racd\sigma^2_{BE}$	$+ rade\sigma^2_{BC}$	$+ racde\sigma^2_{B}$
Observer	C (c=2)	$\sigma^2 + rabd\sigma^2_{CE}$	$+ rabde\sigma^2_{C}$		
Site	D (d=2)	$\sigma^2 + rab\sigma^2_{CDE}$	$+ rabc\sigma^2_{DE}$	$+ rabe\sigma^2_{CD}$	$+ rabce\sigma^2_{D}$
Location	E (e=2,3,..., 7)	$\sigma^2 + rabd\sigma^2_{CE}$	$+ rabcd\sigma^2_{E}$		
AB		$\sigma^2 + rd\sigma^2_{ABCE}$	$+ rcd\sigma^2_{ABE}$	$+ rde\sigma^2_{ABC}$	$+ rcde\sigma^2_{AB}$
AC		$\sigma^2 + rbd\sigma^2_{ACE}$	$+ rbde\sigma^2_{AC}$		
BC		$\sigma^2 + rad\sigma^2_{BCE}$	$+ rade\sigma^2_{BC}$		
ABC		$\sigma^2 + rd\sigma^2_{ABCE}$	$+ rde\sigma^2_{ABC}$		
AD		$\sigma^2 + rb\sigma^2_{ACDE}$	$+ rbc\sigma^2_{ADE}$	$+ rbe\sigma^2_{ACD}$	$+ rbce\sigma^2_{AD}$
BD		$\sigma^2 + ra\sigma^2_{BCDE}$	$+ rac\sigma^2_{BDE}$	$+ rae\sigma^2_{BCD}$	$+ race\sigma^2_{BD}$
ABD		$\sigma^2 + r\sigma^2_{ABCDE}$	$+ rc\sigma^2_{ABDE}$	$+ re\sigma^2_{ABCD}$	$+ rce\sigma^2_{ABD}$
CD		$\sigma^2 + rab\sigma^2_{CDE}$	$+ rabe\sigma^2_{CD}$		
ACD		$\sigma^2 + rb\sigma^2_{ACDE}$	$+ rbe\sigma^2_{ACD}$		
BCD		$\sigma^2 + ra\sigma^2_{BCDE}$	$+ rae\sigma^2_{BCD}$		
ABCD		$\sigma^2 + r\sigma^2_{ABCDE}$	$+ re\sigma^2_{ABCD}$		
AE		$\sigma^2 + rbd\sigma^2_{ACE}$	$+ rbcd\sigma^2_{AE}$		
BE		$\sigma^2 + rad\sigma^2_{BCE}$	$+ racd\sigma^2_{BE}$		
ABE		$\sigma^2 + rd\sigma^2_{ABCE}$	$+ rcd\sigma^2_{ABE}$		
CE		$\sigma^2 + rabd\sigma^2_{CE}$			
ACE		$\sigma^2 + rbd\sigma^2_{ACE}$			
BCE		$\sigma^2 + rad\sigma^2_{BCE}$			
ABCE		$\sigma^2 + rd\sigma^2_{ABCE}$			
DE		$\sigma^2 + rab\sigma^2_{CDE}$	$+ rabc\sigma^2_{DE}$		
ADE		$\sigma^2 + rb\sigma^2_{ACDE}$	$+ rbc\sigma^2_{ADE}$		
BDE		$\sigma^2 + ra\sigma^2_{BCDE}$	$+ rac\sigma^2_{BDE}$		
ABDE		$\sigma^2 + r\sigma^2_{ABCDE}$	$+ rc\sigma^2_{ABDE}$		
CDE		$\sigma^2 + rab\sigma^2_{CDE}$			
ACDE		$\sigma^2 + rb\sigma^2_{ACDE}$			
BCDE		$\sigma^2 + ra\sigma^2_{BCDE}$			
ABCDE		$\sigma^2 + r\sigma^2_{ABCDE}$			
Residual	(r=50)	σ^2			

Table 3.--Components-of-variance model for point-frame readings versus largest circular microplot ratings--combined locations

Method	A (a=3)	$\sigma^2 + rb\sigma^2_{AC} + rbc\sigma^2_A$
Site	B (b=2)	$\sigma^2 + ra\sigma^2_{BC} + rac\sigma^2_B$
Location	C (c=2,3,..., 7)	$\sigma^2 + rab\sigma^2_C$
AB		$\sigma^2 + r\sigma^2_{ABC} + rc\sigma^2_{AB}$
AC		$\sigma^2 + rb\sigma^2_{AC}$
BC		$\sigma^2 + ra\sigma^2_{BC}$
ABC		$\sigma^2 + r\sigma^2_{ABC}$
Residual	(r=50)	σ^2

Table 4.--Analysis of variance for microplot ratings of aerial cover of *Achillea lanulosa* at four locations

Source of variation		Degrees of freedom	Sum of squares	Mean squares
Shape	(A)	1	0.744	0.744
Size	(B)	3	8.36	2.79
Observer	(C)	1	0.620	0.620
Site	(D)	1	68.3	68.3
Location	(E)	3	119.0	39.6 **
AB		3	0.594	0.198
AC		1	0.439	0.439 **
BC		3	4.47	1.49
ABC		3	0.447	0.149
AD		1	0.263	0.263
BD		3	5.56	1.85
ABD		3	0.0355	0.0118
CD		1	1.41	1.41
ACD		1	0.000156	0.000156
BCD		3	3.51	1.17
ABCD		3	0.325	0.108
AE		3	0.0817	0.0272
BE		9	17.2	1.91
ABE		9	1.47	0.164
CE		3	2.76	0.920
ACE		3	0.0367	0.0122
BCE		9	10.1	1.13
ABCE		9	1.58	.176
DE		3	320.0	107.0 **
ADE		3	0.653	0.218
BDE		9	26.6	2.96
ABDE		9	1.31	0.146
CDE		3	0.590	0.197
ACDE		3	1.24	0.415
BCDE		9	12.1	1.35
ABCDE		9	0.601	0.0668
Residual		6262	5540.0	0.884
Total		6399	6150.0	

** - Significant at the 0.01 probability level.

Table 5.--Analysis of variance for microplot ratings of bare soil at six locations

Source of variation		Degrees of freedom	Sum of squares	Mean squares
Shape	(A)	1	17.7	17.7
Size	(B)	3	19.1	6.36
Observer	(C)	1	1.98	1.98
Site	(D)	1	6540.0	6540.0 **
Location	(E)	5	11200.0	2250.0 **
AB		3	12.0	3.99
AC		1	3.30	3.30
BC		3	32.2	10.7
ABC		3	6.31	2.10
AD		1	0.220	0.220
BD		3	3.26	1.09
ABD		3	1.80	0.599
CD		1	1.60	1.60
ACD		1	0.00667	0.00667
BCD		3	5.39	1.80
ABCD		3	10.4	3.47
AE		5	18.6	3.72
BE		15	36.7	2.45
ABE		15	31.0	2.07
CE		5	199.0	39.9 **
ACE		5	54.7	10.9
BCE		15	57.6	3.84
ABCE		15	43.4	2.89
CE		5	3520.0	704.0 **
ADE		5	16.9	3.38
BDE		15	137.0	9.16
ABDE		15	18.0	1.20
CDE		5	124.0	24.8 **
ACDE		5	12.5	2.50
BCDE		15	74.7	4.98
ABCDE		15	49.8	3.32
Residual		9408	58700.0	6.24
Total		9599	81000.0	

** - Significant at the 0.01 probability level.

locations were selected to be different. The mean cover estimates of the eight microplots corresponding to the analysis in table 4 were:

	Mean cover	
Size	Rectangle	Circle
1	0.314	0.320
2	.242	.228
3	.251	.206
4	.254	.221
Mean	.265	.244

Size 1 is the smallest plot, and size 4 is the largest.

Table 5 is the analysis of variance for ratings of bare soil at six combined locations—mountain grassland, mountain bunchgrass-Thurber fescue, upland herb-aspen, pine-bunchgrass, pine–pinegrass, and aspen-weed. Significant differences were found between sites and locations in the main effects and in the interaction terms, observer-by-location, site-by-location, and observer-by-site-by-location. The mean cover estimates of the eight microplots corresponding to the analysis in table 5 were:

	Mean cover	
Size	Rectangle	Circle
1	1.65	1.77
2	1.67	1.84
3	1.68	1.75
4	1.83	1.81
Mean	1.71	1.79

There were 22 analyses of the combined locations type for aerial cover of different plant species, and 20 analyses for basal area of plant species and soil surface items. The same pattern developed throughout all these analyses: differences in the main effects, except for site and location, were almost all nonsignificant. On a very broad basis, then, we can say that differences in microplot shape, microplot size, and observers are nonsignificant statistically for the populations studied. First-order interaction terms that were significant mostly involved site or location differences.

Point-Frame Readings

The ratings from the largest circular microplot (about 3.2-inch diameter) and the point-frame readings are compared statistically in table 6. This table is the analysis of variance for bare soil at the same six locations that are combined in table 5. Mean ratings of each of two observers are compared to point-frame readings in table 6, hence the two degrees of freedom for method.

Table 6.--Analysis of variance for methods comparison of bare soil readings at six locations (largest circular microplot versus point frame)

Source of variation		Degrees of freedom	Sum of squares	Mean squares
Method	(A)	2	27.1	13.5
Site	(B)	1	1250.0	1250.0 *
Location	(C)	5	1820.0	363.0 **
AB		2	3.64	1.82
AC		10	89.3	8.93 *
BC		5	571.0	114.0 **
ABC		10	40.4	4.04
Residual		1764	7870.0	4.46
Total		1799	11700.0	

* - Significant at the 0.05 probability level.
** - Significant at the 0.01 probability level.

For aerial cover, only one analysis out of 22 showed a significant difference (table 7). For basal area and soil surface items, only two analyses out of 19 showed significant differences (table 8).

Point-frame readings were higher in absolute value than the 3.2-inch plot ratings in all but two cases for the aerial cover analyses (table 7). This is to be expected, however, because the vertical projection within a fixed plot boundary will have a maximum value of 100 percent cover, while pin contacts can add up to over 100 percent cover since each contact for a species is recorded. Differences between the two methods were with grass species.

For soil surface items and basal area of plants, only 7 out of 19 analyses showed point-frame readings to be higher in absolute value than microplot ratings (table 8). Thus, there is a tendency for the rated microplots to give somewhat higher readings (12 out of 19) than the point frame, indicating a small positive bias. This bias is not considered to be important from a practical standpoint, however.

Table 7.--Mean values for 3.2-inch-diameter plots and point frames, and nearest plot means, sizes, and shapes for aerial cover

Species or soil item	Number of locations	3.2-inch plot	Point frame	Nearest plot values Mean	Size and shape[1]
Annual forbs	4	0.276	0.310	0.286	1C
Achillea lanulosa	5	.221	.330	.320	1C
Agoseris glauca	3	.363	.473	.365	4R
Antennaria rosea	2	.693	.735	.693	4C
Fragaria virginiana	2	.138	.130	.128	4R
Lathyrus leucanthus	2	.143	.220	.225	1C
Taraxacum officinale	2	.128	.110	.122	3C
Annual grasses	2	.365	1.27	.673	1C
Agropyron spicatum	3	.283	.603	.365	1R
A. *trachycaulum*	2	.123	.595	.175	1C
Bouteloua gracilis	3	.518	.837	.580	4R
Calamagrostis rubescens	2	.418	1.14	.530	1R
Deschampsia caespitosa	2	1.13	2.53	1.14	1C
Festuca idahoensis	3	.970	2.46	.970	4C
Koeleria cristata	2	.163	.320	.163	4C
Poa secunda	3	.132	.367	.258	1C
Sitanion hystrix	2	.128 *	.180	.192	1C
Stipa comata	2	.030	.065	.060	2R
Carex spp.	2	1.11	1.19	1.18	2C
Artemisia frigida	2	.605	1.28	.633	4R
A. *tridentata*	3	.623	.873	.833	1C
Purshia tridentata	2	.833	1.26	.833	4C

* - Significantly different from points.

[1] - R = rectangle, C = circle, 1 to 4 = smallest to largest size.

Table 8.--Mean values for 3.2-inch-diameter plots and point frames, and nearest plot means, sizes, and shapes for basal area and soil surface items

Species or soil item	Number of locations	3.2-inch plot	Point frame	Nearest plot values: Mean	Nearest plot values: Size and shape[1]
Bare soil[2]	6	1.81	1.56	1.65	1R
Bare soil	5	3.06	2.80	2.99	1R
Bare soil	5	2.83	2.34	2.46	1R
Erosion pavement	6	.698	.442	.508	1R
Erosion pavement	5	.829	.760	.788	4R
Rock	3	.127	.150	.148	2C
Rock	5	.422	.448	.446	4R
Litter	7	7.02	7.41	7.47	1R
Litter	5	4.56 *	5.59	5.28	1C
Litter	5	5.51 *	6.05	6.05	1C
Moss and lichens	5	.866	1.18	1.08	1R
Agoseris glauca	2	.102	.020	.025	1C, 2C
Antennaria rosea	2	.572	.125	.367	1R
Agropyron spicatum	3	.095	.077	.078	1C
Bouteloua gracilis	3	.162	.067	.082	1C
Festuca idahoensis	3	.372	.337	.335	3R
Koeleria cristata	2	.065	.040	.040	3R
Poa secunda	2	.080	.120	.110	2C
Carex spp.	2	.375	.020	.152	All too high

* - Significantly different from points.

1 - R = rectangle, C = circle, 1 to 4 = smallest to largest size.

2 - Some items separated because of storage limitations in computer.

Efficiency

The final step consisted of comparing the efficiencies of the various microplots. Surprisingly, the average time required to read the four sizes of plots was about the same, although there was considerable variation among individual plots because of differences in plant size and form, community structure, and observers. The mean times in minutes required for estimating the individual plots by all the observers at all 17 locations were:

	Mean times	
Size	**Rectangle**	**Circle**
1	0.62	0.65
2	.67	.62
3	.71	.67
4	.80	.75
Mean	.70	.67

Time increased gradually from the smallest to the largest plots, but the differences are not significant. The largest plots (2-by 4-inch rectangle and 3.2-inch diameter) do, however, take enough more time to be excluded from consideration on a practical basis. Plot variances were all of about the same magnitude. The microplots were about five times as efficient, timewise, as the point frame.

Conclusions

The rated microplots used in this study are precise, efficient, and accurate, particularly for basal area and ground surface items. The different analyses did not identify any one best microplot or microplots for rating cover (objective 1), although the smaller, circular plots were usually nearer to the point-frame readings in absolute values (objective 3). Rated microplots are much more efficient than the point method from the standpoint of time involved in estimating cover, however. Moreover, the microplots are all about the same in efficiency (objective 2).

In general, the 1/2- by 1-inch rectangle is a good compromise in overall performance, although it has no great advantage over the 0.8-inch-diameter circle. Most of the people involved in the study preferred a rectangular plot over a circular one for rating, however, which tips the scales somewhat in favor of the rectangular plot. It is interesting to note that the 0.8-inch-diameter plot used in this study is very near in size to the 3/4-inch loop presently used in the 3-Step Method.

Rated plots will give a precise estimate of plant cover, a population parameter that can be defined specifically, whereas frequency depends upon several attributes in a plant community. Hence, frequency estimates are often difficult to interpret. Thus rated plots could be of benefit insofar as the existing loop method is concerned.

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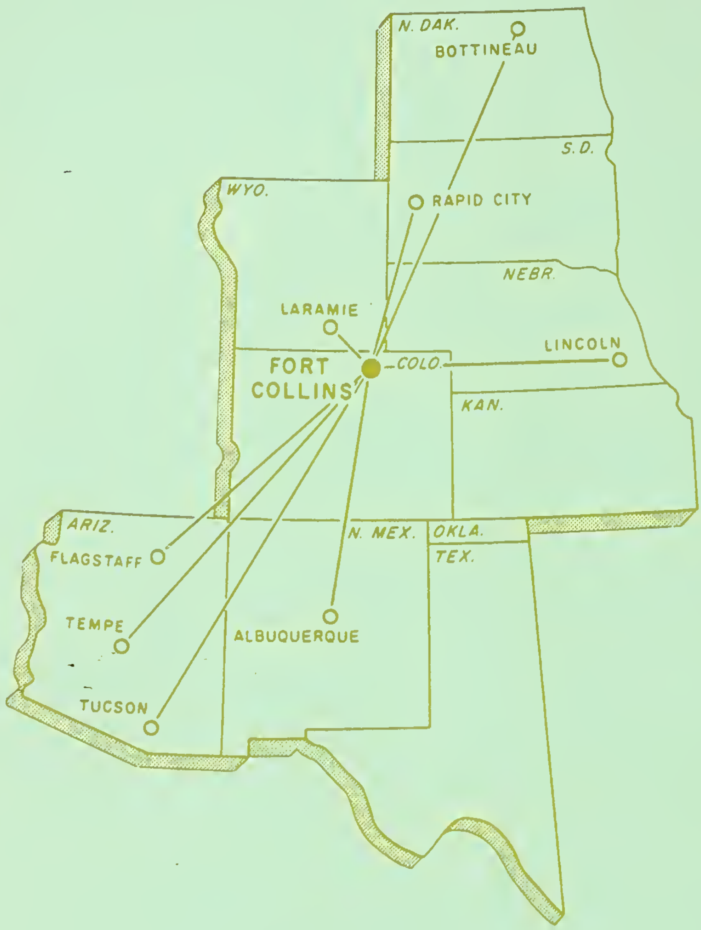

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