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(Condition and Trend)

REPORT ON
3-STEP METHOD FOR MEASURING CONDITION AND TREND OF FOREST RANGES

BY

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REPORT ON 3-STEP METHOD
FOR
MEASURING CONDITION AND TREND OF FOREST RANGES

By Kenneth W. Parker, Range Conservationist (Research)

INTRODUCTION

The range condition and trend study is western-wide in scope. Begun in July 1948, it is being carried out through the cooperation of the six western regions and experiment stations.

The study was brought about by a realization that one of our greatest needs in range management planning is a method for the determination of trend in range condition. Facts on the condition and trend of our ranges are needed in order that decisions may be wisely made. Such facts are necessary for a better understanding of our aims in the administration of forest range watersheds by the general public as well as range users. We vitally need information which will eventually lead to the development of sound condition standards. As yet we have no method of sampling range units for condition and trend which is in general use and which will give us this information.

In appraising range condition and trend, we are dealing with a complex set of factors relating to the vegetation, soil, and native fauna which are constantly changing from one growing season to the next. In range administration we are interested in whether these changes are in the direction of improvement or in a downward trend of deterioration. We want to know how much of the change is due to current weather and how much to grazing use, and in special situations, how much is due to such disturbance factors as: fire, wildlife, insects, rodents, and logging.

As provided for in the Working Plan[1], prepared in 1948, the study has four main objectives. Briefly, these are (1) to develop a method or methods for measuring trend in range condition on national-forest range allotments; (2) to consider the adequacy of present range condition standards; (3) to check the suitability of record maintenance on range allotments as a means of following trends; and (4) to ascertain what use is being made of photographs in recording range condition and trend. The results of the cooperative effort between Research and Administration in meeting these objectives during the first year of the condition and trend study were brought together in a mimeographed report issued in April 1949[2]. Among the more significant findings pertaining to a method for following trend were:

1/ Preliminary Working Plan submitted with the Chief's RR-SUPERVISION, Administrative Studies (Condition and Trend) letter of June 16, 1948 to western Regional Foresters and Directors.

2/ For analysis of methods considered, see "Report on Methods and Techniques for Measuring Condition and Trend of Forest Ranges" submitted with the Chief's RR(G)-SUPERVISION, Administrative Studies (Condition and Trend) letter of April 27, 1949 to western Regional Foresters and Directors.

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1. No region or station endoresed any one method for recording range trend as <u>the</u> method for testing and ultimate western-wide application.

2. All regions and stations agreed that in order to follow trend in condition information must be obtained periodically on density, floristic composition, vigor, litter, and soil capabilities and erosional features.

3. That the initial step toward development of a method for following trend should be in the perennial grasslands and open timber-grassland types in various stages of condition. These types are generally regarded as the most important for range and usually comprise the key areas on an allotment.

4. All regions and stations were in accord that to follow trend most efficiently on a range-unit basis, permanently located open-range plots, transects, or "benchmarks" must be established within the allotment. Trend would be determined by repeated measurement of these plots at periodic intervals.

The most logical approach and the first step toward solution of the problem of developing a method for measuring range trend is to determine how the information on vegetation and soils should be obtained at each of the permanently located sampling sites. Some of the factors for judging trend on these sites, such as density and floristic composition, can be measured with a reasonable degree of accuracy. Other factors, such as plant vigor and erosion rates, must be recorded largely in descriptive terms. Both types of information are essential for a complete picture of trend in condition. In addition to this requirement, the method or methods which are developed for following trend must be simple, reliable, rapid, require a minimum of equipment, and the information obtained easily summarized and interpreted. It must be largely a one-man method which the average ranger can readily apply or at least a method wherein the ranger can play an important part. With the foregoing requirements in mind, the major portion of the 1949 field work was devoted to developing and testing a method for gathering the essential information for recording trend. The method evolved and tested is tentatively designated as the 3-Step Method.

It is the purpose of this report to discuss the 3-Step Method as a means for obtaining information on trend, to present the results of field tests carried out in 1949 and to indicate plans for furtherance of the work in 1950.

<u>THE 3-STEP METHOD</u>

The 3-Step Method incorporates the best features of several measurement methods. As the name implies, it consists of three steps. Step one is an adaptation of the New Zealand [illegible]-point method (similar to Ellison's point analyzer and the Southwestern frequency-point methods) and the line intercept as used in the Southwest. Step two is based on methodology involved in use of the Southwestern Range Condition and Trend Score Card. Step three is derived from the photo-transect method of the Intermountain region.

The method was presented to the field as a preliminary step in the evolution of a method or methods for measuring range trend. It was not regarded as a final method for adoption by Administration, but simply as a concrete, specific proposal for field testing. This procedure was followed in order to stimulate thinking in the development of methods for measuring trend.

The "3-Step Method", upon which the 1949 field work was centered, is described specifically as follows:

Step One. A metal tape 100 feet long is stretched between two permanent iron stakes located in the site selected for sampling. An Engineer's tape, 1/4-inch wide, which has chaining pin notches at the foot marks, appears to be most suitable. Along one edge of the tape 100 observations (at 1-foot intervals in the case of a 100-foot transect) are made at mechanical intervals by means of a 3/4-inch diameter wire loop attached to a long wire shank (about 16" long) for convenience in holding and for plumbing from the tape when the latter is above the ground surface. (Figure 1)

As the loop is dropped to the ground surface, a record is made of whatever plant species is encountered within the loop. Perennial and annual grasses and weeds must have the root crown or a portion thereof definitely within the loop in order to be recorded as an observation. Crown spread is ignored in order to eliminate errors or seasonal differences in vegetation arising from utilization and plant development. In rare cases, two plants of different species may occur within the same loop, in which event the dominant plant is recorded and the other is merely listed, i.e. a perennial would be recorded in preference to an annual. With browse species only the perennial portion of the crown is considered, current annual twig growth on the outer periphery being ignored. As in the case of surface vegetation, this is done in order to eliminate seasonal differences arising from utilization and plant development. If over half the loop is covered with litter and there is no vegetation within, it is recorded as litter. If the loop is less than half occupied by litter, as with a few occasional grass stems, it is recorded as bare soil, or rock (including pebbles above 1-inch in diameter), or erosional pavement, whichever the case may be. Mosses and lichens are observed as in the case of litter. Thus litter, moss, and ground surface devoid of vegetation require estimation; whereas vegetation requires only the simple decision of whether or not it is absent or present within the loop. Rodent activity, such as gopher casts or diggings, is recorded by line-intercept measurement.

The field record, usually by dot or check tally entered on forms such as shown in Figure 2, is rapidly obtained, regardless of plant density, and by one man working alone. The field record is a completed summary with no additional compilation necessary of reasonably reliable indices of (1) vegetation density, (2) floristic composition by frequency for both annual and perennial species, (3) presence of litter, when a plant is not recorded (4) mosses and lichens--if present, (5) bare soil, (6) rock and erosional

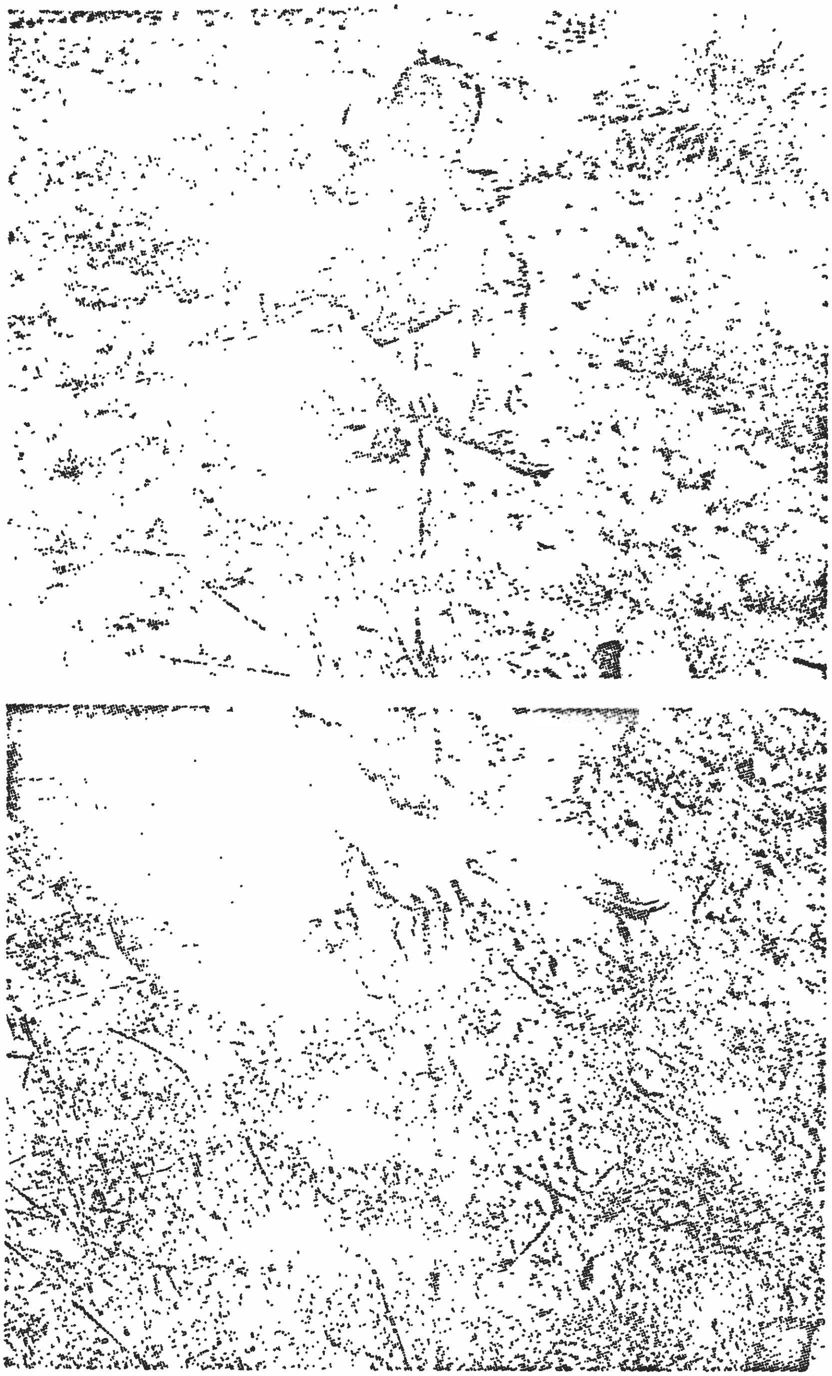

Figure 1. - Illustrating Step One (of the 3-Step Method) - the loop method of measuring vegetation, litter and bare soil. Upper photo - one man makes the readings and records the data by simple dot or check tally as to species, litter, bare ground and [illegible]. Lower photo - closeup of wire loop, showing an observation on perennial grass.

RR- NW
Form____

Record of Permanent Line Transect

Allotment______________________ Cluster No.__________

Date measured__________________ Observer__________

	Transect No.___		Transect No.___		Transect No.___	
Species	Hits	Total	Hits	Total	Hits	Total
Agsp	☒	12				
Pose	☒ ☒ ☐	28				
Bate		2				
Bare ground						
Litter						
Rock						
Moss						
Annuals		8				
Desirable grasses		12				
Total perennial grasses		40				
Desirable weeds		2				

Figure 2. Form for recording data obtained by the loop method or Step One. For use in grassland vegetation.

pavement, and (7) rodent activity (obtained by line intercept).

Where two-storied vegetation is encountered, as with sagebrush, a specially devised form (Figure 3.) may be utilized to record the observations. Although use of this form requires some extra time for compilation, it has the advantage of showing at a glance the extent to which browse species have an understory of herbaceous vegetation. If repeated observations should be made periodically on it, it will quickly reveal whether or not shrub species are increasing. With single-storied vegetation its use is recommended in training personnel because of the ease in cross-checking individual records before the tape is removed from the transect.

Step Two. Also a one-man job, consists of a record of (1) range condition class and (2) range trend items made by means of score cards or check lists. Score cards are used as guides to determine the range condition class and probable trend wherever specific criteria are available. An example of such is shown in Appendix A for the Pacific Bunchgrass type. Whenever specific criteria are not available, the check list alone must suffice Appendix B. The reocrd on condition and trend is made in the vicinity of the permanently staked lines utilized in Step One. If these lines are grouped together in a cluster, as on an acre plot, the record will be made within this plot. If the cluster is long and linear, as by placing the lines end to end, and in line, the record will be made in a strip, i.e., two 100-foot transect lines 200 feet apart would designate an area 100 X 400.

Step two is quite independent from Step One. The completed field record includes estimates or information on the following: (1) Density and composition by paced transect (if not possible, then by square-foot density method). A record of these is considered necessary in order to pick up key indicator species which may not be encountered in Step One. (2) Vigor of key indicator species. (3) Amount of litter. (4) Utilization of key forage species. This record is essential for later interpretation and explanation of the causes of trend. (5) Soil features--indicators of erosion and other characteristics. The record obtained is interpreted into separate adjective ratings of condition classes for vegetation and for soil by means of properly designed score cards (Appendix A). Current trend within the condition class as judged in the field is likewise appraised by means of the same score card.

Step Three. Consists of two key photographs (Figure 4) which form a visual record, in part at least, of the elements measured and observed in Steps One and Two. The photographs consist of:

1. A general type photograph, taken from one end of the permanently located transect line with the other end stake centered in the background. This photograph is necessary for showing general changes (when the photo is repeated) which may take place in the aspect of the type. It is also very helpful in relocation of the sampling area.

2. Close-up of a 3 X 3 plot taken obliquely and also located on one end of the permanently staked line. This clos-up forms a good record of plant

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Record of Permanent Line Transect
(By loop method)

Allotment ________________ District ________________ Cluster No.____

Nat. For.________________ Date__________ By________________ Transect No.____

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Total hits

26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	

51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	

76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	

Total Density :____________

Note: Check overstory browse species on top square of each block, record understory species on bottom square.
L Litter; R - Rock or pavement; Blank - Bare soil
(Plant symbols with complete name should be recorded below)

No. Hits by Species

____

____

____

____

____

Seedling or Annual Species

Litter____________

Moss____________

Bare ground____________

Rock____________

Rodent Activity____________
(Total line intercept)

Figure 3 - Form for recording information obtained Step One in two storied vegetation or for rapid cross checking of men during training.

Developed in Region 3

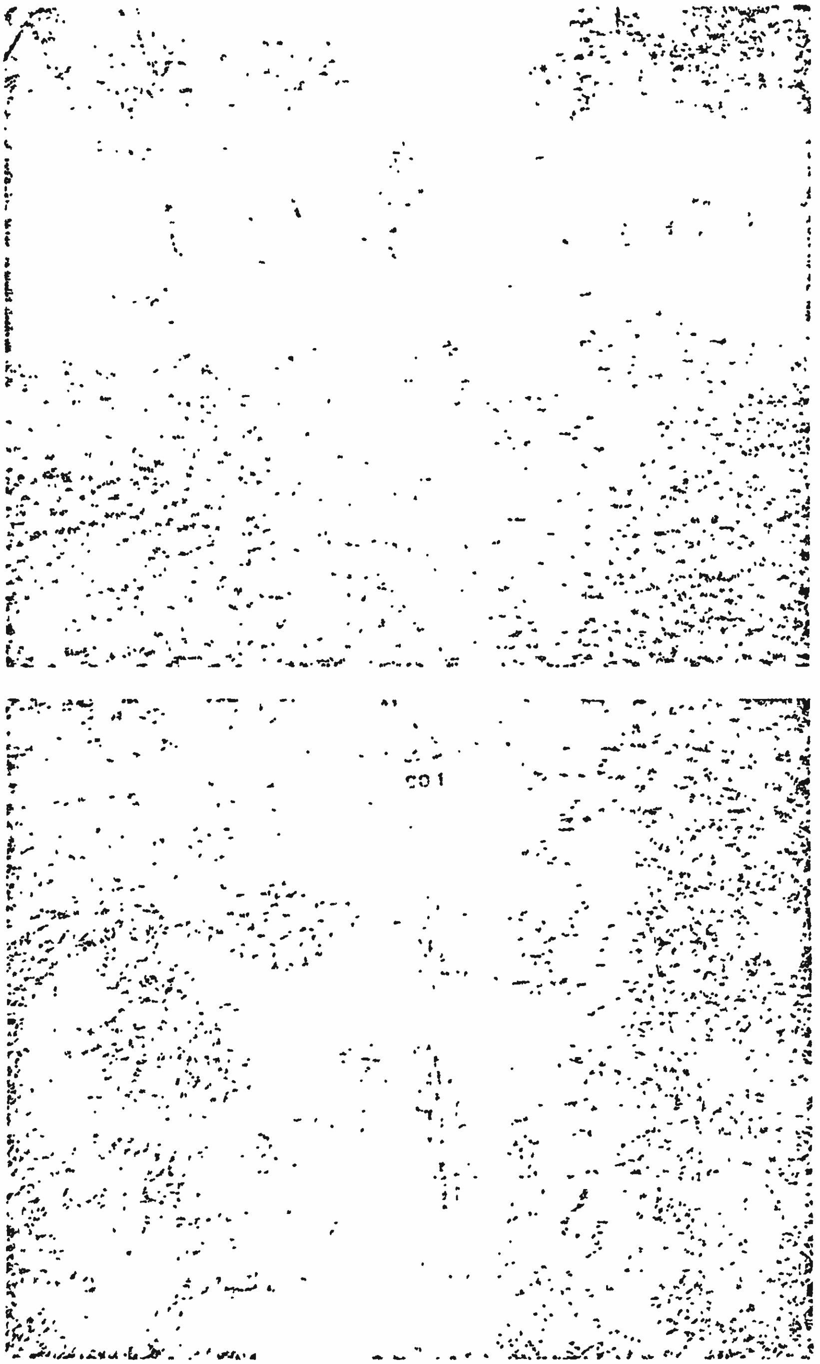

Figure 4. - Step Three of the 3-Step Method consists of a general type photo and an oblique close-up of a 3x3 plot, each of which are taken from one end of the transect line. Mixed grama-oak savannah woodland, Coronado N.F., Arizona.

cover and often reveals movement of soil and changes in cover whenever repeated.

Additional photopoints may be established within the vicinity of the transect if deemed desirable for recording special situations such as hedged browse and erosional features.

Initial photographs and the retakes, although a 1-man job, require special training and aptitude.

The time required for record taking by the 3-Step Method is considered to be extremely low. For Step One (the loop method) the time required in all regions varied from 10 to about 35 minutes per transect line. The time required generally increases with the complexity of the vegetation. For example, in Oregon the average time of six men on transect lines located in a site rated as "high-fair" was 28.3 minutes, whereas on a poor condition site, the time required averaged 15.8 minutes. In Arizona the average time for all three steps on 20 transects was 40.7 minutes per transect, representing 19.8 minutes for Step One, 13.1 minutes for Step Two (range condition rating), and 7.8 minutes for Step Three (photos). Although these times are for men with long experience in record taking, it is believed that after proper training most individuals could install and obtain the complete record on one transect within an hour's time, excluding travel time.

During the 1949 field tests it was not possible to test each of the three steps involved in the method. This was largely because of insufficient time and the lack in many regions of well-developed score cards required in Step Two. However, the soundness of the last two steps of the method is considered to have been adequately demonstrated during the past several years. The range condition and trend score card, developed and tested in the Southwest, has been adopted by Administration for use on all national forests in the region. Experience with the photo-transect method in the Intermountain region indicates the general photo and the oblique closeup to be most suitable for showing changes in condition. Accordingly, the major effort in 1949 was spent in testing Step One - the loop method.

RESULTS OF 1949 TRIALS WITH STEP ONE - THE LOOP METHOD

HOW THE LOOP METHOD ORIGINATED

The original study plan for conducting the 1949 field tests contemplated intensive testing in all regions of the frequency-point method for measurement of the important elements of the site. The frequency-point method consists simply of dropping a small diameter rod sharpened to a fine point (similar in dimensions to a hat pin) at mechanical intervals along one edge of a steel tape or transect wire fitted with 100 balls of solder. In the tests 100 observations were taken at 1-foot intervals.

At the onset of the summer field work on the Starkey Experimental Range in Oregon it was readily apparent to the seven men taking part that the frequency-point method had several important limitations, namely: (1) As shown in Table 1, there was no sharp difference between two distinct condition classes, fair and poor, with respect to Agropyron spicatum (Agsp) and in total vegetation. In fact, the frequency point density was slightly greater on the poor with 12 hits as compared to 10 hits on the fair condition range. And yet, it was clearly evident to all that Agropyron spicatum was more abundant and the density was greater on the fair in comparison to the poor. (2) Single-stemmed species such as Agropyron spicatum (it often assumes a single-stemmed habit of growth in Oregon), although often common, were seldom recorded by the frequency-point method. (3) Being the record of an extremely fine point, there was much chance for large differences between men, particularly where any of the men had poor eyesight. And (4) being a fine point reading, it would always be questionable as to how accurately the line might be replaced in follow-up measurements. This discrepancy would introduce a new error of sampling.

Table 1. Field data on vegetation by frequency point method from two sites in different condition on Starkey Experimental Range.

Species	Fair Condition No. of hits	Poor Condition No. of hits
Agsp	3	4
Feid	4	*
Koer	*	*
Daun	*	*
Pose	*	5
Total grasses	7	9
Acla	1	*
Anlu	-	1
Trifolium	*	*
Podo	*	1
Sedum	-	1
Lup	1	-
Bate	1	*
Total weeds	3	3
Total vegetation	10	12

* Present as a significant component of the vegetation but not recorded.

Because of the above limitations, it was apparent that the frequency-point method would not be suitable for use in the Pacific bunchgrass type--although previous tests in the shortgrass type of Colorado and the Southwest indicated the method to have possibilities. The next step in Oregon was to test a stem count method involving the use of wire frames of three sizes, one frame containing an area of 2 square inches, another 4 square inches, and another 6 square inches. Tests with these frames, which were spaced mechanically at 25 intervals along the transect, soon indicated large differences between individuals. These differences arose largely from inability of the men to recognize a similar number of plant segments within a frame; in other words, the unit of measurement was difficult to define. Furthermore, it was difficult to summarize the field data following its collection. It was apparent that what was needed for reducing these differences between men was a method which would combine the advantages of the frequency point (with its easily defined unit of measurement) and a plot that was estimated (with a larger sample of the vegetation). Accordingly, a wire loop 3/4-inch in diameter, made from 14-gauge welding rod, was tested, at the suggestion of Fred Kennedy. The first tests revealed that it might have possibilities for reducing differences between men, and for yielding information descriptive of what could be seen with the eye. The simple tally of 100 observations was in itself a summarization of the field data.

The 3/4-inch wire loop is thus a compromise between a record obtained by a point and a plot that is estimated--and the readings for vegetation in most instances require only the simple decision of whether or not the loop is occupied by a part of the root crown in grasses and weeds or the period crown of shrubs. As previously mentioned, two plants of different species may rarely occur within the same loop. Future tests may indicate the desirability for discarding the arbitrary rule recording the dominant plant and the placing of both plant species in the record of vegetation.

The frequency point was used for readings on bare soil and for litter in the tests at Starkey and Manitou because at the time it was thought that it might be a satisfactory measure of these site factors. But it was discarded in all later tests for several reasons. First of all, adoption of the loop for all readings on vegetation, soil, and litter has a big advantage in that the information obtained is from one method alone. Frequency point readings on litter tended to be too high with that which could be seen on the ground, since a single straw or pine needle might be recorded as an observation on litter. Although use of the loop for bare ground and litter involves an estimate as to whether or not the loop is half covered with litter, the results in subsequent tests indicate a better appraisal of litter, and the differences between men are not prohibitive. Future study may indicate the desirability of setting up the requirement that the loop be completely occupied by litter in order to be recorded as an observation. Also, it may be advantageous in some range types to group litter observations into depth classes.

COMPARISON OF LOOP METHOD WITH OTHER METHODS

As previously indicated, the loop method is essentially a compromise between frequency and area-estimate methods. During the course of the 1949 trials, several questions concerning the use of the loop method arose. These related mainly to the density index obtained of vegetation (i.e., 40 loops with perennial vegetation = 40 percent density) and litter. Also, the expression of composition largely in terms of frequency of occurrence in the 100 observations recorded is questioned. In other words, how do the measurements obtained by the loop method compare with those obtained by other measurement methods?

An informal test conducted in Colorado in the ponderosa pine-bunchgrass type compared the floristic composition recorded by the loop method with that indicated by 10 1-square-foot plots spaced at 10-foot intervals on the same transect line. Data on the latter were recorded by plant species, number of plants, and area. Composition based on area compared favorably with that indicated by the loop method.

A more intensive study conducted in the mixed grama-oak savannah type of southern Arizona compared four measurement methods, namely: (1) the line intercept, (2) the frequency point, (3) the 3/4-inch diameter loop, and (4) the paced transect. The tests involved the measurement by the first three methods of 20 transect lines (100 feet in length) placed in 10 different sampling sites, varying in range condition from good to poor. The paced transect was made on a rectangular plot (150x100 feet), enclosing the 100-foot transect. Data were then subjected to correlation analysis with respect to density of vegetation, amount of litter, and floristic composition.

Comparison as to Density of Vegetation.

The density figures obtained by the line intercept method in the Arizona tests were used as a base for comparing the other methods because line intercept density is generally considered as a reliable index of the actual percentage of ground occupied by vegetation. The density figures obtained by the line intercept method closely parallel those secured in charting quadrats. If this is so, the question naturally occurs, why not use it? The intercept method is too tedious, particularly in dense vegetation, and too time-consuming in summarization of data for general administrative use.

Correlation of the figures on density obtained by the three other methods with those secured by the line intercept method was satisfactory in all cases. As shown in figure 5, where the actual data for each method are plotted against the respective regression lines, the variance from each regression line is not great where the line intercept density is less than 4 percent and not prohibitive above this point. For the frequency point r = .9388; for the paced transect r = .9544, and for the loop method the correlation is best with r = .9719. Since the relationship is linear and the line intercept is a measure of actual density, one must conclude that the data obtained from the three methods in Arizona are likewise good indices

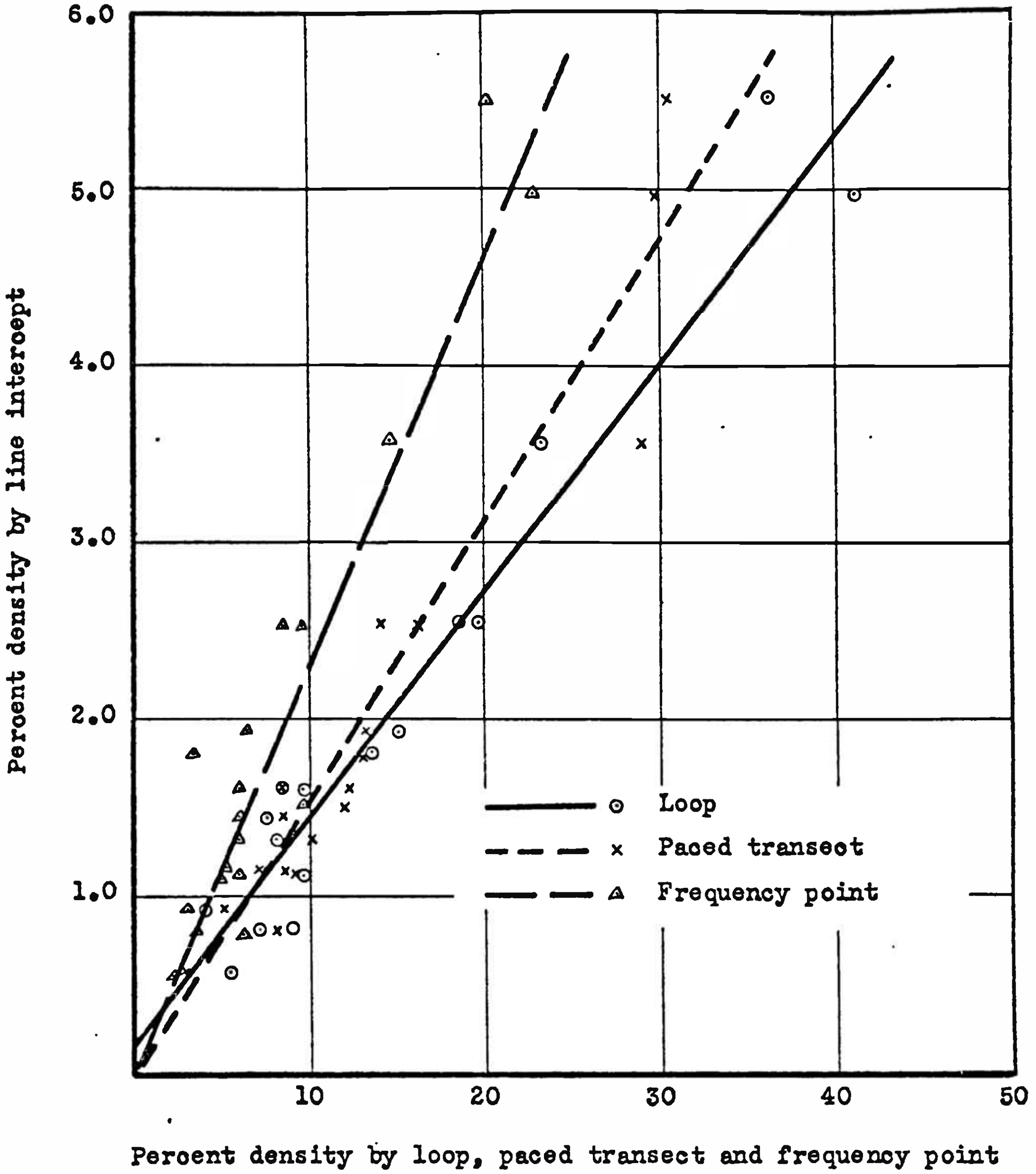

Figure 5. Density indices as obtained by loop, frequency point and paced transect methods compared with actual density of vegetation as determined by the line intercept method.

of the area occupied. However, line intercept density is much lower than that indicated by the other methods, i.e., where line intercept equals 2 percent, the frequency point will be 9 percent, the paced transect 13 percent, and the loop method 15 percent.

The Arizona methods tests were conducted in grassland types varying from high density sod cover and a good cover of large coarse bunchgrasses to a sparse stand of smaller bunchgrasses. It is unfortunate that range types with single-stemmed species (such as western bluestem wheatgrass) predominating were not available. It is possible that in such types totally different relationships between frequency index of area and area by intercept would obtain, such as showed up at the Starkey Experimental Range. Comparison of methods tests similar to those conducted in Arizona should be carried out in other range types, including those with a predominance of single-stemmed species.

Another question which arises with respect to the 3-Step Method is: How does density obtained by the loop method in Step One compare with density indicated by the paced transect in Step Two? This is of interest because after the initial installation of transects on an allotment, wherein a complete record is obtained by all 3 steps of the method, subsequent complete remeasurement (because of lack of personnel available for doing the job) might be limited to 3 or 5 or even 10-year intervals, but with accomplishment of Step Two possible on a yearly basis. The correlation coefficient between the loop and paced transect methods in Arizona was also high, r being .9371. As shown in figure 6, where the actual field data for the 20 transect lines are plotted against the computed regression line of the two methods, there are few discrepancies. Accordingly, the paced transect method appears to fit nicely into the 3-Step Method, since the data closely parallel those obtained by the loop method. It is doubtful if the paced transect in itself would be adequate for use on allotments where the highest level of accuracy obtainable is desired. Moreover, it is not suitable for shrub types. The uniformity between men is less than with the loop method and the sampling error in remeasurement should be larger, since the same identical step points cannot be repeated.

The Arizona trials comparing four methods were confined to grassland vegetation. For browse, loop method density apparently is very close to that obtained by the line intercept density. As shown by the Tahoe National Forest data, presented in table 2, the loop measurements on sagebrush (*Artemisia tridentata* and *A. cana*) (for four men on five different transect lines where the same lines were remeasured again) with but few exceptions closely approximated those obtained by the line intercept method. Comparable records were obtained in Wyoming on big sagebrush by four men on seven transect lines. However, there were no repeat measurements in the latter trials. Thus for crown density on shrubs, the percentage plant cover index obtained by the loop method appears to be very close to the density as measured by the line intercept method. Although not formally tested, experience indicates that the frequency point is not so reliable an

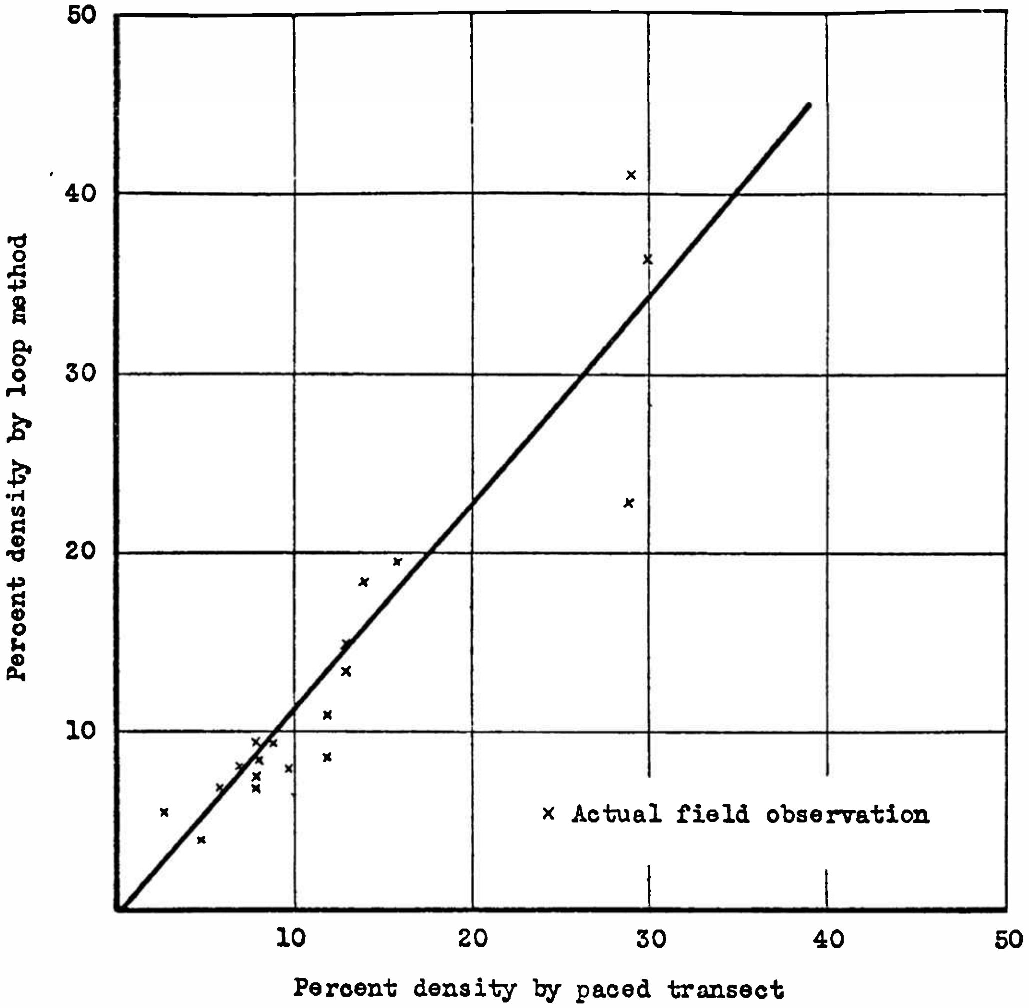

Figure 6. Indices of density of vegetation as determined by loop and paced transect methods are closely similar.

index of crown density because the point can easily slip through the crown of a shrub without being recorded as a "hit."

Table 2. - Field data on sagebrush measurement by loop method and actual measurement by line intercept method (Tahoe N.F., Calif.)

Man 1		Man 2		Man 3		Man 4		
First trial	Second trial	First trial	Second trial	First trial	Second trial	First trial	Second trial	Actual line intercept
%	%	%	%	%	%	%	%	%
22	23	22	22	24	25	16	16	25.20
22	19	21	23	22	23	18	20	20.25
27	30	28	27	28	29	27	28	28.45
21	22	24	25	20	22	25	25	21.60
7	7	6	5	5	5	4	4	5.80

Comparison as to Litter Cover.

Correlation analysis of the data obtained in measurement of litter in the Arizona tests indicated a fairly close relationship between three methods. (Data on litter cover were not obtained by the paced transect method.) The correlation coefficient for loop vs. line intercept was .8995 and for loop vs. frequency point it was about the same, r being .9081. The regression lines and actual field data are plotted in figure 7. As in the case of density of vegetation, the relationship between indices of the percentage litter cover obtained by the frequency point and loop method appears to be linear when compared to actual area as determined by the line intercept method.

Floristic Composition.

As shown in figure 8, floristic composition, based on the density indices of each method and weighted according to the plant species encountered in making the measurement, was quite comparable for five methods. Weighting was accomplished by grouping the plants into four groups according to their ecological status, securing a floristic composition figure for each group based on the density index of each method, multiplying this by an arbitrary factor for each group and adding the resultant figures for each group of plants. The weighting procedure was necessary in order to summarize the data in a convenient form for correlation analysis. The total weighted figure for each method on each transect was used in the correlation analysis. An example of the method used in securing a weighted figure for composition is presented in table 3. The arithmetical mechanics of weighting are similar to that followed in range surveys for forage acre factor. Group 1, given a weighting factor of 10, included mostly the tall grass dominants, or climax grasses such as beardgrasses (Andropogon spp.) sideoats grama, and tall threeawn; Group 2, with a weighting factor of 7, included species which commonly replace the tall dominants under heavy grazing use, such as curlymesquite grass and blue grama; Group 3, weighted as 3, was made up mostly of Rothrock grama, a short-lived perennial which replaces the more desirable perennials under long continued overuse. Group 4, weighted by 1, includes species characteristic of great disturbance or poor site such as fluffgrass (Triodia pulchella).

Table 3. - Example of method used for obtaining weighted figures on floristic composition.

Item	Plant group								Total weight
	Group 1 (factor=10)		Group 2 (factor =7)		Group 3 (factor =3)		Group 4 (factor=1)		
	%comp.	%x10	%comp.	%x7	%comp.	%x3	%comp.	%x1	
Line intercept	15.3	153	80.2	561	4.5	14	0.0	0	728
Loop	15.8	153	73.7	516	10.5	32	0.0	0	706
Frequency point	20.0	200	80.0	560	0.0	0	0.0	0	760
Paced transect (hits only)	11.1	111	88.9	622	0.0	0	0.0	0	733
Paced transect (comp. on 100	7.0	70	85.0	595	7.0	21	0.0	0	686

The correlation coefficients obtained from analysis of the data on floristic composition indicated a close relationship for all methods when compared to that obtained by the line intercept method. Thus, in line intercept vs. loop r = .9482, for frequency point r = .9859, for paced transect (hits only) r = .9887, and for paced transect (composition by 100 paces) r = .9305. The distinction between paced transect (hits only) and paced transect (composition by 100 paces) is that the former records only those plants actually hit by the toe, whereas in the latter method species are recorded at the end of each pace regardless of whether or not they are "hit". The latter method is used in actual field accomplishment of Step Two.

Summarizing, the Arizona tests indicated a fairly close and consistent relationship between the indices of density of vegetation, amount of litter cover and floristic composition as obtained by the loop and paced transect methods and as measured by the line intercept method. Moreover, the relationship of the indices obtained by the first two methods appears to be linear with the latter method, which is generally recognized to be an area estimate. This was likewise true of the frequency point method. It will be recalled that this method was not suitable for measurement in the Pacific bunchgrass type as encountered on the Starkey, in Oregon. The condition and trend study is aimed at securing a method that will have western-wide application on forest range types. The 3-Step Method, which utilizes the loop method in Step One and the paced transect in Step Two meets this requirement better than the frequency point. Both the loop and paced transect methods are essentials of the 3-Step Method and, as will be discussed later in actual application on a range unit basis, one or both may be used, depending on the level of accuracy desired in measurement.

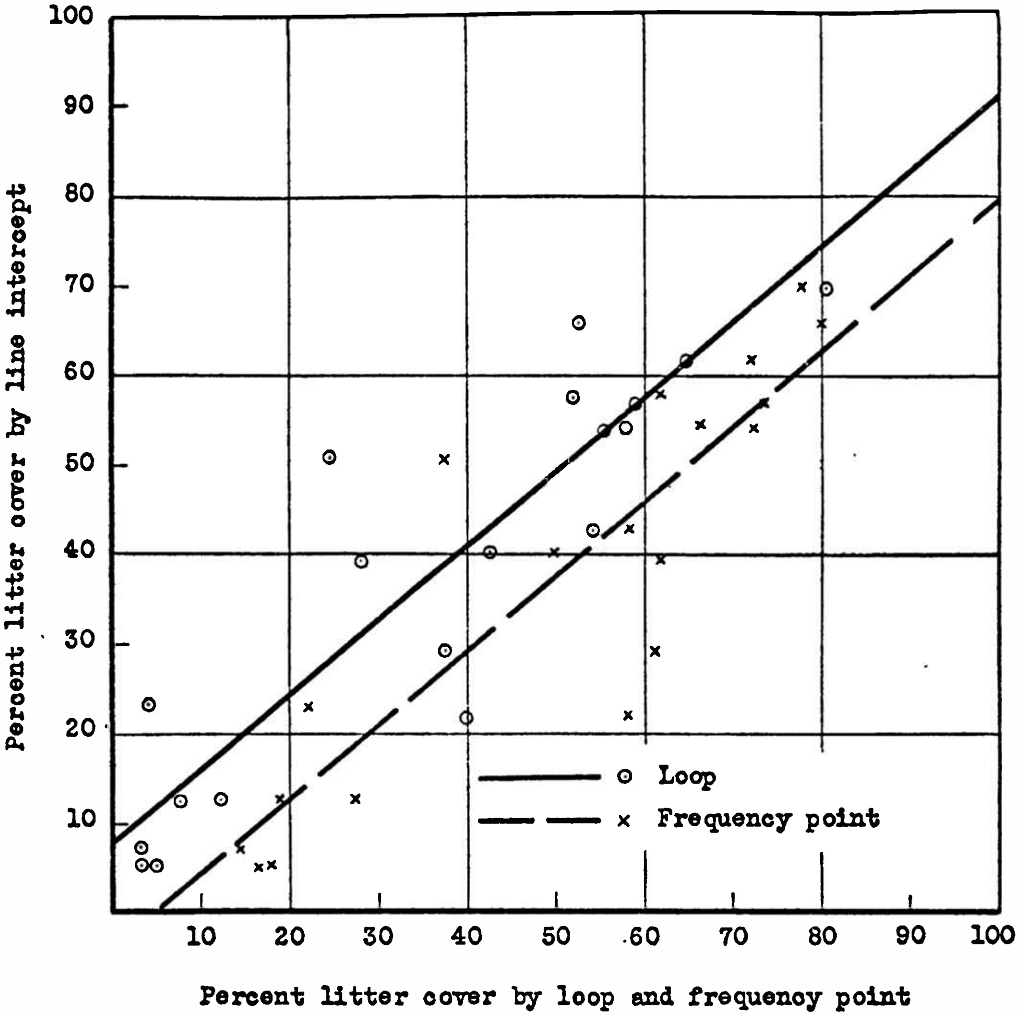

Figure 7. Linear relationship between loop and frequency point and line intercept determinations of percent litter cover.

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WHERE THE LOOP METHOD WAS TESTED

The loop method of measuring various elements of the site, as shown in Table 4, was tested in a wide variety of range types in various stages of condition. Attention was focussed primarily on the perennial grassland and open-timber types because of their importance in forage production and their significance as key areas. However, many other range types were encountered during the course of the study. These range types and condition classes on which the loop method was tested represent a large segment of national-forest range in the West. It was the consensus of opinion of the men who had taken part in the tests that the loop method offered promise of being a practical measurement tool for the determination of trend in all of these types and condition classes.

In this discussion of where the loop method was tested, two range types are of especial interest because of the sampling problems involved and the wide differences in growth characteristics of the vegetation. These types are the California annual type and the big sagebrush-grass type.

The California annual type, although of minor importance on national-forest range, is of interest because of its similarity in cover characteristics to cheatgrass which is of wide occurrence. The California annual type is especially difficult to measure because of the single-stemmed growth of the many species involved, and the aerial portion of these plants may occur in two or more levels. The vegetation is also of high density. The uniformity with which different individuals can measure the California annual grass type is indicated by the data presented in Table 5. It is fully appreciated that one transect line with measurements by three men is an inadequate test. However, it is thought that the data presented do indicate uniformity between men and together with data from other range types indicate the wide latitude of types to which the loop method might be applicable. Confidence in the use of the loop method is increased when we consider the data obtained on the California annual type by a similar method used by Huffaker and Holloway.3/ Their method consists of a sampling frame which covers 1/4 square meter and utilizes 28 brass rods or point designators. The species of greatest development within a radius of 1 inch was recorded at each brass rod. The method was used successfully in following changes in vegetation during a two-year period as brought about by the biological control of Klamath weed with certain introduced insects.

The big sagebrush-grass type was encountered in California and Wyoming. It is of importance because of its wide distribution on forest ranges. The vegetation is usually two-storied with grasses and weeds growing beneath the crowns of the shrubs. The transect tape, when stretched, may

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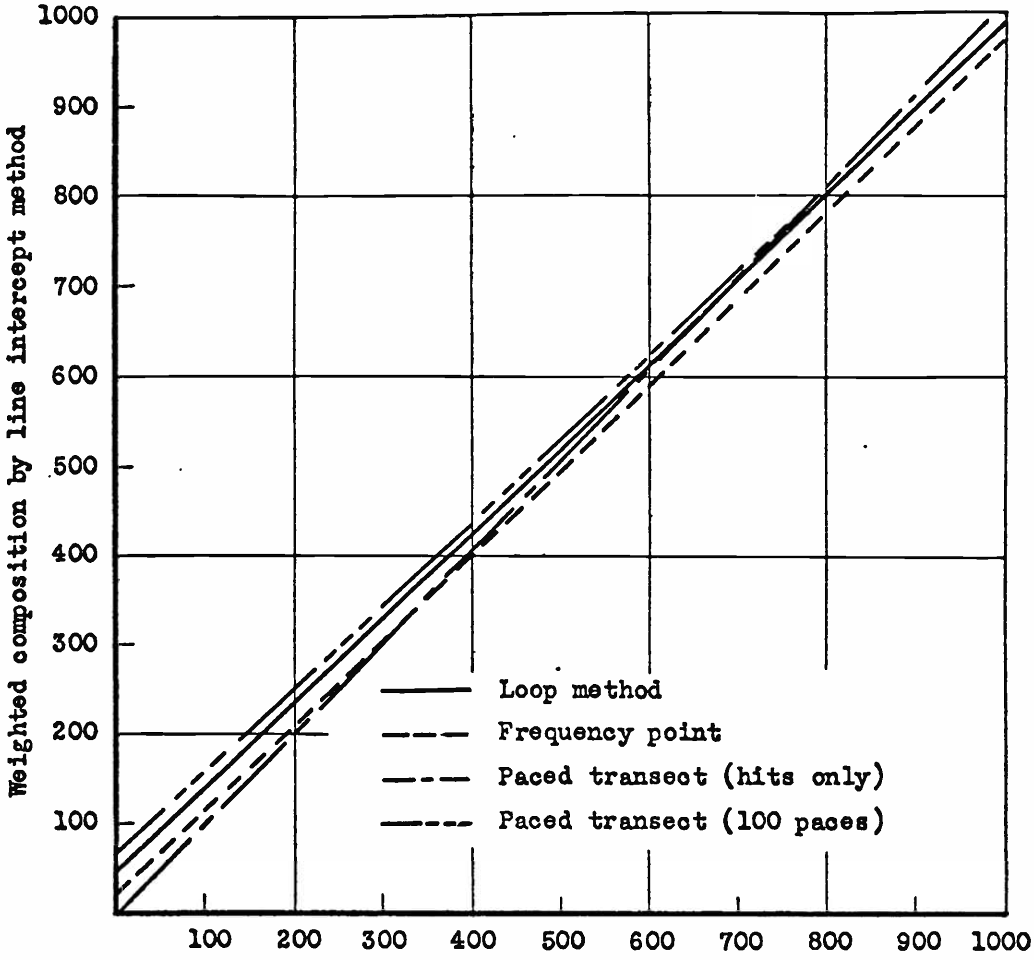
3/ Huffaker, C. B., and J. K. Holloway, 1949, Changes in Range Plant Population Structure Associated with Feeding of Imported Enemies of Klamath Weed (*Hypericum perforatum* L.), Ecology, Vol. 30, No. 2, pp. 167-175.



Weighted composition by loop frequency point
Paced transect (hits only) and paced transect (100 paces)

Figure 8. Linear relationship between loop, frequency point paced transect (hits only) and paced transect (100 paces) and line intercept determination of indices of floristic composition.

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Table 4. - Location of 1949 tests, personnel involved, range types and condition classes, and time of year when tests were conducted.

Location	Personnel	Range type	Condition classes	Time of year
Region Six-- Whitman N.F. Starkey Exp. Range, Oreg.	Kennedy Iverson Pechanec Holscher Harris Garrison Parker	Pacific bunchgrass in "biscuit-swale" Topograph	Hi-fair Fair Poor	June 20-26
Region Two-- Pike N.F. Manitou Exp. Range, Colo.	Schwan Cramer Costello Parker	Ponderosa pine-bunchgrass	Good Fair Poor	June 27 - July 15
Region Five-- Tahoe N.F. Sierraville R.D. California	* Wood Saarni Hormay Parker	Big sagebrush-grass Wet & dry meadows Mt. grassland (Wyethia) Bitterbrush Ponderosa pine-bunchgrass California annual type (near Berkeley)	Poor Poor to fair Poor Poor Hi-fair Good	August 1-12
Region One-- Beaverhead N.F. Vigilante Exp. Range, Montana	* Johnson Lommasson Woolfolk Peterson Parker	Mt. grassland	Low-fair Fair Good	August 15-26
Region Four-- Bridger N.F. Cokeville R.D. Wyoming	Phinney Ellison Houston Parker	Big sagebrush-grass	Poor to fair	September 12-16
Region Three-- Coronado N.F. Nogales R.D. Arizona	Traugh Bostick Pearse Parker	Mixed grama-oak savannah	Poor Fair Good	October 3-7

*Associate Director Talbot and Director Tebbe each spent about a week working with the group and had many valuable comments regarding the work.

Table 5. - California annual grass type--field data on the same transect line for three men.

:	Man 1	Man 2	Man 3
Avena fatua	7	7	10
Bromus mollis	49	54	52
Festuca megalura	5	1	2
Lolium multiflora	13	11	10
Hordeum gussonianum	4	3	6
Bromus rigidus	4	1	2
Unknown (weed)	0	1	1
Litter	18	22	17
Bare soil	0	0	0

be 2 feet or more above the ground surface, necessitating that observations be made by "plumbing" the wire loop. A similar situation obtains with other shrub types such as bitterbrushgrass. In measuring such types for the purpose of eventual determination of trend, it is important that the overstory vegetation be recorded as well as the understory cover. Both stories of vegetation may be recorded on the specially devised form presented in Figure 3. From the standpoint of determining trend in browse types, this is an important record because there is a marked difference in potential trends between a brush stand with grasses beneath the crowns of the shrub and one with no grass at all. As will be discussed later, there was no significant difference between men in the measurement of browse and grasses in the Wyoming trials. As shown previously in Table 2, the crown density measurements of sagebrush in California obtained by the loop method closely parallel those obtained by the line intercept method.

HOW THE LOOP METHOD WAS TESTED

The tests were conducted in each region in much the same pattern. Two or more days were spent by the group at the beginning in initial training with the discussion of the 3-Step Method--particularly Step One. Following this initial training period a minimum of two transect lines were located by iron stakes within each of the various sites selected for sampling. All transect lines were 100 feet long. Where only one range type was involved, all condition classes available were sampled by the loop method. In California seven distinct range types were sampled--most of which had only one condition class readily available.

Each of the transect lines was measured by each member of the group who repeated his measurement on the same lines a day or so later after replacement of tape. No reference was made to previous notes, but occasional consultations were necessary on certain standards of measurement. For example, it was found that prior consideration and agreement was needed on how some growth forms should be measured and recorded. Growth forms of weeds and shrubs are especially variable: These may vary from open, scraggly, difficult to define forms to dense, compact crowns that are easily defined and measured. The former require special definition in order to attain a high degree of uniformity between men in measurement. Specific definitions for growth forms difficult to measure have as yet to be determined more precisely.

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The necessity of measurement standards to fit certain growth forms is not peculiar to the loop method alone but is an essential attribute of all sound methods of measuring vegetation.

Tests conducted with the loop method as a means for securing information on range trend were concerned primarily with the following major sources of variation.

1. Change due to trend in condition as influenced by grazing use and weather. To be obtained by repeated measurement of essentially the same lines over a period of time. In the field tests broad changes that might be expected within a period of time were simulated by deliberately selecting different sites in the same range type that were judged to be different with respect to range condition.

2. Measurement error arising from different men taking the records. It is important that this error be small, because on most ranger districts it is unlikely that the same man will make the measurements of the same plots over a long period of time. If the error is large and not recognized as such, then conclusions may be drawn with respect to trend that are highly erroneous.

3. Measurement error due to replacement of tape when transects are remeasured. It is important that as exact replacement of the line as is possible be made, otherwise a new error of sampling is introduced. This, if large, may also lead to erroneous conclusions with respect to trend.

4. Measurement error of same man. Unless the plots are to be remeasured by the same man, this error is not as important as 2, above.

It is likely that this error will be smaller than 2, but it will increase if men tend to develop a bias within themselves by constantly changing or adopting new standards or different criteria of measurement. This would also influence the difference between men. As for example, measuring the perennial crown of a shrub by ignoring current annual twig growth and the next time recognizing it.

It is especially important that errors 2 and 3 or 3 and 4 be small, otherwise, a great and probably prohibitive number of transects will be required to accurately measure the variation resulting from change in range condition. Accordingly, the data obtained in each region by the loop method were subjected to regular analysis of variance procedures to determine differences between men and the combined variation due to men and line replacement. Where the range type had two or more condition classes represented, the record obtained by the loop method was subjected to further analysis to determine which data might be most meaningful for depicting trend. Inasmuch as all plants were identified and recorded as to species, it was possible to group them as to growth form (grasses, weeds and browse) and as to special indicators of various successional stages resulting from grazing use. This procedure was followed in order to facilitate analysis of data and to permit comparison between different range types encountered within the regions.

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DIFFERENCES ARISING FROM LINE REPLACEMENT

Differences arising from replacement of the tape, as would be necessitated in remeasurement of permanently located transect lines at periodic intervals, were for the most part not significant in the tests conducted in Oregon, Colorado, California, and Montana. (Data are lacking for Wyoming and Arizona, since the time scheduled for making complete remeasurement of all lines was insufficient.) A measure of this source of error was obtained by comparison of the first trial and second trial data for all lines. An example of the method of analysis carried out for this determination is presented in Table 6 (utilizing data from the Vigilante on climax species, involving thirteen transect lines, four men and each man repeats his measurement after line replacement). Since the tape was removed and stretched between the same stakes a day or so later, the mean square error term (listed as 5.0366 in Table 6) includes error due to line replacement plus any individual bias of the man making the remeasurements.

Table 6. - Example of Analysis of Variance procedure used in the analysis of data (Vigilante data for climax species)

Analysis of Variance	D.F.	S.S.	M.S.	Sig.
Trials	1	5.0866	5.0866	-
Lines	12	3126.5385	260.5449	**
Men	3	1.2597	.4199	-
Line X Men	36	1021.6153	28.3782	-
Error	51	1026.4134	20.1258	-
Total	103	5178.9135		

**Significant at the 1 percent level.

A summarization of the differences arising from line replacement for various elements of the site for the four regions in which this could be tested is presented in Table 7. It is readily apparent that in the bulk of these tests there was no significant difference due to line replacement. The few instances where there was a significant difference due to line replacement are difficult to explain. In the case of litter this was determined by means of the frequency point method in Oregon and Colorado, and in California and Montana by the loop method. This would indicate the latter as a superior method in that differences due to line replacement are not significant. However, in due fairness to the frequency point method, it is worthy of note that at Manitou in Colorado heavy rains occurred between the initial and repeat measurements so that litter on the areas in unsatisfactory condition was washed together into bunches or riffles from its former dispersed state. Hence, measurements made on litter in the initial trials could not be repeated with confidence in the follow-up trials.

Table 7. - Summarization of differences due to line replacement for various elements of the site, as determined by analysis of data from four regions.

Element measured	OREGON Starkey	COLORADO Manitou	CALIFORNIA: Tahoe	MONTANA Vigilante
Climax grasses	N. S.	N. S.	No test	N. S.
Total grasses	*	N. S.	N. S.	**
Weeds	N. S.	N. S.	No test	N. S.
Browse	No test	No test	N. S.	N. S.
Rock-bare soil	N. S. (FP)	N. S. (FP)	N. S.	N. S.
Litter	**(FP)	**(FP)	N. S.	N. S.

* Significant at 5% level.
** Significant at 1% level.
FP = Frequency point method.

Replacement of the tape and remeasurement involve the question of whether or not it is possible to return to exactly the same points for observation. It is obvious that the chances for doing this accurately are minimized as the point to be observed decreases in size. One good reason for this is the coefficient of thermal expansion of steel. With a tape 100 feet long the variation in total length arising from fluctuation in temperature could be ±.03 feet or more. Thus, the chances for returning to the same point as in the loop method with a 3/4-inch diameter circle are much greater than in the case of a fine point as with the frequency point method.

The record obtained in all tests (except those in Arizona) was a simple "dot" record on transect lines 100 feet long with 100 observations made at 1-foot intervals. This type of record did not permit examination of the data to see if exactly the same loops were being recorded on remeasurement. In other words, it is possible that differences due to line replacement were obscured by compensation, i.e., an observation missed at one point on the line in the first measurement may be picked up in the second, and vice versa. In Arizona the specially devised form shown in Figure 2 for recording each observation was utilized to help answer this question.

In Arizona, permanently staked lines 100 feet long measured in early October were remeasured by the same man again in February, without reference to the data obtained in the first trial. As shown by the data presented in Table 8, the observations are partially compensating. Thus, for four lines the average total vegetation was 29.4 (out of 100 loops) which was comprised of 22.2 (75.5%) loops with identical readings for vegetation and 7.1 loops (24.1%) with records made at different points on the line. Transects 1 and 2 were in a high density, shortgrass type of curlymesquite (*Hilaria belangeri*) and grama (*Bouteloua gracilis*; *B. hirsuta*) where the tape was close to the ground surface. Transects 3 and 4 were in a tall bunchgrass type composed largely of beardgrass (*Andropogon* sp.) and sideoats grama (*B. curtipendula*) where the tape was frequently as much as a foot above the soil surface. In spite of this, the data from transects 3 and 4 compare favorably with lines 1 and 2 with respect to line replacement and observation of the same loops. It would seem, however, that with tall vegetation such as sagebrush the number of identical points or loops on a line that could be observed would decrease because of the greater height of the tape above the ground surface. Whether or not this is true is not known. It is possible, too, that if lines shorter than 100 feet in length had been utilized the lines could be retraced with a greater degree of confidence. Differences due to movement within the center part of the transect line can be overcome to some extent by the placement of witness stakes at one or more points between the end stakes. Proper length of line yet remains to be determined.

Table 8. - Arizona data on four transect lines with 100 loop observations taken on different dates by the same man on the same lines and on the same lines but at different points on these lines.

Transect number	Date measured	Number of observations with vegetation in identical loop	Number of observations with vegetation in different loops	Total vegetation A*	Total vegetation B*
1	Oct. 1949	36	4	40	
	Feb. 1950	36	5	41	42
2	Oct. 1949	25	11	36	
	Feb. 1950	25	9	34	37
3	Oct. 1949	14	2	16	
	Feb. 1950	14	5	19	20
4	Oct. 1949	14	12	26	
	Feb. 1950	14	9	23	23
Average		22.2	7.1	29.4	30.5

* A = same line and attempt to record same 100 loops.
B = same line as in A but all 100 loop observations different from A.

From the standpoint of observing trend and reducing error due to line replacement, it is important, if possible to do so, to retrace the same identical lines and points because of the greater confidence that can be placed in the data. This would be particularly true where vegetation was sparse and the floristic composition varied greatly. In fairly uniform vegetation of relatively high density, it may not make much difference whether or not the same points are observed from one measurement period to the next. In order to answer this question, the same four lines were remeasured as described above but the 100 loop observations were deliberately spaced half way between. As shown in column B, Table 8, the readings for total vegetation closely paralleled those shown in column A where an attempt was made to retrace the identical loop readings. The average of the four lines was 30.5 compared to 29.4 and the readings for individual lines compared favorably in all cases.

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UNIFORMITY BETWEEN MEN

The question of whether or not different individuals can measure range vegetation alike is highly important in the determination of range trend. If differences between men are large, it is likely that erroneous conclusions will be drawn from the data. For example, if one person is inclined to make "low" readings and another "high" on the same transect lines, the difference between the two measurements will be ascribed to change when actually there may have been little or no change.

Analysis of the data obtained by the loop method in the six western regions was carried out by the variance procedure summarized in Table 6. Summarization of "f" table results from the individual regional analyses for the differences between men in the use of the loop method for recording various elements of the site are presented in Table 9 (also see Appendix for analyses by individual regions). It will be noted that the error between men was not significant in 17 out of 30 cases where this could be tested. On the other hand, there were 13 instances where the error was significant at the 1-percent level and 2 cases where it was significant at the 5-percent level. If we eliminate the items measured by the frequency point method and consider only those obtained by the loop method, we find 16 cases out of 26 where the differences between men were not significant. The results from these trials are considered to be very encouraging. This is especially true when appraised in the light of the well-known discrepancies between men in the use of other range measurement techniques.

Table 9. - Summarization "f" table results for differences between men in use of the loop method for recording various elements of the site (see Appendix for individual regional analyses).

Element measured	OREGON Starkey	COLORADO Manitou	CALIFORNIA Tahoe	MONTANA Vigilante	WYOMING Bridger	ARIZONA Coronado
Climax grasses	**	N.S.	No test	N.S.	N.S.	N.S.
Total grasses	**	N.S.	*	**	N.S.	*
Weeds	N.S.	**	No test	**	N.S.	No test
Browse	No test	No test	N.S.	**	N.S.	No test
Rock-bare soil	N.S.(FP)	**(FP)	N.S.	N.S.	N.S.	**
Litter	**(FP)	**(FP)	**	N.S.	N.S.	N.S.

* = Significant at 5% level.
** = Significant at 1% level.
FP = Frequency point method.
N.S.= Not significant.

The "f" table results shown in Table 9 for differences between men are not entirely indicative of the level of reliability of the loop method even though the analysis of variance may indicate no significant difference. It the mean square between men and the interaction men X lines are insignificant when compared with pure error, it might merely indicate poor technique, This would be true whenever the pure error term was large. The pure error mean square in all analyses for all regions was small in comparison to the expected error between lines. An example of this type of comparison is presented in Table 10 for measurements of total grass by the loop method in all regions. Although deliberate selection of sampling sites increased the error term between lines, it is believed that it would still be proportionately large in comparison with the pure error term if the lines had been randomly placed. This indicates the loop method to be a reliable method of measurement, regardless of whether or not the "f" term is significant.

Table 10. - Comparison of expected mean square error term of differences between lines in total grass and pure error term.

Location of trials	Between Lines Mean Square Value	Pure Error Mean Square Value
Oregon	3480.106	11.965
Colorado	1310.248	13.342
California	4043.974	5.528
Montana	352.054	6.203
Wyoming	119.060	9.806
Arizona	210.039	1.989

In the conduction of the tests with the loop method, every precaution was taken to achieve a minimum disturbance of vegetation and soils. In spite of this care, some disturbance of plants, litter and loose rock did occur. Hence, part of the differences between men can be ascribed to this cause and not to failure to measure alike. In the Oregon trials another source of error arose from the use of both an engineer tape and a wire transect line with balls of solder spaced at one foot intervals. The latter was later found to have the balls incorrectly spaced. Hence it is advisable to use steel tapes because they are standard instruments.

Error between men in the application of the loop method may arise from a number of sources, namely:

1. Failure to adhere to the same standards or criteria of measurement. For example, the definition of litter followed in the tests was any dead vegetative material, regardless of origin. In one series of tests one individual adhered to this definition at the start of the tests but changed his concept afterwards to record only perennial grass leaves and stems, ignoring pine needles which were abundant.

2. Improper plant identification is an error inherent with any method and can only be reduced through constant training. (There is an especial need for training in the recognition of plants by vegetative characteristics). This error is apt, to be large at the beginning of growth or at the end of the season when either the plants have dried up or have been heavily utilized.

3. Poor eyesight or failure to examine the ground surface closely for plants of extremely small size.

4. Failure to straddle the tape line at all times and to make the measurements from the same edge of the tape.

5. Failure to properly plumb the loop from the tape - particularly when the latter is a foot or more above the ground surface. Improvement of the wire loop by weighting or other means, to secure more accurate plumbing, is considered to be highly desirable.

SENSITIVITY OF THE METHOD

Of equal importance to securing uniformity between men is the requirement that the method be sensitive in reflecting changes in range condition. Obviously it was not possible in these tests to await a year or more for known changes (i.e., as arising from drought) to take place on the transect lines established in connection with the study. However, it is possible on the basis of the same data (collected primarily to determine uniformity between men), to examine this material from the viewpoint of sensitivity of the method. It will be recalled that in selection of sampling sites within a range type, whenever it was possible to do so, these were deliberately placed in different condition classes. Among the best data collected in this manner are those from the Starkey Experimental Range in Oregon. Accordingly, these data will be examined for their value in indicating possible broad changes as might occur from one condition class to another and as to smaller changes within a condition class.

The tests in Oregon were conducted on the Pacific bunchgrass range. In this range type the item of "climax" grasses is of especial importance because of its value in the delineation of range condition classes. Furthermore, increases or decreases in this group of choice grass species are an important indicator of the direction of trend in condition. Changes with respect to climax species from the poor to the fair condition class have been observed to occur on the Starkey within a 10-year period. In spite of significant differences between men in making the measurements, the record obtained by each of the six men as shown in Table 11 indicated a clear-cut difference between three condition situations -- poor and fair -- and the intermediate stage listed as "hi-poor". The data presented for each condition class are the average of three transects located as a "cluster" in each condition class in much the same fashion as they would be if applied on a range unit basis.

Thus the simple arithmetic cluster averages indicate sharp differences between the three condition situations. This is likewise true of the individual lines, although the variation between individuals is apparent. For example, as shown in Table 12 the readings on transect line 2 ranged from 1 to 6. In spite of this variation there was only a single case where the readings overlapped. This was between Man 3 on line 2 in the poor condition site with a reading of 6 and Man 6, line 8, in the high-poor condition with a similar reading of 6. Apparently the loop method is sufficiently sensitive to pick up broad changes as may occur in the relative abundance of the climax species shown in Tables 11 and 12.

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Table 11. - Transect cluster averages of climax species (Agsp, Koer, Feid, Daun) as determined by six men with the loop method in three different range condition sites. Starkey Experimental Range, Oregon

Man	Range condition		
	Poor	Hi-poor	Fair
	Av. 3 lines	Av. 3 lines	Av. 3 lines
1	2.7	10.7	39.3
2	3.7	12.3	37.3
3	2.7	12.0	37.0
4	3.0	8.3	34.3
5	3.0	11.0	42.3
6	1.7	9.0	32.0

Now as to the sensitivity of the method within a single condition class, the same data on climax species may be further analyzed to determine: (1) The minimum number of lines necessary to sample each condition situation; (2) the magnitude of change that would be necessary before it could be picked up by different men and by the same man. These determinations may be accomplished by carrying out separate analyses of variance from the data presented in Table 12 for each condition situation. The mean square error terms so obtained are summarized in Table 13.

Table 12. - Field data on climax species obtained by the loop method by six men in two trials on the same nine transect lines in three condition situations. Starkey Experimental Range, Oregon.

Transect:	Man No. 1		Man No. 2		Man No. 3		Man No. 4		Man No. 5		Man No. 6	
	Trials		Trials		Trials		Trials		Trials		Trials	
No.	1	2	1	2	1	2	1	2	1	2	1	2
							FAIR CONDITION					
4	38	34	37	32	37	36	33	36	41	45	31	28
5	44	54	41	50	41	51	39	32	50	52	36	45
6	36	31	34	32	32	34	31	36	36	39	29	32
							HIGH-POOR CONDITION					
7	12	11	15	12	14	12	8	8	12	12	12	8
8	10	11	12	8	11	7	8	8	7	9	6	6
9	10	10	10	10	11	11	9	9	14	10	9	11
							POOR CONDITION					
1	3	3	4	4	3	3	3	4	4	3	2	2
2	3	3	4	5	2	6	2	5	3	3	1	4
3	2	2	3	2	3	3	4	3	2	2	2	3

Table 13. - Summarization of mean square error terms determined from data presented in Table 12.

Source of variation	Degree of freedom	Range condition		
		Fair	Hi-poor	Poor
Trials	1	30.25	8.03	2.78
Lines	2	144.08	23.25	2.19
Men	5	82.92	9.32	1.71
Interaction (MxL)	10	15.25	3.22	.49
Error	17	14.90	2.09	1.01
Total	35			

From the mean square error terms presented in Table 13 it is possible to calculate (not shown herewith) the number of lines necessary to adequately sample each condition situation for trend. This analysis indicated the following: 12 lines for the fair condition class, 22 lines for the high-poor, and 3 lines for the poor. The average magnitude of differences on these lines that would have to be attained for significance where different men make the measurements would be as follows:

Fair condition with a present mean of 37.95, a change in average loop reading in either direction of 9.5 or 25 percent;

High-poor condition with a present mean of 10.10, a change in either direction of 2.83 or 28 percent;

Poor condition with a present mean of 3.05, a change in either direction of 1.27 or 42 percent.

Where the same man could repeat the measurements the minimum difference necessary to show change would be much smaller than where different men made the readings. For example, in the fair condition class an average change of 3.15 or 8.3 percent would be shown as significant.

Although the data utilized in the above calculation are for climax species, it is believed that similar relationships obtain with other factors of the site. This is of importance because the climax species might be entirely lacking on a range in very poor condition and increase in the secondary species would have to be relied upon as a measure of improvement. As a matter of fact in any condition situation, changes in the amount of the litter cover, bare soil, and rock would also be important considerations in determining the direction of trend.

Elsewhere in the other regions, the loop method yielded reasonably sound information for detection of differences of varying magnitude. In Table 14 are listed similar calculations as carried out with the Starkey data but for other site factors. The method appears reasonably sensitive with respect to these other site factors. It is especially sensitive to changes in browse. For example, in California where the average loop reading on the lines with browse (big sagebrush) was 32.3, the magnitude of difference necessary was only 2.0 and could be picked up with a minimum of 12 lines. The degree of confidence in this difference would be at odds of 19 to 1.

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Table 14. - Magnitude of differences, for several site factors, that could be detected by the loop method, with confidence at odds of 19 to 1. (By Roy Chapman - Washington Office)

Location	Site Factor	Average Loop Index of Density	Magnitude of Difference Required (Plus or minus)	Number of Lines Required
Colorado	Secondary grass species:			
	Poor condition	35.2	3.0	6
	Fair condition	34.8	2.0	8
	Good condition	29.2	6.0	5
California	Browse	32.3	2.0	12
	Litter	28.3	5.0	22
Montana	Total grasses	41.4	3.5	22
Wyoming	Total grasses	14.2	2.0	7
	Browse	27.4	2.0	5
Arizona	Total grasses	27.4	4.0	6

These analyses indicate the loop method to be reasonably sensitive in picking up changes that may occur within a range condition class. They are sufficiently promising to warrant further field testing as to sensitivity. Information on the magnitude of changes in condition that can be expected during periods of time as short as 3 years within the majo range types should also be concurrently collected.

OPTIMUM NUMBER OF OBSERVATIONS ON A LINE

The loop method, as initiated and upon which all trials in all regions were based, involves the recording of 100 observations made at 1-foot intervals along the edge of a steel tape. The selection of 100 points for observation was purely arbitrary and was done for convenience in the summarization of the data. The question arises, would half this number, for example, be sufficient or do we need more than 100, say 200, observations for the sake of accuracy?

A test was conducted on the Coronado National Forest in southern Arizona on the mixed grama type, in order to secure an estimate of the accuracy involving different numbers of observations per transect line. In this test, 20 transects, each 100 feet long, deliberately placed in different densities of grassland vegetation, were measured by one man. On each line, 200 points were observed by the loop method and recorded as they occurred on the transect line. This method of recording permitted later

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Table 14. - Magnitude of differences, for several site factors, that could be detected by the loop method, with confidence at odds of 19 to 1. (By Roy Chapman - Washington Office)

Location	Site Factor	Average Loop Index of Density	Magnitude of Difference Required (Plus or minus)	Number of Lines Required
Colorado	Secondary grass species:			
	Poor condition	35.2	3.0	6
	Fair condition	34.8	2.0	8
	Good condition	29.2	6.0	5
California	Browse	32.3	2.0	12
	Litter	28.3	5.0	22
Montana	Total grasses	41.4	3.5	22
Wyoming	Total grasses	14.2	2.0	7
	Browse	27.4	2.0	5
Arizona	Total grasses	27.4	4.0	6

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analysis by 6-inch, 1-foot, and 2-foot intervals, representing 50, 100, and 200 points, respectively.

The optimum number of points per transect line was determined by utilizing the following equation in the analysis of the data from each treatment:

$$\sigma p = \sqrt{\frac{Pq}{N}}$$

wherein P = percentage loops with vegetation
q = 1-P or percentage misses
N = number of points observed

The error term secured is then expressed as a percentage of P.

Results of the analysis are presented in Figure 9. As might be expected, accuracy increases as the number of points per transect increases with 200 loops the most accurate, 50 the least, and 100 intermediate. Lines with 50 observations per line are inadequate since the percent mean term is high, exceeding 20 percent on all densities of vegetation below 32 percent. The curves for 100 and 200 observations per line flatten out rather rapidly wherever the index of density for vegetation exceeds 20 percent. At this point, the percent mean error terms are 20 and 14 percent. Since the index of vegetation density obtained by the loop method usually exceeds 20 percent, it is thought that 100 observations per line is a fairly sound base for sampling. From a practical viewpoint, this is also an optimum number because of the greater ease in record compilation than with either 50 or 200 loops. The time required in field examination is markedly less than with 200 loops.

PLACEMENT OF TRANSECTS IN CLUSTERS

There are several sound reasons for the placement of two or more transects in a cluster at each site selected for sampling. It affords a larger sample of the vegetation and helps prevent the overlooking of rare species which may be valuable indicators of trend. It provides a measure of the variation within a sampling site and helps smooth out the differences in measurement between men. From a practical viewpoint, placement of transects in clusters is desirable because of the greater amount of information obtained per man hour. The question of how many transects that should be placed in a cluster will be governed by the variance in density of vegetation both within transect clusters and between clusters. In addition to this, the number of transects in a cluster will be governed in part by the ease of travel. If travel is easy, it is better to have fewer transects in a cluster and more clusters established for sampling the range. If travel is difficult, cost in terms of time becomes a limiting factor and

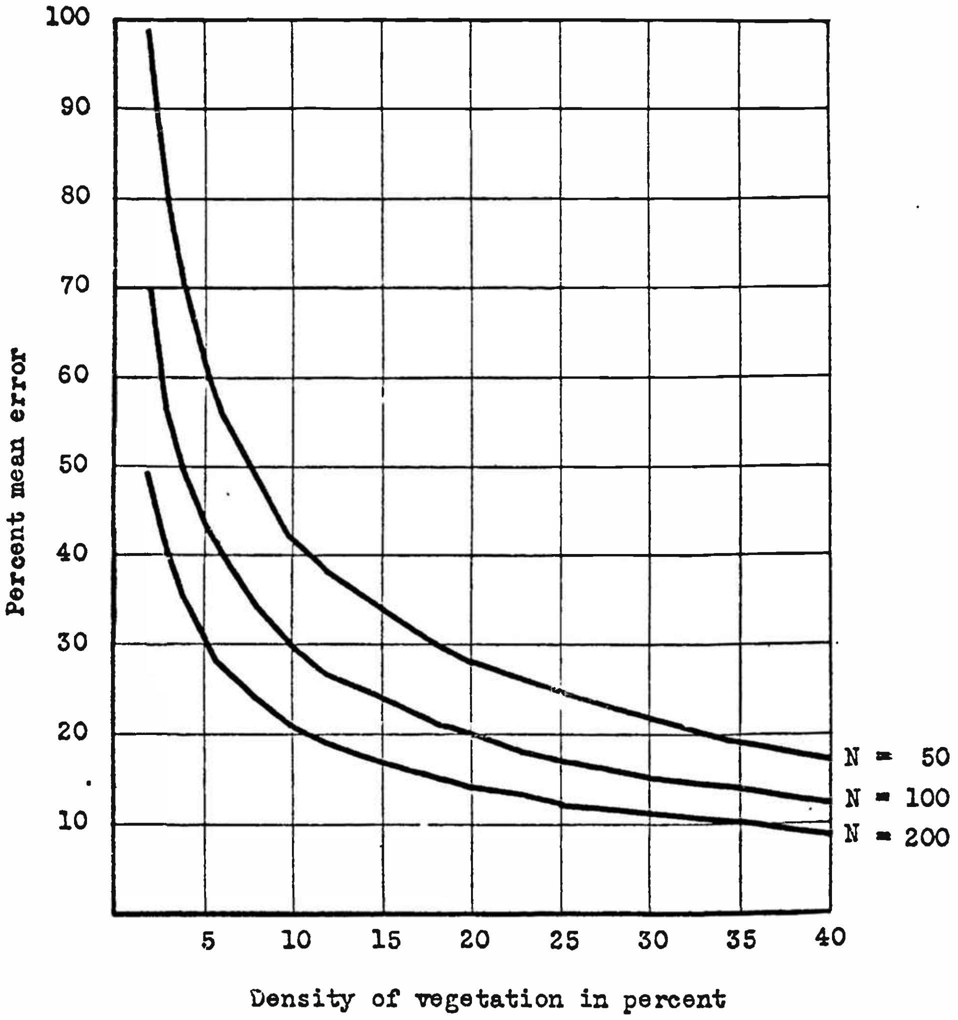

Figure 9. Percent mean error comparison of 50, 100, and 200 loop observations per transect as influenced by density of vegetation.

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more units in a cluster, with fewer clusters will be required.

Similar problems of sampling are encountered in the Forest Survey. Hasel of the California Station has developed a method of statistical analysis for determining the optimum number of plots to place within a cluster. This method was followed in the analysis of data obtained on the Coronado National Forest in Arizona, involving 16 transects, representing 8 clusters of 2 transects per cluster. The 8 clusters sampled areas varying from good to poor range condition. Results of this analysis are presented in Table 15 and are presented as an illustration of how the method might be used elsewhere.

Table 15. - Analysis for the determination of optimum number of transects per cluster (Arizona-Coronado N. F. data).

Source	DF	Sum squares	Mean square	Designation
Between clusters	7	97.0	13.857	* KA + B
Within clusters	8	84.0	10.50	B
Total	15	181.0		A + B

* K = plots in a cluster (2 in this example)

To determine A:

$$KA + B = 13.857$$
$$2A + B = 13.857 \text{ and } B = 10.50$$
$$2A = 3.357$$
$$A = 1.678$$

Tl or average travel time between transect clusters = 35 minutes.
Tp or average time required for each transect = 19.85 minutes.
R or cost ratio = $\frac{Tl}{p} = \frac{35}{19.85} = 1.76$

$$\frac{Sw}{Sb} = \frac{\sqrt{10.5}}{\sqrt{1.618}} = 2.501$$

Then N or number transects required = 2.501 $\sqrt{1.76}$ = 3.326 or N = 3.

The above analysis indicates that for the conditions encountered on the Coronado three transects at a sampling site would be sufficient. The relative sampling efficiency of transects placed in clusters as compared to independently located transect lines may also be computed. This calculation indicates that 8 clusters of 3 lines each (total 24 lines) would be equivalent to 19 transect lines separately located. The saving in travel time from one sampling site to the next is apparent. This saving would no doubt be increased in follow up remeasurements when the sampling sites would have to be relocated, perchance by personnel unfamiliar with their location.

The time data used in the analysis was the time required (av. 19.85 minutes) to accomplish Step One of the 3-Step Method. Re-analysis, with 40.5 minutes per transect, the time required for all three steps, indicates that a minimum of two lines per cluster would be required. However, for greater confidence, a guarantee against loss of a transect through destruction, assurance in picking up key indicator species, and in order to meet unforeseen eventualities it is suggested that a minimum of three transects per cluster be utilized as the sampling unit. At least this number per cluster should be utilized until experience and analysis of data prove otherwise.

ADVANTAGES AND LIMITATIONS OF LOOP METHOD

Results of the 1949 field tests indicate the loop method to have much promise as an administrative tool for securing information on trends in range vegetation. It is simple, readily understood, and men can be easily trained in its use. It provides reasonably accurate indices of density, of vegetation, floristic composition, amount of litter as it occurs between plants, bare soil and exposed rock. Equipment required is extremely simple. The measurements may be obtained by one man within a reasonable period of time. Data obtained are readily interpreted and are subject to statistical analysis if that appears desirable at any time. Differences between men in many of the 1949 trials were not significant and, where they did occur, were not prohibitive. Additional testing for uniformity between men is probably not necessary. Sensitivity of the method in reflecting wide changes as from one range condition class to another is adequate. Likewise, the method appears to be reasonably sensitive for detecting smaller changes within a condition class, although this would justify some further testing. Accordingly, the method is believed to be technically sound and that it will be met with acceptance and approval of range ecologists.

The loop method has certain limitations which should be recognized. These limitations may be segregated into two groups: those which can only be overcome or reduced by adoption of proper precautionary measures and those which may be corrected for by further refinement of the method.

First of all, the loop method is not a method to be applied without insturction. Careful and thorough field training of personnel must be carried out prior to actual application. The sample obtained is so small that, in order to determine trend, the utmost care and precision must be observed in obtaining the initial and subsequent measurements. Like any other method plants with unusual growth forms will have to be specifically defined and the definitions carefully adhered to in order to achieve the greatest uniformity between men. Personnel gathering the data must be able to identify or recognize the more important range plant species. If rangers collect the data, they may need assistance and guidance in its analysis and interpretation.

Features of the loop method which should be further investigated in order to achieve necessary refinements include:

1. Additional testing on the sensitivity of the loop method for reflecting

minor changes in vegetation. To carry out this evaluation on the magnitude of changes that may be detected will require assembly of certain information. This would be with respect to the magnitude of changes and the rate with which they may occur in the more important range types, as determined by other methods.

2. Loop method readings do not express forage or herbage production. The only indication of this would be in the appraisal of vigor as called for in the check list of Step Two and the reflection of the loop index of density and plant composition on forage production. Information on the trend in herbage or forage production would be of great value. This will be followed up.

3. Additional testing is needed in several other important range types not encountered in 1949, including aspen, mountain brush, and the high mountain grassland of the Intermountain region.

4. The index of litter cover tells nothing as to its volume or depth. Information on the latter might be obtained by recording the litter readings in depth classes.

5. The present size (3/4" diameter) of the loop appears adequate for most situations. However, it is possible in special cases that loops of two sizes might be used, including the present size in combination with a larger one to pick up rare but important indicator species. The use of different size plots or "double sampling" is standard practice in the Forest Survey for recording tree seedlings, pole size reproduction, and volume of timber.

6. The present length of transect line is 100 feet. It is not known whether this is the most efficient length of line for sampling. It is possible, too, that lines of shorter length would afford greater accuracy in making the measurements.

7. The possibilities of improvement of equipment in order to secure greater uniformity between men should be followed up. As, for example, improvement of the plumbing quality of the loop and finding a better means for stretching the tape.

8. Exact specifications for staking out transect lines, witness stakes, metal tags for marking the sampling areas, close-up frames for photoplots, simplified forms for recording all data, etc., should be worked out.

APPLICATION OF 3-STEP METHOD ON AN ALLOTMENT BASIS

Application of the 3-Step Method for measuring range trends on an allotment basis was attempted at several locations (Tahoe, Bridger, Coronado) during the field season of 1949. Results were not too satisfactory largely because of insufficient time, lack of range condition score cards or check sheets (in most regions) for Step Two, and the more urgent need for securing adequate tests in connection with Step One (the intensively measured line transect). However, the 1949 field work pointed out several needs with respect to personnel requirements and sampling procedures which must be fulfilled to make the work most effective on an allotment basis.

Here are the more important needs which pertain to personnel:

1. Training in the field of all personnel expected to take part in establishment and subsequent record taking by the 3-Step Method must be accomplished prior to initiation of the work on a range unit basis. In addition to instruction in methodology, training is needed in ecological perception and plant identification.

2. The initial installation of sampling sites should be under the direction of a technician familiar with sampling techniques. However, the ranger should take an active part, both in this initial establishment and in all subsequent record taking by the 3-Step Method. After all, he is the land manager responsible for action taken, and it is he who must put to use the information that is gained from the records. Moreover, the ranger, because of his familiarity with the range, can be of invaluable assistance in the location of key areas. It is believed that the average ranger can secure the subsequent records called for in the 3-Step Method. This is especially true of the record on condition, trend and utilization as required in Step Two. Some rangers may need help in retaking photographs. Many of them will probably require the assistance of a specialist in the interpretation of data and the significance of certain changes, as in composition of flora.

Just how large a part the average ranger can take is a moot question. It will probably vary greatly between ranger districts. There is general complaint in all regions that the ranger's work load is now so great that time is not available for adequate yearly range inspections and the maintenance of necessary allotment records. This is of real concern because it poses a practical question to the administrator. Who will make the initial installation, secure the subsequent records, and interpret the results once we have devised a method or methods for following trend in condition on a range-unit basis? The answer will need to be forthcoming at the completion of the condition and trend study.

As to sampling procedures that must be either fulfilled or recognized in the practical application of the 3-Step Method on an allotment basis, the following remarks are pertinent:

1. In the administration of national-forest range, we are attempting to manage such vast areas that the question of what we would like to do in the way of record taking on condition and trend is largely colored by what we can do with the limited funds and personnel available. The application of the 3-Step Method, or any other method, for that matter, at an acceptable statistical level of sampling for each and every one of the some 10,000 grazing allotments in the West is not feasible. The problem becomes simpler if we recognize that on most national forests and ranger districts, allotments might be segregated into three or more groups. For

example: one group of allotments; where range conditions are generally satisfactory and there is little need for anything more than routine inspections; a second group where range condition is unsatisfactory and trend is uncertain and where more detailed information is needed than would be supplied by the ordinary inspection; and a third and usually small group of allotments where condition and trends are highly controversial and where the most factual record attainable is required. To meet these three situations, the method applied for following trend must be flexible and supply information whose continuity will not be broken by later adaptations. Some allotments listed now as noncritical may later become so, necessitating a more careful check. The 3-Step Method appears to meet this requirement of flexibility. On most allotments, the intensity of sampling that is possible is limited. The method that is utilized must combine precise methods of measurement with extensive wide-scale estimates. The precise method should provide bench marks for repeated measurement and as definitely marked points to which we can constantly return to check personal judgment of the general condition within a large extensive type. Use of the 3-Step Method anticipates this need.

In the first group of allotments mentioned above, it would seem advisable to apply the 3-Step to a very few, carefully selected representative allotments, including any which may be designated as demonstrations of good management. It would also be a means of eventually providing information needed for the development of sound condition and trend standards. In the second group of allotments, a larger number of representative allotments would be sampled by all three steps and a still larger number by Step Two or possible Step Three alone. In the third group, all three steps would be applied and the range units intensively sampled. Even here the number of allotments selected will be limited.

2. In following trend on a range unit basis, we are interested primarily in two things: (1) The initial range condition at the time of sampling; (2) collection of subsequent data as from permanently established grazed range plots or transects which will indicate trend in condition after the initial examination. The intensity with which the sampling should be carried out to attain these objectives will vary with the complexity of range types and different condition classes encountered. Sampling units should be confined to usable range, excluding areas that are: waste, barren, dense timber, and inaccessible to livestock because of steepness. The best method of distributing the sampling units in the usable portions of the range has as yet to be determined. On the basis of the experience attained during the 1949 field season, the sampling units should be concentrated largely within the key areas of the allotment. Several methods of application of the 3-Step Method on a range unit basis have been suggested and will be discussed in the following section on plans for continuance of the range condition and trend study in 1950.

PLANS FOR CONTINUANCE OF WORK IN 1950

The main field jobs ahead in 1950 are further refinement of the loop method and application of the 3-Step Method on an allotment basis. Inasmuch as both types of jobs cannot be effectively carried out within a single region because of the limited time scheduled within each region, it seems best to segregate the work by regions. Accordingly, it is planned to continue the tests with the 3-Step Method in regions 2 and 4 and to study its application on a range unit basis in the remainder of the regions.

In all regions one or two days will be spent at the beginning of the work to determine what information is now available by major range types as to the magnitude of changes in range condition that can be expected during 3, 5, 10 and 20-year periods. For example, changes will be considered that have been appraised quantitatively by other methods for the measurement of decline in condition brought about by long continued heavy grazing use, or improvement on deteriorated range resulting from desirable management, or changes resulting from fluctuations in weather. If specific information is available, ways and means will be considered to check the loop method against the method by which the information on changes was collected; i.e., the procedure utilized to determine the relationship of the loop indices of vegetation with those obtained by other methods as followed in Arizona. If such checks do seem highly desirable, the plans set up in the following sections will have to be modified in order to provide sufficient time for effective carrying out of the field work. This is especially true in the regions where it is now planned to proceed on an allotment basis.

CONTINUANCE OF TESTS

Tests to be conducted to achieve further refinement of the loop method will be centered on the features previously listed as needing further investigation. Whenever possible, tests will be combined in order to obtain information on more than one feature.

1. Additional testing for sensitivity of the loop method. The work will be carried out in Region 4 and will require four men (Ellison, Phinney, Parker, and one other). Procedure to be followed will be permanent location of 3 transect clusters (3 lines each) in the following range types found on the Manti National Forest: aspen, sub-alpine grassland and mountain brush. (A crested wheatgrass planting should if possible be included because of the increasing need for information on changes which may occur in reseeded stands). One cluster should be located in each of 3 condition situations in each type. Complete record, by each of the 4 men will be made at each cluster area by means of the loop method; the Ellison point analyzer estimate and the line intercept. Seven field days will be required for securing the data.

Analysis of the data will be by regular analysis of variance procedure for each range type to determine the uniformity between men, the magnitude of changes that may be detected by each method, and the minimum of transect lines necessary to record these changes. Correlation analysis of data will be carried through for comparison of methods in order to evaluate the quantitative aspects of the 3-Step Method in terms of area-estimates made by the point-analyzer and intercept methods.

If feasible to do so, a photo-transect established some five years ago will be re-examined to appraise the magnitude of change that may have taken place on each photo plot during this period. Ways and means will be considered in the field to determine if these changes can be expressed in the indices of ground conditions as measured by the loop method. For example, this might be done by taking 50 loop readings, with 10 readings recorded on each of 5 lines spaced mechanically across each of the ten 3' X 3' photo plots. Ocular comparison in the field, with photos taken five years previously would permit grouping plots that were closely similar as to vegetation and other characteristics and in accordance with change or lack of change; Then with repeat photos taken at the time of the loop measurements, later comparisons within these groups of photo plots might be made which would indicate the degree to which the loop method might reflect these changes.

2. Expression of herbage production, It is proposed to determine the feasibility and practicability of supplementing the information obtained by the loop method with data on weight or volume of herbage. Tests will be conducted in Colorado and will require 3 men (Schwan, Costello, Parker). A fourth man, if available, will facilitate the work.

Three methods will be tested. The first was suggested and demonstrated by Costello during the 1949 field season. This consisted of dropping a wire frame 12 x 24 inches at 20-foot intervals along a 100-foot transect. At each location the herbage is clipped, segregated and weighed into five groups as follows: (1) single stemmed grasses or grasslike species; (2) bunchgrasses; (3) sodgrasses; (4) weeds;)5) browse. Litter is also collected and weighed. The second method is the volume-weight estimate of Pechanec and Stewart and would be used on the same plots above, prior to clipping. The third method is that developed in California by Wood. A wooden frame 6-5/8" x 37" which is laid on the ground surface, with a white screen and scale, marked in tenths of a foot in the background. One plot per transect would be established. Weight of the herbage is then estimated by the degree to which the screen is masked. Permanent record of this can be made by photographing the plot with the screen in the background. Estimates may be checked by clipping and weighing in ounces the herbage from the plot and multiplying by a factor (1632) for conversion into pounds per acre. Litter may also be gathered and weighed.

The procedure to be followed will be to locate 2 transect clusters (3 lines per cluster) within a minimum of three condition situations of the ponderosa pine bunchgrass range type. These will be sampled for herbage production by the three methods described above. Measurement of the same lines will also be made by the loop and the line intercept methods for further determination of the realtionship to indices of density obtained by the two methods. Correlation analyses will be made between weight of different classes of forage plants, and the loop and line intercept indices of abundance. It is estimated that the field data can be secured in seven days' time, weather permitting. Step Two and Three will be carried out on the same transects which will be permanently established on some allotment where they will be of value for later study.

It is fully appreciated that sampling carried out for herbage production if carried out prior to the end of the growth season, will not reflect the maximum and that if done on grazed range will be influenced by utilization. The work in Colorado is planned for the first two weeks in August at the height of growth. It is believed that an estimate of herbage production obtained at that time or at similar times in the season, regardless of stage of growth and utilization, should be of value in depicting trend in production. Such figures, if obtained yearly may reflect either buildup or breakdown in herbage production over a period of years. The influence of dry or unusually favorable weather conditions would have to be recognized in considering such data over a period of years.

3. Information on further evaluation of the 3-Step Method on a range type basis will be forthcoming from all regions, since it is anticipated that different types will be encountered in application of the method to a range unit, as well as from the specific tests described, in 1 and 2 above.

4. Reliability of the index of litter cover. The advisability of grouping data into depth classes, and whether or not it is best to record by a partial or full loop will be determined by utilizing the weight data obtained on litter in 2 above. These data will be correlated with those obtained by the loop method which will be segregated as to various depth classes such as: trace, consisting of occasional straws or needles; light, less than ¼ inch deep; moderate, ¼ to ½ inch deep; and adequate, more than ½ inch deep. Readings by the loop on litter will also be made by the usual estimate of more than half the loop being occupied and by the requirement that it be fully occupied. Correlation analyses on these data can then be made with the litter weight data.

5. Information on the possibilities of double sampling will be obtained in the study outlined in 2 above. The clipped sampling plots will be used for listing rare but important indicator species not likely to be picked up by the loop method.

6. To determine the most efficient length of line in sampling, one cluster of transect lines from each condition situation established in the study discussed in 2 above will be utilized. The initial data on these 9 lines will be recorded on the form shown in Figure 3 by 3" intervals for the first 25 feet, 6" intervals for the next 25 feet, and at 1-foot intervals for the remaining 50 feet for a total of 200 observations. This will permit comparison by 25, 50 and 100-foot-long lines, with 100 loop observations per line. Then, by computing the standard errors and the percent mean errors for each set of lines, the number of lines necessary in each instance for attaining the 10 percent level of accuracy in sampling may be determined.

To determine the effect of line length on the error arising from replacement of the tape, the same lines above will be remeasured and the readings again entered on the same type of form. These data for the two trials can be readily grouped into different intervals for comparison; for example, the first 5 feet from each end of each transect, the next 10 feet, etc. Since the chances for returning to the same loop reading spots are greatest at the two ends of the tape, the greatest variance should occur at the center of the line. It is believed that these comparisons will be indicative of the proper length of line necessary to assure greatest accuracy in remeasurement.

The length of line that is necessary for most efficient sampling probably varies by range types. This may also be true of the effect of line length on sampling error of line replacement. Hence it would seem desirable to replicate these tests in other types. It is believed that similar tests to these can also be carried out in connection with the work now planned for region 1, Montana, which will be described under the section, Application on an Allotment Basis. In addition, if possible and advisable, additional tests on proper length of transect will be carried out elsewhere.

7. Ideas for improvement of equipment will be solicited during the field season and if considered worthy of trial, will be tested at the first opportunity. In addition, it is planned to consult several instrument makers as to the feasibility of improving the plumbing quality of the loop, as by weighting, use of small leveling tubes, shortening the wire shank and attaching to a cord, etc.

8. Exact specifications as to staking lines, numbering, etc. will be prepared at the end of the field season incorporating ideas and suggestions from all regions.

APPLICATION ON AN ALLOTMENT BASIS

Actual application of the 3-Step Method on an allotment basis will be conducted in four regions (1, 3, 5, and 6). Major objectives of this work will be:

1. To determine the most efficient distribution of samples to measure condition and trend on a range allotment. Efficiency will be determined by a combination of cost and variation. The sub-sampling procedure by range types will be utilized in regions 5 and 6. In regions 1 and 3 sampling areas will be stratified by range condition classes and key areas within range types. In all regions the possibility of double sampling, i.e., use of the 3-Step Method on clusters and Step Two at points between clusters in order to obtain a better sample of the range unit will be studied. In each instance, the needed intensity of sampling to determine condition and trend will be determined.

2. To further determine the advantages and limitations of the 3-Step Method for measurement of condition and trend. Part of this objective will be the further evaluation of the method as to sensitivity and uniformity between men in judging condition and trend.

3. To specify, using the conclusions from (1) and (2) above recommendations as to how the condition and trend work may be best applied generally and how best to carry it out in special problem situations.

In carrying out these tests, specific study phase plans are being prepared for each regional study prior to the field work. In each region it is planned to spend a minimum of 10 work days with 2 days devoted at the start to necessary training. Personnel have been selected and allotments have been definitely decided upon. In region 1, an allotment on the Lewis and Clark; region 3, probably on the Gila; region 5, Harvey allotment on the Lassen; and region 6, Flagtail allotment on the Malheur. On both the Harvey and Flagtail cooperative studies between research and administration are being carried out to convert these units into demonstration allotments.

In order to meet the major objectives outlined above, each regional study phase plan will provide specifically for procedures to be followed, records to be taken and types of analyses to be made of the data. The following excerpts taken from the study phase plan for the Pacific Northwest are illustrative of this essential preliminary planning.

"Procedure in conducting the study:

One hundred and twenty plots were laid out on the Flagtail Allotment using the subsampling procedure in the fall of 1949. Ten clusters of 3 plots each were located in each of the 4 types. These plots were established for the determination of utilization during 1949 and 1950. Since cluster locations are strictly at random and chosen from aerial photographs, the same locations lend themselves to use in this study on condition and trend...Each cluster is 400 feet long and 300 feet wide. This will give 12 plots each 50 feet wide and 200 feet long from which three will be drawn at random...

The center stake for the plot used in utilization estimates should mark the beginning of the line transect to be used in the "3-Step" method. In addition it should mark the middle of the north side of a plot on which the individual descriptions of condition and trend are to be written up.

Before cattle enter the allotment or shortly after the beginning of the grazing season, records of condition and trend will be taken on all plots and line transects using the "3-Step" method...

Tentative condition and trend standards for each of the four types will be developed prior to starting the study. The four types present are the meadow, sagebrush-grass, ponderosa-pine-pinegrass and bitterbrush-grass. In addition to the standards, to facilitate training, instructions for the judging of criteria of condition and trend and the completion of the score card will be prepared prior to the start of the study...

Two 2-man crews will be used in the trial. Each crew will take all of the records, except the photographs, on all of the plots. To prevent personal error between individuals of the crew from entering into either the within cluster or between cluster variation, it would be advisable if one individual of the crew measured all of the line transects and one individual made all of the condition and trend writeups. The difference between the two crews will be used as a measure of personal error...

Only one crew, or an individual that is not a member of either crew, will take the photographs required by "Step 3"...

Records to be taken:

In "Step 1" records of basal area of vegetation, species composition, amount of ground covered by litter, rock and bare ground will be secured by each 2-man crew along the line transects using the loop method... These data will be recorded on Form ____...

Under "Step 2" records of condition and trend will be secured by each 2-man crew on the plots in each cluster associated with the line transect...Specific criteria of condition and trend observed on each plot, and the observer's summation of these in a score card form will be recorded on Form______. Pace transect data will also be recorded on this same form...

Under "Step 3" records should be taken for each photograph carefully describing the camera point, etc...

Records of time required to perform each of the individual jobs in the 3-Step Method should be recorded by each crew. The following specific records of time required will be needed: time required to locate and walk to each cluster; time required to locate and walk between plots within the cluster; time required to measure each line transect; time required to make each condition and trend writeup on each plot; and time required to take photographs. Since all of the jobs except the last are being done on the basis of a 2-man crew records should be recorded in man-minutes required. This will permit a study of most efficient crew organization.

Other general time records that should be made part of the file on this study are as follows: time required to lay out the random locations of plots and clusters on the allotment; time required to select random locations in the office; and time required to analyze the data (confined to that estimated to be needed for analyzing the data from the permanent sampling system and not all of the analyses involved in this study). Such records will be very helpful in planning and analyzing the over-all cost of this approach to condition and trend analyses.

Analysis of data:

1. To determine the most efficient distribution of samples using the subsampling procedure, there are many groups of data that might be used. Only those that can be expressed numerically can, however, be analyzed statistically. The most meaningful data for determining the optimum number of plots per cluster, clusters per type and clusters per allotment will be those index of total density of all vegetation, density index of desirable perennial grasses, crownspread of desirable shrubs, percent of ground covered by litter, numerical index of condition, numerical index of trend (if one can be worked out), and the time requirements for the various jobs. The analysis of variance for any type using any one of the first six groups of data listed above will be as follows:

	Degrees of freedom
Between clusters	9
Within clusters	20
Total	29

Between crews (personal error)	1	
Crew x cluster interaction	9)	error for testing
Crew x within interaction	20)	personal error
Total	30	

To determine the most efficient number of line transects or plots per cluster the variance between clusters and between plots within clusters plus the cost data are used...

This analysis should be conducted on the basis of time requirements for a 2-man crew and also the estimated time requiremtns for one man working alone. There may be considerable difference in optimum number of plots per cluster using the two sets of time requirements...

2. To determine the advantages and limitations of the 3-Step Method one of the most significant items will be the degree of reliability with which different individuals can measure the line transects and arrive at comparable numerical expressions on condition and trend...

The final step in determining advantages and limitations of the 3-Step Method will be to compare the reliability of the data secured with the cost involved in each of the three steps, and the costs involved in securing the records on an entire allotment. This analysis must be quite largely based on judgment, together with the costs involved to achieve a desired degree of sampling error. Costs should include not only field costs but those involved in compilation and analysis.

3. To devise a practical system of sampling condition and trend for use on an entire allotment, if from the analyses in (1) and (2) above the 3-Step Method proves sufficiently accurate and not too costly, will require skillful use of the conclusions from the analyses above together with careful notes taken on costs, and various phases of crew performance noted during the conduct of the study. Some of the items to be considered are as follows:

a. Optimum number of plots per cluster, clusters per type, or clusters per allotment can be determined from the analyses above.

b. Number of men per crew can be determined in part from the analyses of the data plus knowledge of equipment to be carried and other similar phases of the job.

c. The need for conducting the pace transect can be determined from the analysis of data.

d. How many photographs should be taken must be based largely on judgment."

The procedure to be followed in the case of the work in regions 1 and 3 will differ from that proposed for the Pacific Northwest (and California). The first step in sampling an allotment will be to prepare a map of range condition within the various major range types encountered on the allotment as an overlay to the range survey map. The basis for the condition classes shown on this map will be the preliminary standards prepared in advance by administration and research. It is thought that the overlay map may be quickly prepared from information on subtypes shown on the survey map, together with the ranger's and grazing staff man's knowledge of the allotment with necessary followup field checks.

Sampling sites for transect clusters will be randomly located and stratified by range type and condition class. Analysis will be carried out in accordance with the usual procedure for proportionate sampling. Two crews of 2 men each will be utilized and differences between men in making the measurements will be determined. Data on costs, number of clusters necessary for each condition class, number of lines per cluster, etc., will be handled much in accordance with the procedure outlined in the Pacific Northwest plan.

In consideration of the data obtained, questions will be considered as: How should transect data be handled (by individual clusters or grouped together) for the most effective analysis of data for depicting trend? For example, what happens when the information from all transects is averaged together and what is the picture when stratified and weighted as to area of condition classes or as to range types? What range types and condition classes should be most intensively sampled, and how many permanent transect clusters will be required adequately to follow trend? What is the optimum number of transects per cluster, the proper number of clusters per range type or condition class, considering variation within and between clusters and the relative costs? What standards can be set up to define key areas and to distinguish usable range from unusable? We will want to know the degree of confidence that can be placed in the overlap maps--in other words, what errors are involved in mapping and how great a change in condition must be expected to overshadow these errors? Are the errors of mapping range condition classes any different than would be the case in mapping sub-types by the range inventory method? In the case of all methods careful estimates of the time, personnel, and equipment required will be needed to determine practicality of the method before final recommendations for application on an allotment basis.

APPENDIX A
(Front Page 1)
Enter Rating
in Block and
Add.

PACIFIC NORTHWEST REGION
RANGE CONDITION SCORE CARD
(Bunchgrass Range)

CONDITION - FORAGE (RATING)

Density of Perennial Herbage Cover
Excellent = 10-9 Good = 8-7 Fair = 6-5
Poor = 4-3 Very Poor = 2-0 ☐

Density of Annuals (Check only)
Excessively abundant____ Abundant____ Sparse____ Trace____

Composition
Kocr, Feid, Agsp predominate but with many other perennial grasses (Pose, Daun) and weeds present such as Hisc, Sior, Arso = 10-7

Agsp predominates with Feid, Kocr, and Daun as relics = 6-5

Pose and Acla predominate with Agsp as relic = 4-3

Annual weed and grasses predominate = 2-0 ☐

Vigor of Kocr, Feid, Agsp, Daun
Excellent = 10-9 Good = 8-7 Fair = 6-5 Poor = 4-3
Very Poor = 2-0
(Subtract 1 to 3 for hedged browse species, i.e. Amelanchier prunus, Crataegus, Symphoricarpus) ☐

Accessibility of Kocr, Feid, Agsp
50% or more accessible (check only)______
50-25% accessible Subtract 1
Less than 25% accessible Subtract 2 ☐ Total score ☐

CONDITION - SOIL

STABILITY OF SOIL SURFACE (Check list)

+ = stability ✓ = not exceptional - instability

Erosion pavement on bare surfaces ________
Amount of litter cover on soil surface ________
Rill marks (miniature gullies) ________
Alluvial deposits (water deposited sediment) ________
Wind deposits (wind carried soil) ________
Gullies ________
Effectiveness of vegetation and litter in protecting soil surface ________
Bare soil (not covered with moss or litter) ________
Recent rodent activity ________
Trampling displacement or soil slippage caused by grazing animals ________

Plant pedestaling on Kocr, Feid, and Agsp ____
(steep sided or sloping sided and
stabilized with moss?)

Compaction by grazing animals and its effect
on water infiltration ____

SOIL STABILITY (RATING)

No Evidence of Soil Movement - run-off is clear, density of vegetation good, spaces between plants well covered with litter. = 30-27

Soil Movement Slight but difficult to recognize; may be detected by occasional spots with litter dammed against vegetation, forming miniature alluvial fans; sediment deposited on leaves; there may be evidence of past accelerated erosion but soil mantle is now stabilized by vegetation and litter; gullies, alluvial deposits, and rills completely healed; rodent activity normal; trampling displacement slight, no noticeable compaction. = 26-21

Soil Movement Moderate - definitely discernible, may be accelerated in spots and stable elsewhere; on stony soils erosional pavement forming with occasional exposed pebbles; occasional alluvial deposits and rills may be present; gullies, if present, not raw; effectiveness of plant cover and litter in controlling soil movement is questionable; rodent activity may not be noticeable; compaction present but not excessive; occasional pedestals; run-off murky.. = 20-15

Soil Movement Advanced - stony soils with noticeable erosion pavement; rills, alluvial deposits, and plant pedestals may be numerous; raw gullies may be present, rodent activity may be excessive; trampling displacement and compaction may be common; plant cover and litter definitely not effective in preventing soil movement; run-off is muddy. = 14-9

Soil Movement Severe - subsoils exposed, erosion pavement may be complete on stony soils, litter lacking; rills and alluvial deposits may be numerous; gullies, if present, are raw; desirable forage plants occur only as relics; rodent activity generally severe; plant pedestals have largely eroded away; run-off from summer storms flashy and muddy. = 8-0

SUMMARY OF RANGE CONDITION SCORES

Adjective Interpretation	FORAGE	SOIL
EXCELLENT = 27 or more		
GOOD = 21 to 26		
FAIR = 15 to 20		
POOR = 9 to 14		
VERY POOR = 8 or less		

(Enter score card rating in proper space above)

TREND IN FORAGE CONDITIONS

GOOD (OR EXCELLENT) CONDITION

Circle pertinent item and balance

	Plus	Minus
Agsp, Kocr, Feid reproducing the stand	2	
Utilization not over 50% on Agsp, 40% on Feid, 25% on Kocr	1	
Browse in healthy condition	1	
Death loss or breaking up of Agsp, Kocr, Feid, noticeable		2
Pose, Stipa, Daun, Brma invading		2
Utilization of Agsp, Feid, Kocr excessive		1
Browse hedged and dying		1

FAIR CONDITION

Agsp, Kocr, Feid invading bare spots and replacing undesirables such as Pose	2	
Utilization not over 40% on Agsp, 30% on Feid, 20% on Kocr	1	
Browse recovering from past grazing damage	1	
Low value species Pose, Anlu reproducing markedly		2
Utilization exceeds standards for fair condition		1
Browse hedged, dying, dead and inferior species, if present, closely grazed		1

POOR CONDITION

Agsp, Kocr, Feid, Daun invading bare spots and coming in on and replacing Pose, Anlu, and other less desirable plants	2	
Utilization not over 25% on Agsp, 20% on Feid, 10% on Kocr, 10% on Pose	1	
Browse recovering from past grazing damage	1	
Low value species including Anlu and annuals reproducing markedly		2
Utilization exceeds standards for poor condition		1
Browse hedged, dying, dead, and inferior species, if present, closely grazed		1

VERY POOR CONDITION

Pose, Stipa, Brma, Melica, Daun definitely becoming established	2	
Utilization deferred no use by livestock and game	1	

TREND IN SOIL CONDITIONS

Circle pertinen
item and balanc

GOOD (OR EXCELLENT) CONDITION

	Plus	Minus
Normal cover of litter is being replaced each year	3	
No visible accelerated erosion	2	
No trampling displacement occurring	1	
Rodent activity normal or below	1	
Litter is not accumulating		3
Plant cover breaking up and exposing small spots of bare soil		2
Trampling displacement occurring		1
Rodent activity increasing		1

FAIR AND POOR CONDITION

Litter is building up and covering bare spots between grass clumps	2	
Gullies, if present, healing, with sides well covered with perennial grasses	2	
Rills and alluvial deposits being stabilized with perennial grasses	2	
Trampling displacement insignificant	1	
Pedestals of Agsp, Kocr, Feid healing on sides	1	
Litter is not accumulating and soil surface is being exposed		2
Gullies not healing over with perennial grasses		2
Rills and alluvial deposits not being stabilized with perennial grasses		2
Trampling displacement noticeable		1
Pedestals of Agsp, Kocr, Feid, steep sided		1

VERY POOR CONDITION

Anlu, Acla, Pose, Sihy, Melica, Brma, annuals and mosses are increasing and covering up bare soil surfaces	2	

This score card does not measure the <u>rate</u> of trend but is intended only to indicate the <u>direction</u> of change within the previously determined forage and soil condition classes. An excess score in the plus column indicates upward trend, whereas an excess score in the minus column indicates downward trend. A close balance indicates there is no marked trend up or down. Do not grade items which do not apply.

SUMMARY OF RANGE TREND RATINGS

FORAGE

UP ______
STATIC ______
DOWN ______

SOIL

UP ______
STATIC ______
DOWN ______

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APPENDIX B
(Front of Sheet)
Cluster No. ______

FIELD CHECK SHEET
FOR RANGE CONDITION AND TREND*

National Forest ______________________ Ranger District ______________
Range Unit ____________________ Examiner ____________ Date ____________
Location of area sampled ____
(Name and indicate by cross reference to map if possible)

GENERAL INFORMATION:

Range type ______________________ Condition ______________
Apparent trend ______________________ Slope percent ______________
Aspect ______________________ Elevation ______________
Type of vegetation bordering area examined ______________________
Distance to permanent water __________ Distance to salt ground ______________
Past utilization (avg. past 10 yrs.) None __________ Light __________
Moderate __________ Heavy __________ Excessive __________
Avg. Current Utilization - Key species ______ | ______ | ______ | ______ | ______
Indicate percent volume removal ______ | ______ | ______ | ______ | ______
Kind of animal covering bulk of use ______ | ______ | ______ | ______ | ______
End of grazing season, date ______________________________

DENSITY: Paced transect ______________
(Paced transect preferred; if not possible, use ocular)

COMPOSITION OF VEGETATION: Paced transect ______________
(With paced transect note additional species not encountered on line as trace)

Grasses	%	Weeds	%	Shrubs	%
Total					

List the species; which determine aspect ______________________
Most abundant ______________ Provide bulk of forage ______________
______________ Undesirable species ______________________
Species which appear to be increasing ______________________
Species occur as: Mixture __________ Patches __________ Pure stand __________
Timber species reproducing ______________
(Yes or no)
Species: ______________________ Approximate age: ______________
(Approx. no. per acre)

*Developed in Region 2.

VIGOR:

Grasses (Write in key species in proper space): Excellent ____________
Good ____________ Fair ____________
Poor ____________ Very Poor ____________

Name tufted grasses breaking up or dying ____________
Average diameters of tufted grasses ____________
Average spacing of tufted grasses ____________
Age classes (name species): seedlings only ____________ old plants only ______
all age classes present ____________

Browse (write in species name in proper space): vigorous ____________;
recovering (new sprouts, seeding or filling in) ____________; damaged ________;
hedged ____________; part dead ____________; dead ____________

MULCH OR LITTER - On soil surface between plants.

Complete coverage ____________; deep ____________; shallow ____________
Partial coverage ____________; sparse ____________; none ____________
Is litter accumulating? ____________
(Yes or no)

SOILS

Depth (record in inches): deep ____________; shallow ________ thin ____
Depth of organic layer in inches ____________
Fertility: High ________; moderate ____________; low ____________
Erodibility: High ____________; moderate ____________; slight ________
Sheet Erosion: local litter movement ____________;
erosional pavement present ________; absent ________
Deep fibrous rooted perennials pedestaled (name) ____________
Gulley Erosion: No gullies ____________ Deep (cutting through subsoil) ________
Shallow (cutting surface soil only) ________; active ________; healing ________
Gullies occasional (less than 30% of drainages classed as gullies) ________
Gullies frequent (more than 30% of drainages classed as gullies) ________
Stream banks: Slopes grass (name) covered ____________ Bare ________
(Yes or no)
Shrub (name) covered ____________ Bare ________ Bank caving ________ Channels
(Yes or no) (Yes or no)
clogged with sediment ____________
(Yes or no)

ANIMAL INDICATORS

Rodent and rabbit populations (name): Apparently normal or below ________;
Abundant ____________; Excessive ____________
Big game populations (name); None ____________; lightly stocked ________;
Moderately stocked ____________; excessive numbers ____________

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APPENDIX

Table 1

Field Data on Climax Species
(Feid, Agsp, Kocr, Daun)

Starkey-Oregon

Transect No.	Man No. 1 Trials		Man No. 2 Trials		Man No. 3 Trials		Man No. 4 Trials		Man No. 5 Trials		Man No. 6 Trials	
	1	2	1	2	1	2	1	2	1	2	1	2
1	3	3	4	4	3	3	3	4	4	3	2	2
2	3	3	4	5	2	6	2	5	3	3	1	4
3	2	2	3	2	3	3	4	3	2	2	2	3
4	38	34	37	32	37	36	33	36	41	45	31	28
5	44	54	41	50	41	51	39	32	50	52	36	45
6	36	31	34	32	32	34	31	36	36	39	29	32
7	12	11	15	12	14	12	8	8	12	12	12	8
8	10	11	12	8	11	7	8	8	7	9	6	6
9	10	10	10	10	11	11	9	9	14	10	9	11

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	6.2593	6.2593	1.027	-
Lines	8	25351.6297	3168.9537	492.9078	**
Men	5	226.1852	45.2370	7.0363	**
LxM	40	433.1481	10.8287	1.6843	*
Error	53	340.7404	6.4291		
Total	107	26357.9630			

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Table 2

Starkey-Oregon

Field Data on All Grasses

Transect No.	Man No. 1 Trials		Man No. 2 Trials		Man No. 3 Trials		Man No. 4 Trials		Man No. 5 Trials		Man No. 6 Trials	
	1	2	1	2	1	2	1	2	1	2	1	2
1	21	22	16	16	25	28	27	19	23	21	18	20
2	20	17	19	22	17	23	19	25	23	19	15	23
3	23	20	20	20	20	20	27	24	23	21	13	22
4	60	59	54	50	55	58	51	52	67	70	43	47
5	66	76	52	63	59	69	57	42	69	71	54	62
6	55	53	48	46	50	56	53	54	61	65	45	56
7	29	29	30	30	26	32	22	26	27	32	24	23
8	25	26	26	23	28	23	22	22	23	27	19	18
9	30	28	26	29	27	29	27	25	32	29	22	24

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	49.342	49.342	4.124	*
Lines	8	27840.852	3480.106	290.857	**
Men	5	874.157	174.831	14.612	**
LxM	40	1186.926	29.673	2.480	**
Error	53	634.158	11.965		
Total	107	30585.435			

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Indicator Weeds
(Acla, Enlu)

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	7.2593	7.2593	3.0357	--
Lines	8	495.8334	61.9792	25.9166	**
Men	5	18.6667	3.7333	1.5612	--
LxM	40	122.1666	3.0542	1.2772	--
Error	53	126.7407	2.3913		
Total	107	770.6667			

Rock
(By frequency point)

Analysis of Variance

Trials	1	3.704	3.704	1.813	--
Lines	8	8710.074	1088.759	532.922	**
Men	5	8.630	1.726	1.184	--
LxM	40	65.037	1.626	1.256	--
Error	53	108.296	2.043		
Total	107	8895.741			

Litter
(By frequency point)

Analysis of Variance

Trials	1	154.083	154.083	5.689	*
Lines	8	24548.630	3068.579	113.303	**
Men	5	826.157	165.231	6.101	**
LxM	40	1278.926	31.973	1.181	--
Error	53	1435.417	27.083		
Total	107	28243.213			

Table 4

Manitou-Colorado

Field Data on Climax Species
(Asc, Far, Kcr, Shy, Dain, Asm together)

Line No.	Man No. 1 Trials 1	:	2	Man No. 2 Trials 1	:	2	Man No. 3 Trials 1	:	2	Man No. 4 Trials 1	:	2
1	4	:	4	2	:	4	2	:	4	3	:	3
2	2	:	6	2	:	6	0	:	6	3	:	8
3	4	:	4	6	:	6	5	:	4	9	:	4
4	2	:	0	2	:	3	1	:	0	2	:	0
5	0	:	0	0	:	0	0	:	0	0	:	0
6	0	:	0	0	:	0	1	:	1	0	:	0
7	27	:	29	12	:	16	23	:	17	13	:	14
8	5	:	4	4	:	5	5	:	3	10	:	3

Analysis of Variance

	DF	Sum. Sq.	Mean Sq.	F	Sig.
Trials	1	0.390	0.390	10.267	--
Lines	7	2059.859	294.266	73.493	**
Men	3	20.046	6.682	1.669	--
LxM	21	284.079	13.528	3.379	**
Error	31	124.110	4.004		
Total	63	2488.484			

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APPENDIX

Table 5

Manitou-Colorado

Field Data on Secondary Grass Species

Line No.	Man No. 1 Trials		Man No. 2 Trials		Man No. 3 Trials		Man No. 4 Trials	
	1	2	1	2	1	2	1	2
1	29	30	27	30	26	36	31	41
2	28	36	33	33	34	32	34	29
3	31	33	31	32	25	23	27	27
4	52	44	35	48	55	48	50	46
5	13	18	12	17	14	19	13	19
6	52	54	54	56	54	52	60	56
7	20	21	17	18	22	18	28	28
8	38	36	38	33	38	35	42	36

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	6.890	6.890	1.936	—
Lines	7	9171.734	1310.248	98.205	**
Men	3	91.797	30.599	2.293	—
LxM	21	343.828	16.373	1.227	—
Error	31	413.610	13.342		
Total	63	10027.859			

APPENDIX
Table 6
Manitou-Colorado

Indicator Weeds
(Efi, ANT, Afr together)

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F.	Sig.
Trials	1	1.890	1.890	1.547	--
Lines	7	555.109	79.301	27.130	**
Men	3	44.922	14.974	5.123	**
LxM	21	200.203	9.533	3.261	**
Error	31	90.613	2.923		
Total	63	892.737			

Bare Ground
(By frequency point)

Analysis of Variance

Trials	1	27.563	27.563	1.096	--
Lines	7	2271.688	324.527	10.743	**
Men	3	486.688	162.229	5.358	**
LxM	21	495.062	23.574	1.281	--
Error	31	936.437	30.208		
Total	63	4217.438			

Total Litter
(Grass & pine needles by frequency point)

Analysis of Variance

Trials	1	689.062	689.062	9,456	**
Lines	7	31263.250	4466.178	61.291	**
Men	3	1896.500	632.167	8.675	**
LxM	21	966.000	46.000	1.584	--
Error	31	2258.938	72.869		
Total	63	37073.750			

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APPENDIX

Table 7

Tahoe-California

Field Data on Total Perennial Grass & Grasslike Plants

Line No.	Man No. 1 Trials		Man No. 2 Trials		Man No. 3 Trials		Man No. 4 Trials	
	1	2	1	2	1	2	1	2
1	35	36	41	39	35	35	37	32
2	41	55	64	53	50	56	61	63
3	1	1	2	2	2	1	3	2
5	6	6	8	7	8	8	4	6
6	23	19	14	17	20	19	17	17
7	79	75	78	74	72	73	73	74
8	24	24	28	27	21	24	27	26
9	13	17	14	17	17	21	25	26
10	5	6	5	4	4	5	6	8
11	16	14	18	19	17	17	17	16
12	15	16	20	19	17	19	18	15
13	0	0	0	0	0	0	1	1

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	0.1666	0.1666	33.184	—
Lines	11	44483.7083	4043.9735	731.491	**
Men	3	56.2083	18.7361	3.389	*
LxM	33	471.0417	14.2740	2.582	**
Error	47	259.8334	5.5284		
Total	95	45270.9583			

Table 8

Tahoe-California

Field Data on Browse
(Living plus dead)

Line	Man No. 1		Man No. 2		Man No. 3		Man No. 4	
	Trials		Trials		Trials		Trials	
No.	1	2	1	2	1	2	1	2
3	35	33	32	31	32	32	32	32
4	36	33	33	35	36	37	36	35
5	28	33	28	27	32	33	31	32
6	22	22	24	25	21	22	25	25
9	6	4	7	9	5	4	6	5
10	5	5	6	6	5	4	7	7
13	39	40	43	41	36	41	38	45

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	2.5714	2.5714	1.030	--
Lines	6	9375.9286	1562.6548	625.713	**
Men	3	11.5714	3.8571	1.544	--
LxM	18	87.9286	4.8849	1.956	--
Error	27	67.4286	2.4974		
Total	55	9545.4286			

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APPENDIX

Table 9

Tahoe-California

Field Data on Soil Plus Rocks

Line No.	Man No. 1 Trials 1	2	Man No. 2 Trials 1	2	Man No. 3 Trials 1	2	Man No. 4 Trials 1	2
1	10	14	9	14	13	14	16	12
2	21	21	21	18	20	21	29	17
3	38	39	41	42	42	41	38	40
4	40	39	45	46	45	44	43	46
5	32	32	28	30	31	29	32	27
6	28	26	28	25	28	26	28	29
7	0	2	1	1	0	0	1	0
8	30	27	21	24	26	27	27	31
9	45	39	48	44	46	46	40	39
10	45	43	41	43	44	43	45	45
11	41	43	45	43	40	41	46	45
12	30	32	41	36	33	32	36	39
13	28	24	31	28	26	26	35	27

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	12.4616	12.4616	2.557	---
Lines	12	16832.6154	1402.7180	287.839	**
Men	3	39.3077	13.1026	2.689	---
LxM	36	329.6923	9.1581	1.879	*
Error	51	248.5384	4.8733		
Total	103	17462.6154			

Table 10

Tahoe-California

Field Data on Litter

Line No.	Man No. 1 Trials 1	Man No. 1 Trials 2	Man No. 2 Trials 1	Man No. 2 Trials 2	Man No. 3 Trials 1	Man No. 3 Trials 2	Man No. 4 Trials 1	Man No. 4 Trials 2
1	42	38	34	34	43	35	34	35
2	32	19	11	24	25	18	6	15
3	26	27	25	25	24	26	27	26
4	23	27	19	17	16	18	20	19
5	31	25	33	33	26	27	29	31
6	26	32	33	32	30	32	29	28
7	15	10	19	22	20	19	19	19
8	40	43	46	47	45	42	43	39
9	13	22	17	17	17	16	13	15
10	34	38	32	34	32	33	22	28
11	40	40	33	34	40	39	34	35
12	40	36	27	33	42	40	30	31
13	27	30	23	29	34	31	22	25

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	7.0096	7.0096	1.378	--
Lines	12	6791.9615	565.9968	58.612	**
Men	3	253.4134	84.4711	8.747	**
LxM	36	795.9616	22.1100	2.290	**
Error	51	492.4904	9.6567		
Total	103	8340.8365			

Table 11

Vigilante-Montana

Field Data on Climax Species
(Feid, Agsp, Kocr, Camo)

Line No.	Man No. 1 Trials		Man No. 2 Trials		Man No. 3 Trials		Man No. 4 Trials	
	1	2	1	2	1	2	1	2
1	33	32	31	31	17	21	39	30
2	27	20	30	18	14	16	37	18
3	21	15	12	13	18	19	16	30
4	14	18	9	8	14	17	10	5
5	31	34	29	30	30	39	28	30
6	30	30	29	30	28	36	20	27
7	22	19	19	21	24	21	8	27
8	18	22	22	22	23	26	17	22
9	25	23	26	22	25	23	23	29
13	25	15	33	27	26	24	22	24
14	31	30	34	31	35	35	36	27
15	19	19	20	25	26	19	23	20
16	28	22	25	27	27	24	29	22

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	5.0866	5.0866	3.957	—
Lines	12	3126.5385	260.5449	12.946	**
Men	3	1.2597	.4199	47.930	—
LxM	36	1021.6153	28.3782	1.410	—
Error	51	1026.4134	20.1258		
Total	103	5178.9135			

Table 12

Vigilante-Montana

Field Data on Total Grass

Line	Man No. 1		Man No. 2		Man No. 3		Man No. 4	
	Trials		Trials		Trials		Trials	
No.	1	2	1	2	1	2	1	2
1	45	46	43	43	48	52	43	43
2	40	49	42	43	44	51	44	48
3	49	48	46	47	52	52	51	52
4	58	62	48	50	49	55	57	55
5	37	43	34	38	36	43	40	40
6	39	36	38	41	34	40	34	39
7	41	37	37	39	41	38	29	41
8	41	42	36	41	36	39	32	30
9	41	42	37	41	41	40	36	41
13	41	39	47	44	44	43	38	39
14	44	47	47	46	47	52	49	44
15	26	30	29	33	36	33	33	30
16	34	33	30	32	33	33	33	32

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	76.1635	76.1635	12.279	**
Lines	12	4224.6539	352.0545	56.758	**
Men	3	101.9519	33.9840	5.479	**
LxM	36	484.4231	13.4562	2.169	**
Error	51	316.3365	6.2027		
Total	103	5203.5289			

Table 13

Vigilante-Montana

Total Weeds

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	.4712	.4712	10.862	—
Lines	12	6904.8654	575.4054	112.423	**
Men	3	64.1827	21.3942	4.180	*
LxM	36	221.4423	6.1512	1.202	—
Error	51	261.0288	5.1182		
Total	103	7451.9904			

Browse
(Omit "dead")

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	.3462	.3462	5.588	—
Lines	12	421.0962	35.0914	18.141	**
Men	3	58.8462	19.6154	10.140	**
LxM	36	144.9038	4.0251	2.081	*
Error	51	98.6538	1.9344		
Total	103	723.8462			

Bare Ground & Rock

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	11.6806	11.6806	1.350	—
Lines	8	8616.5278	1077.0660	124.488	**
Men	3	43.0417	14.3472	1.658	—
LxM	24	120.5833	5.0243	1.722	—
Error	35	302.8194	8.6520		
Total	71	9094.6528			

Litter Plus Selaginella or Moss

Analysis of Variance

	DF	Sum Sq.	Mean Sq.	F	Sig.
Trials	1	28.0384	28.0384	2.344	—
Lines	12	5442.9038	453.5753	37.924	**
Men	3	57.5384	19.1795	1.604	—
LxM	36	731.7116	20.3253	1.699	*
Error	51	609.9615	11.9600		
Total	103	6870.1538			

APPENDIX
Table 14
Bridger-Wyoming

Field Data on Climax Grasses
(Feov.-Stco. Agda, Agtr, Heki)

Line No.	Man No. 1	Man No. 2	Man No. 3	Man No. 4	Total
1	3	2	8	8	21
2	10	10	16	6	42
3	10	13	18	15	56
4	20	16	15	24	75
5	20	19	20	22	81
6	18	16	24	21	79
7	10	10	10	13	43
Total	91	86	111	109	397
Mean	13.0	12.3	15.8	15.6	

LSD = 3.2 at 5%

Analysis of Variance

Source	DF	Sum Sq.	Mean Sq.	F	Sig.
Lines	6	775.357	129.226	15.862	**
Men	3	68.107	22.702	2.786	No
Error	18	146.643	8.147		
Total	27	990.107			

Field Data on Total Grass

Line No.	Man No. 1	Man No. 2	Man No. 3	Man No. 4	Total
1	14	14	13	12	53
2	23	28	24	16	91
3	21	27	26	25	99
4	28	24	26	21	99
5	25	26	23	27	101
6	24	26	27	33	110
7	15	16	13	17	61
Total	150	161	152	151	614
Mean	21.4	23.0	21.7	21.6	

LSD = 3.5 at 5%

Source	DF	Sum Sq.	Mean Sq.	F	Sig.
Lines	6	714.357	119.060	12.142	**
Men	3	11.000	3.667	2.674	No
Error	18	176.500	9.806		
Total	27	901.857			

Field Data on Weeds

Line No.	Man No. 1	Man No. 2	Man No. 3	Man No. 4	Total
1	10	10	8	7	35
2	8	9	10	10	37
3	10	7	7	6	30
4	10	12	9	9	40
5	11	10	15	15	51
6	9	9	10	8	36
7	8	13	9	8	38
Total	66	70	68	63	267
Mean	9.4	10.0	9.7	9.0	

LSD - 2.0 at 5%

Source	DF	Sum Sq.	Mean Sq.	F	Sig.
Lines	6	62.714	10.452	3.113	*
Men	3	3.821	1.274	2.635	No
Error	18	60.429	3.357		
Total	27	126.964			

[illegible]
Table 15
Bridger-Wyoming

Field Data on Browse

Line No.	Man No. 1	Man No. 2	Man No. 3	Man No. 4	Total
1	17	18	20	19	74
2	13	14	15	16	58
3	27	24	23	23	97
4	22	23	28	26	99
5	26	29	27	27	109
6	13	13	12	11	49
7	19	20	19	23	81
Total	137	141	144	145	567
Mean	19.6	20.1	20.6	20.7	

LSD = 2.0 at 5%

Analysis of Variance

Source	DF	Sum Sq.	Mean Sq.	F	Sig.
Lines	6	741.500	123.583	39.572	**
Men	3	5.536	1.845	1.693	No
Error	18	56.214	3.123		
Total	27	803.250			

Field Data on Bare Ground & Rock

Line No.	Man No. 1	Man No. 2	Man No. 3	Man No. 4	Total
1	12	18	8	6	44
2	6	4	2	1	13
3	11	8	7	13	39
4	5	2	4	2	13
5	1	1	2	4	8
6	21	14	16	14	65
7	26	23	21	20	90
Total	82	70	60	60	272
Mean	11.7	10.0	8.6	8.6	

LSD = 3.2 at 5%

Source	DF	Sum Sq.	Mean Sq.	F	Sig.
Lines	6	1403.714	233.952	29.833	**
Men	3	46.857	15.619	1.992	No
Error	18	141.143	7.842		
Total	27	1591.714			

Field Data on Litter

Line No.	Man No. 1	Man No. 2	Man No. 3	Man No. 4	Total
1	25	22	28	33	108
2	28	28	25	33	114
3	18	23	24	21	86
4	34	39	38	38	149
5	34	32	33	24	123
6	28	33	30	28	119
7	31	25	38	31	125
Total	198	202	216	208	824
Mean	28.3	28.8	30.8	29.7	

LSD - 4.4 at 5%

Source	DF	Sum Sq.	Mean Sq.	F	Sig.
Lines	6	543.857	90.643	5.983	**
Men	3	26.285	8.762	1.729	No
Error	18	272.715	15.151		
Total	27	842.857			

6340

Table 16
Coronado-Arizona

Field Data on Climax Grasses

Line No.	Man No. 1	Man No. 2	Man No. 3	Total
1	4	4	4	12
2	3	3	3	9
3	8	7	7	22
4	9	11	12	32
5	5	3	4	12
6	4	2	4	10
Total	33	30	34	97
Mean	5.5	5.0	5.7	

LSD - 1.16 at 5%

Analysis of Variance

Source	DF	Sum Sq.	Mean Sq.	F	Sig.
Lines	5	136.278	27.256	31.841	**
Men	2	1.445	.722	1.186	No
Error	10	8.555	.856		
Total	17	146.278			

Field Data on Total Grasses

Line No.	Man No. 1	Man No. 2	Man No. 3	Total
1	39	36	39	114
2	36	35	38	109
3	16	16	15	47
4	26	21	28	75
5	26	25	26	77
6	25	22	25	72
Total	168	155	171	494
Mean	28.0	25.8	28.5	

LSD = 1.81 at 5%

Analysis of Variance

Source	DF	Sum Sq.	Mean Sq.	F	Sig.
Lines	5	1050.444	210.089	105.625	**
Men	2	24.111	12.056	6.061	*
Error	10	19.889	1.989		
Total	17	1094.444			

APPENDIX
Table 17
Coronado-Arizona

Field Data on Bare Ground

Line No.	Man No. 1	Man No. 2	Man No. 3	Total
1	32	36	31	99
2	52	52	48	152
3	31	38	28	97
4	20	24	25	69
5	57	59	54	170
6	60	64	55	179
Total	252	273	241	766
Mean	42.0	45.5	40.2	

LSD - 3.0 at 5%

Analysis of Variance

Source	DF	Sum Sq.	Mean Sq.	F	Sig.
Lines	5	3407.777	681.555	120.501	**
Men	2	88.111	44.056	7.789	
Error	10	56.556	5.656		
Total	17	3552.444			

Field Data on Litter

Line No.	Man No. 1	Man No. 2	Man No. 3	Total
1	28	27	29	84
2	12	10	13	35
3	53	46	55	154
4	54	55	47	156
5	15	15	18	48
6	13	13	19	45
Total	175	166	181	522
Mean	29.2	27.7	30.2	

LSD - 4.1 at 5%

Source	DF	Sum Sq.	Mean Sq.	F	Sig.
Lines	5	5082.667	1016.533	101.319	**
Men	2	19.000	9.500	1.056	No
Error	10	100.333			
Total	17	5202.000			