The Micro-unit Forage Inventory Method[1]

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Of all the measurements used in range research and range administration, none has been so difficult and expensive to obtain and none so sorely needed for correct decision-making as *weight* of forage per acre. This paper describes a refined weight-estimate method used to determine forage production and disappearance in pounds per acre on the Southern Plains Experimental Range near Woodward, Okla. The method was developed, tested, and modified from 1948 to 1952. Since then, it has been the primary tool for evaluating forage response in all phases of range research at Woodward.

In itself, the micro-unit forage inventory method offers only a few new techniques and principles. Primarily the method recombines and modifies sampling techniques proposed and used by others, especially those of Pechanec and Pickford (1937). The recombination created a simple, rapid, precise, low-cost method to determine the elusive "pounds of each species per acre."

Description of Method

The micro-unit method uses the objective principle of counting, or taking inventory of, estimated micro-units of range forage by species within micro-plots. Definitions used in this article are: (1) micro-unit, an arbitrary small quantity of forage, usually 10 grams (field weight), (2) micro-plot, a small quadrat 1.917 square feet in area, and (3) forage, current-year growth of grass and forbs above juncture of stem and root. In brief, an examiner delimits a micro-plot and counts the number of whole and fractional micro-units of each species.

Essence of the method is that the micro-unit to be estimated is physically present within an arm's length, it can be seen and touched, and its weight can be checked by clipping and weighing to the nearest gram within about 30 seconds. The time required by a single examiner to delimit, estimate, and record one plot is usually 30 to 60 seconds. The only ability that must be developed is that of estimating a small weight unit of each species, and great accuracy can be developed rapidly by most willing technicians.

The remainder of this description is concerned with the simple but exacting details that will permit technicians to use the method without redeveloping reliable detailed procedures.

The Micro-unit and Estimate

The micro-unit is estimated by a visual appraisal combined with the sense of touch. Factors to be taken into account when estimating a micro-unit include: (1) length, width, and thickness of leaves and stems; (2) inherent specific gravity of different species and phenotypes; (3) ratio of leaves to stems; (4) moisture content as reflected by turgidity, shape, and color; (5) presence of growth from previous years; and (6) degree and type of grazing by insects, rodents, wildlife, and livestock.

In short, a man learns to estimate, among other characteristics, the compressed basal diameter, compressed crown diameter, and compressed leaf length measurements shown to be highly correlated with weight by Hickey (1961). But man's eye, hand, and mind can determine and take into account numerous factors which relate to weight that cannot be readily measured. Furthermore, the examiner concerns himself only with the micro-unit, not the entire plant. Stated another way, an experienced estimator carries in his mind and constantly uses numerous "regression formulas" of the effect of many plant characteristics on weight.

The learning process includes estimating, clipping, weighing, modifying the estimate, and reweighing until the estimator becomes experienced and expert with weights of range forage. On the sagebrush range type at Woodward, a man who knows the vegetation, but who has no previous weight-estimating experience, can usually become proficient with two days of intensive practice. A man with previous experience can usually regain his micro-unit concepts in half a day.

Micro-unit estimates are of actual field weights which are converted later to air-dry or oven-dry values. During the training period, representative clippings of each major species are placed in moisture-tight plastic bags for determination of percent dry matter. If the survey lasts several weeks, moisture samples must be taken whenever a significant change occurs in plant moisture, usually at one- or two-week intervals.

The Micro-plot and Inventory

After the micro-unit concept of each species is well established, a trainee delimits a micro-plot with a small quadrat frame and becomes proficient in *counting* and recording the num-

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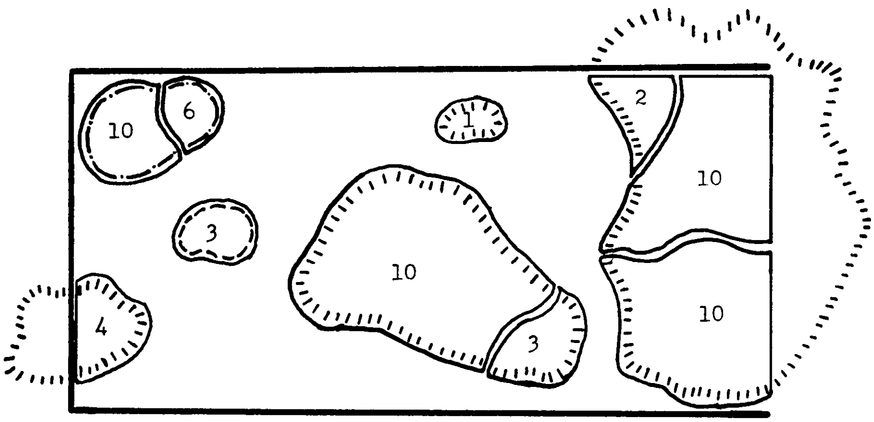
[1] *Cooperative investigation of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and the Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma.*



Symbol	Item	Grams/plot
	Micro-unit (10 grams), or fraction of unit	---
	Blue grama	40
	Little bluestem	16
	Side-oats grama	3
	Total	59

FIGURE 1. Method of counting whole and fractional micro-units within a micro-plot.

ber of micro-units (Figures 1 and 2). Micro-plot totals can be checked by clipping. Training efficiency can be gained by having the men estimate each other's quadrats. If additional practice is needed, the examiners can work in pairs for the first few hours of the actual survey.

Size, shape, and delineation of plot are important factors which contribute to final accuracy of any survey method (Christidis, 1931; Pechanec and Stewart, 1940; Green *et al.*, 1952; Brown, 1954). However, Jolly (in Brown, 1954) stated, "Fortunately, size of unit is often much less critical than the experimenter imagines, and quite a large alteration in size of unit will sometimes produce only a small effect on the final accuracy of his results (assuming the total amount of sampled material to remain constant)." Jolly also stated that for a given sampling method, more accurate results are usually obtained from a large number of small plots than from a small number of large ones.

After much field study at Woodward, it became apparent that small plots which could be delineated rapidly, and with all portions close to the observer's eye and hand, were absolutely essential for accuracy and speed. A dominant consideration affecting this decision was the mental fatigue associated with prolonged periods of estimating and counting micro-units in larger plots.

A rectangle with length about twice the width was selected as the best compromise on shape because (1) it could be delimited quickly and accurately, (2) it retained some advantage of a circle which has the least border-effect bias of all shapes, and (3) it had some linearity which increased sampling efficiency. In addition, the plot size was calculated so that a constant of 50 could be multiplied by grams per plot to give pounds per acre.

Final measurements of the quadrat were 11.5 by 24.0 inches. The quadrat was constructed of ¼-inch milled steel rod, and all measurements were made from rod centers (Figure 3). Quadrats larger than those used at Woodward may be desirable where vegetation is sparse and smaller quadrats may be more efficient where vegetation is dense.

One end of the quadrat was left open and the resultant points were sharpened so they could be pushed *through* the basal portions of plants at ground line. Time and effort are required to work the perimeter of a closed quadrat down to ground line, and errors frequently occur. The

Form H
(Rev.5-'60)

GRAZED

FORAGE INVENTORY
Southern Plains Experimental Range, Woodward, Oklahoma

Pas. 19; Line 2; Type of Data: clipped ____ estimated √
Date: 7-1, 1961. Examiner: J. B. Remarks: MONTHLY

Plot No.	Weight of forage in grams — Grasses			Bluestems			Other grasses						Total grass	Total forbs	GRAND TOTAL FORAGE
	Bgr	Scr	Etr	Asc	Aha	Pvi	Pst	Lco	Ecu						
1	11						T		5				16	1	
2				2			8			Tpu			10	9	
3	11						2			2	Csc		15	T	
4				38				T		T	T		39		
25	14			3			4						21		
Total															

FIGURE 2. Field data sheet for "grazed" areas showing species symbols and extent of field compilation. A similar sheet of a different color is used for "ungrazed" areas.

FIGURE 3. Primary equipment (shears, micro-plot quadrat, field forms, and gram scales) needed to inventory forage by the micro-unit method.

open end of the quadrat is "closed" with a pencil, or short rod, which is again pushed *through* the basal portion of the plants. Frequently, no plants are located across the open end and no marker is needed.

Maintenance of Reliability

Concept of micro-units is maintained during the survey by clipping about every tenth plot or by clipping micro-units from that plot. If vegetation on the plot to be clipped is sparse (three to five grams) the examiner clips the next plot having more forage. If a quadrat falls on an area of extremely dense forage (80 to 200 grams) it is usually more accurate to clip the plot than to estimate it. The reason for this is explained later under the subheading "Nature of Variation Associated with Estimates."

Several reasons exist for the estimator to continually check his micro-unit concept by clipping rather than to use a double-sampling technique (Wilm *et al.*, 1944). These include: (1) the time factor as shown under the subheading "Time Comparisons"; (2) the need of having another examiner clip and weigh the plot, or the need of the examiner carrying unweighed sacks of clipped forage with him (to prevent introducing subconscious bias from the learning process); and (3) the necessity under several varied conditions of clipping sufficient plots to calculate valid correction constants. Then too, if a break of time were to occur during the inventory, the problem of obtaining sufficient clipped samples to calculate correction constants would be intensified.

Measuring Production and Disappearance

Forage production in pounds per acre can be measured on ungrazed areas with the micro-unit forage inventory method at any selected time by using an appropriate area-sampling system. Micro-plots can be completely randomized, randomized in clusters, or mechanized along randomized stratum lines. All human bias must be eliminated when delimiting each micro-plot.

In a grazed pasture, weight of forage is measured under cages to determine production. This is usually done at end of summer. An equal number of micro-plots is then measured in the grazed portion of the pasture, and the difference between "grazed" and "ungrazed" yields is summerlong disappearance.

Winter-forage disappearance due to livestock grazing is obtained by caging the summer "grazed" micro-plots during the winter and re-inventorying them in the spring for comparison with an inventory of micro-plots grazed during winter. Total winter disappearance, grazing plus attrition, is obtained by comparing yield of micro-plots grazed during winter with end-of-summer "ungrazed" yields.

Monthly production and disappearance data are obtained by taking "grazed" and "ungrazed" measurements at monthly intervals. After the "ungrazed" micro-plot is inventoried, on May 31 for example, a "May-grazed" micro-plot is located, inventoried, and then caged with the cage from the "May-ungrazed" micro-plot. The "May-grazed" micro-plot becomes the "June-ungrazed" micro-plot when it is inventoried on June 30. Monthly production on the plot is obtained by subtraction of the first-of-the-month measurement from the end-of-the-month measurement.

Precision and time are gained by leaving the micro-plot quadrat in place under the cage from one reading to the next. Hall (1959) showed that sampling error of growth measurements in forests was reduced 25 percent by remeasuring plots as compared with subtracting results of successive inventories on different plots.

Equipment

The only precision equipment needed is a small gram scale. The scale used at Woodward is six inches long and ¾ inch in diameter, is graduated in two-gram units, and has a capacity of 200 grams. Its weight is five ounces. It is a German-made scale labeled as "Feine Federwaage, Tragkraft 200 gram," and

FIGURE 4. Typical sand sagebrush range. Examiner is recording grams of a species within a micro-plot.

was purchased from the Oxwall Tool Co., Ltd., 133-10 32nd Avenue, Flushing 54, N. Y., at a cost of about $7.20.[2] Inventory equipment needed includes: quadrat, shears, scale, field forms, clipboard, kraft sacks and rubber bands for weighing forage, pencils, plastic sacks, cages, and anchoring pins.

Testing the Method

The micro-unit method was compared with clipping in three trials conducted on the Southern Plains Experimental Range. The experimental range is located on rolling, stabilized, sand dunes, and the predominant soil type is Pratt loamy fine sand. Annual precipitation averages 23 inches, but varies from ten to 43 inches.

Native vegetation of the area is dominated by an overstory of sand sagebrush *(Artemisia filifolia* Torr.), with an average canopy cover of 38 percent. The understory of grasses and forbs produces an annual average of 1,050 pounds of oven-dry forage per acre. Average forage production consists of 20 percent sand dropseed *(Sporobolus cryptandrus* (Torr.) A. Gray); ten percent sand lovegrass *(Eragrostis trichodes* (Nutt.) Wood); six percent blue grama *(Bouteloua gracilis* (H.B.K.) Lag. ex Steud.); 16 percent little bluestem *(Andropogon scoparius* Michx.), sand bluestem *(A. hallii* Hack.), and switchgrass *(Panicum virgatum* L.); 31 percent other grasses; and 17 percent forbs (Figure 4).

General procedure in the trials was to inventory a series of micro-plots by the micro-unit method. Afterwards, the plots were clipped. The quadrat frames were pinned in place to prevent movement. Examiners were range technicians well acquainted with the vegetation and the micro-unit method. Order of examining the plots was arranged so that each man made an equal number of first, second, and third inspections of each plot to equalize "examiner disturbance."

Trial 1 was conducted in early winter on a one-acre area which was predominately blue grama. Three examiners estimated the forage weight of individual species in 75 micro-plots, and then the vegetation was clipped and weighed in two categories, blue grama and "all other species." Each examiner estimated and clipped a non-test plot located at every tenth micro-plot to maintain his micro-unit concepts. A time record was kept of all operations.

Trial 2 was conducted in late summer on micro-plots located along a stratum line in a native pasture. Vegetation varied greatly since the stratum line crossed numerous vegetative sites. Two examiners estimated the forage on 25 plots on two successive days to measure the repeatability of the method. Both the estimates and clips were by individual species. Examiners maintained reliability of micro-units by checking estimates outside the plots.

A third trial was conducted and the data were included in the averages of all trials. For the sake of conciseness, specific results from trial 3 were not reported because they were similar to those of trials 1 and 2. Additional data were obtained by calculation of statistics from pasture inventories made by the micro-unit method.

All data were subjected to analysis of variance, calculation of correlation coefficients, and other statistical tests. Sampling error, as used herein, is the standard error of the mean expressed as a percentage of the mean. Odds are 19:1 that a mean with a five percent sampling error would be within ten percent of a complete inventory of the area. Number of plots required (n) to sample the forage yield within plus or minus ten percent of the mean, with a five percent probability of error, was calculated by the formula:

[2] *Mention of specific instrument and manufacturer is for identification and does not imply any endorsement by the U. S. Department of Agriculture.*

$t^2s^2 \div L^2$, where t is at five percent level for infinite degrees of freedom, s is standard deviation, and L is allowable error (here, ten percent of the mean).

Results

Estimated Versus Clipped Weights

Forage weights estimated by the micro-unit method closely approached the average weights obtained by clipping. Estimated average weights varied with each examiner from two to 13 percent less than the clip in trial 1 and from nine percent more to nine percent less than the clip in trial 2 (Table 1). In ten comparisons, estimated weights averaged eight percent less than clipped weights. Two reasons for these conservative-type estimates are breakage of mature foliage associated with repeated "examiner disturbance" and the tendency of examiners to underestimate high-producing plots, as discussed in more detail under the subheading "Nature of Variation Associated with Estimates."

Estimated weights on individual micro-plots were highly correlated with clipped weights. Correlation coefficient of estimated weights with clipped weights averaged 0.87 in the ten comparisons and ranged from 0.74 to 0.96.

Differences Between Examiners and Days

Differences between estimates of the same plot by individual examiners were relatively small. Eight comparisons of estimates showed an average difference between men of only seven percent with a range of one to 15 percent. Average correlation between estimates of examiners was 0.86, and the range was from 0.81 to 0.92.

Repeat estimates of plots by examiners on successive days showed technicians were highly consistent in their ability to estimate forage weights. Second-day estimates were about 100 pounds per acre, or two grams per plot, lower than first day estimates (Table 1). Repeat estimates were expected to be slightly lower than first-day estimates since handling mature vegetation to estimate its weight by the sense of touch as well as sight causes slight breakage and loss. However, first- and second-day estimates were highly correlated, 0.91, in three comparisons.

Time Comparisons

The micro-unit method was approximately four times as fast as the clip method in trial 1. Average time required to estimate the forage in a micro-plot was 34 seconds when travel time between plots spaced 15 feet apart was included. An average of 59 seconds per micro-plot was required when one plot in ten was checked by clipping.

Four minutes and ten seconds was required to clip and weigh the forage in a micro-plot and to travel to the next plot. Clipping and weighing each individual species would have increased the time requirement.

In grazed pastures, about two minutes were required to estimate a micro-plot. Much of this time was used to move cages and to travel between plots. Inventory time was also influenced by number of species, degree of species intermixture, quantity of forage present, and number of micro-plots read per cage.

Number of Plots Required

Number of plots required to sample within ten percent of the mean was calculated from actual forage inventory data of two different pastures at Woodward, one relatively uniform and one highly variable. In a high-rainfall year, 1961, a valid estimate of yield on a 25-acre seeded blue grama pasture required 28 micro-plots. In the same year on 25 acres of sand sage rangeland, a valid estimate required 193 plots. In a year of low forage production, 1956, 36 and 73 plots were required to sample the blue

Table 1. Comparison of clipped and estimated (micro-unit method) forage weights and their sampling statistics

Item	Trial 1, 75 micro-plots				Trial 2, 25 micro-plots				
		Micro-unit method				Micro-unit method			
	Clip	Man	Man	Man	Clip	Man A		Man B	
	method	A	B	C	method	1st day	2nd day	1st day	2nd day
Forage weight, lb./acre[1]	1768[a]	1650[b]	1534[c]	1740[a]	1386[ab]	1386[a]	1246[b]	1492[a]	1382[a]
Standard error, lb./acre	62	56	50	52	123	120	102	130	108
Sampling error of mean, %	3.5	3.4	3.3	3.0	9.0	8.7	8.2	8.7	7.8
Coeff. of variation, %	31	29	28	26	45	43	41	44	39
Plots needed (n)	36	33	30	26	77	72	65	73	58
Difference from clip, %	....	−7	−13	−2	....	1	−9	9	1
Correlation coeff.[2]	....	.86	.74	.81	....	.87	.88	.96	.87

[1]Field weight. Comparable means with different letters are significantly different at the five percent level by the Duncan multiple range test.

[2]Correlation coefficient of estimated and clipped yields; all are significant at the one percent level.

Table 2. Number of cages (n) required for a valid estimate of total perennial grass yield in relation to number of contiguous micro-plots under a cage, to uniformity of vegetation, to level of production, and to size of pasture[1]

Pasture kind and size and level of production	Average yield pounds/acre	Cages required when number of contiguous micro-plots per cage is—[2] 1	2	3	4
Blue grama, uniform vegetation:					
Low production, 1956:					
12 acres	477	29	....	....	....
25 acres	565	36	....	....	....
High production, 1961:					
1 acre	1600	14	11	8	....
12 acres	1494	27	18	10	....
25 acres	1440	28	20	17	....
Native sand-sage, variable vegetation:					
Low production, 1956:					
25 acres	744	73	59	40	34
50 acres	740	80	67	50	38
160 acres	762	87	56	37	38
High production, 1961:					
1 acre	2802	176	....	....	....
25 acres	2948	193	....	....	....
50 acres	2658	247	....	....	....
160 acres	2844	233	140	123	95

[1] Valid in this instance implies a 95 percent probability of being within 10 percent of the population mean. Yields are field weights measured in fall.
[2] Adjacent plots 1.917 square feet in size were combined to alter size of sample plot. Estimation of individual plots larger than 1.917 square feet is extremely tiring and soon becomes inaccurate.

grama pasture and the native range, respectively (Table 2).

Number of plots required for a valid estimate of yield was not directly proportioned to size of pasture or area. For instance, a valid estimate of yield in 1961 on a one-acre area of the seeded blue grama pasture required 14 plots; a 12-acre area of the same pasture required 27 plots; and the entire 25-acre pasture required 28 plots (Table 2). Klingman *et al.* (1943) also found that nearly as many plots were required on small as on large areas.

Number of plots required to sample production of an individual native range species within ten percent of its mean was many times that required to sample total forage. In a native pasture in which 240 quadrats were sufficient to sample total forage within ten percent of the mean, the number required to sample sand dropseed was 769, sand lovegrass 2,104, and blue grama 7,606. Other investigators also found that large numbers of plots were required to secure low sampling errors for individual species (Harris, 1951; Pechanec and Stewart, 1941).

Cage requirements per pasture were materially reduced when more than one micro-plot was read per cage. Cage numbers were reduced about 30 percent by reading two plots per cage, about 50 percent by reading three, but only 57 percent by reading four (Table 2).

Nature of Variation Associated with Estimates

In ten comparisons, estimated yields were eight percent smaller than clipped yields. Also, estimated yields varied less than clipped yields. There are at least three reasons for these discrepancies.

One reason is examiners tend to cluster yield estimates about the mean (Pechanec and Pickford, 1937). In the ten comparisons, coefficients of variation were 46 percent for clipped yields and only 41 percent for estimated yields. Clustering lowers the mean because a given percentage error multiplied by low yields influences the mean less than the same percentage error multiplied by high yields.

A second reason is that examiners overestimated low-yielding plots by only about eight percent, and they underestimated high-yielding plots by about 16 percent. This discrepancy in accuracy of estimates is also shown by a correlation coefficient of 0.70 for estimated and clipped yields of high yielding plots and 0.82 for low-yielding plots (Table 3).

A third and minor source of error in estimating was the tendency of examiners to overlook small plants. This tendency became greater as size of plot increased.

Discussion

The prime consideration of an inventory method is its accuracy, and the micro-unit method proved acceptably accurate when compared with clipping in the tests at Woodward. Some other important advantages of the micro-unit method are: estimates are based on a specific observation of each plant, not on a generalized view or concept of the mass; estimates can be rapidly verified by clipping; vegetation can be left in place for re-estimation later; growth from previous years can be eliminated; small plots permit economical caging; small plots which can be studied from one position increase speed and accuracy; and the small plots can be delimited rapidly and accurately with the open-end quadrat frames.

Disadvantages of the micro-unit method include: estimating skill must be developed; considerable mental concentration is required, and distracting or uncomfortable working conditions can cause errors; forage production is usually underestimated slightly; rank, high-producing vegetation cannot be estimated as accurately as sparse vegetation; and highly variable vegetation requires relatively large numbers of small sampling plots because larger plots cannot be estimated accurately. A minor disadvantage is that individual examiners vary slightly in their ability to estimate. To overcome this, all members of a crew should inventory a proportionate share of each pasture or experimental treatment.

The reader should be forewarned about the difference in precision of measuring forage production and forage disappearance. Forage disappearance when calculated as the difference between grazed and ungrazed plots, is never measured as accurately as forage production, because variance of a difference is greater than the variance of either parent mean (Boyd, 1949). This is true whether yields are obtained with the micro-unit method or by clipping. The use of paired plots (Klingman *et al.*, 1943) overcomes much of the disadvantage of the difference method for calculating disappearance. One micro-plot is chosen by a mechanical or random method and then matched with a similar plot. One of the pair is selected at random as the ungrazed plot and the other becomes the grazed plot.

The micro-unit method is not a panacea, and it should be tested under local conditions before being used extensively. There is still great need for a forage measurement technique that is completely objective and can be used by inexperienced examiners. Until such a method is developed, the micro-unit method should have a place on many western ranges.

Summary

The micro-unit forage inventory method was developed as a simple, rapid, low-cost technique to measure forage production and disappearance on rangeland at Woodward, Oklahoma. Forage yields are measured by using the objective principle of counting estimated micro-units of each species within micro-plots. A micro-unit is an arbitrary small quantity of forage, usually ten grams, and a micro-plot is a small quadrat 1.917 sq. ft. in area.

The micro-unit is estimated by a visual appraisal combined with the sense of touch. Factors taken into account include: size of leaf and stem, leaf-stem ratio, moisture content, previous-year's growth, utilization, and phenotypic variations. Range technicians can rapidly develop the necessary estimating ability. The estimated micro-unit can be checked quickly, usually within 30 seconds, by clipping and weighing. The scale used is about the size of a fountain-pen.

The rectangular quadrat frame selected to delimit a micro-plot in the sand sage vegetation measured 11.5 by 24.0 inches. One end was left open to facilitate rapid and accurate placement. The dominant factor in selecting this small micro-plot was mental fatigue caused by estimating and counting micro-units in larger plots.

Forage production and disappearance can be obtained with the micro-unit method on a monthly, seasonal, or yearly basis. This is done by using a standard area-sampling technique and caged and uncaged plots. Cage numbers per pasture can be materially reduced by reading more than one micro-plot per cage.

The micro-unit method was compared with clipping in three trials. Forage weights estimated by the micro-unit method averaged eight percent less than clipped weights, and varied from 13 percent less to nine percent more. Estimated and clipped weights were highly correlated, 0.87. Differences between yield estimates of the same plot by individual examiners were slight, only about seven percent. First- and second-day estimates of micro-plots by the same examiners were highly correlated, 0.91.

Micro-plot yields were estimated in 34 seconds, whereas four minutes and ten seconds was required to clip each micro-plot. In grazed pastures, about two minutes was required to estimate a micro-plot, move the cage, and travel to the next plot.

Number of micro-plots required for a valid estimate of yield varied directly with uniformity of vegetation and only indirectly with area. A 12-acre area of seeded blue grama was adequately sampled with 27 plots and a 25-acre area with 28 plots. On 25-acre pastures of highly variable native range, from 73 to 193 plots were required.

A study of the differences be-

Table 3. Difference between and correlation of clipped and estimated (micro-unit method) forage yields in relation to quantity of forage per micro-plot[1]

Clipped yields		Difference of estimate from clip	Correlation coefficient
Weight class	Weight/acre		
	(Pounds)	(Percent)	
Lowest 20 percent	825	8	.82
2nd-low 20 percent	1190	2	....
Middle 20 percent	1515	−7	.81
2nd-high 20 percent	1935	−10	....
Highest 20 percent	2545	−16	.70
All plots	1602	−8	.87

[1] Yields from 155 micro-plots were grouped by weight class. Data are field weights measured in the fall.

tween estimated and clipped yields showed that estimates were slightly smaller but less variable than clipped yields. Reasons for this were: examiners clustered their estimates about the mean; they underestimated high-yielding plots 16 percent while they overestimated low-yielding plots only eight percent; and they occasionally overlooked small plants.

Important advantages of the micro-unit method include: accurate estimation of yields; use of estimates which can be quickly verified by clipping; and use of small plots which can be delimited rapidly, studied intimately from one position, and caged economically. The main disadvantage to those not familiar with estimating will be the initial development of estimating skill.

The micro-unit method is not a panacea. Until a forage measurement technique is developed which is completely objective and which can be used by inexperienced examiners, the micro-unit method should have a place on many western ranges.

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