Determining Range Condition from Frequency Data in Mountain Meadows of Central Idaho

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Abstract

Although a useful method for monitoring changes in species composition, frequency sampling does not provide herbage production or cover data needed to use existing range condition guides. Responding to this need, frequency sampling procedures were investigated for determining range condition. Eighteen mountain meadow sites were sampled with 100 nested frequency quadrats. These quadrats had 5 plot sizes contained (nested) within 1 frame: 5×5 cm, 10×10 cm, 25×25 cm, 25×50 cm, and 50×50 cm. Rooted frequency of occurrence within each plot size was recorded by species. Discriminant analysis related a site's frequency data to its known range condition class, resulting in 2 range condition guides for mountain meadows based on frequency data. One guide was formulated with data from the 10×10-cm quadrat size, and a second guide was based on summed data from the 4 largest plot sizes. Both guides had equal resolution, correctly classifying 15 of 18, or 83%, of sites examined. Our procedures should prove valuable in developing condition guides based on frequency data in other areas and in other vegetation types.

Among the first to recognize that plants could be used as indicators of successional stages were Sampson (1919) and Jardine and Anderson (1919). Dyksterhuis (1948, 1949) refined the idea of plants as successional indicators and developed range condition classes based on a site's existing vegetation in relation to the site's potential climax. Continuing the work of Weaver and Hansen (1941), Dyksterhuis used the terms *decreasers, increasers,* and *invaders* to describe a species' ecological response to grazing pressure. Decreasers and increasers are species of undisturbed climax communities, whereas invaders are nonclimax species. Greater relative proportions of decreasers and increasers to invaders indicate higher successional stages. Current U.S. Soil Conservation Service (SCS) range analysis procedures use the decreaser, increaser, and invader concepts (USDA 1976).

In contrast to Dyksterhuis' purely ecological approach, Parker (Parker, K.W. 1951. A method for measuring trend in range condition on national forest range. USDA, Forest Service Mimeo.) introduced a condition classification concept that included livestock production and soil stability as *additional* criteria for evaluating plant species. Similar to the decreasers, increasers, and invaders presented by Dyksterhuis, Parker developed categories of *desirables, intermediates,* and *least desirables.* But Parker, instead of relying solely on a species' ecological role, included forage quality, palatability, and rooting characteristics as criteria for classifying species into his desirability groups. Most U.S. Forest Service (USFS) regions use Parker's desirable, intermediate, and least desirable categories in their range analysis procedures. Because different criteria are employed to judge plant species, the USFS and SCS methods may differ dramatically in their condition ratings of the same plant community.

Whichever species classes are used in evaluating a site's range condition, those of Dyksterhuis or those of Parker, an investigator must first record the plant community's species composition. Species composition is the relative abundance of the species present in a plant community and is usually determined by measuring yield, cover, density, or frequency. It is important to realize that composition estimates will differ depending upon which measure is used. Since species composition is a relative comparison, it describes a community only in relation to the parameter upon which the composition estimates are based. Estimates of composition based on different parameters are not equivalent. For sampling ease and repeatability, a stable, objective measure is preferred for estimating

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species composition. Estimates based on yield or cover, however, fluctuate with seasonal and yearly climatic changes (Craddock and Forsling 1938, Odum 1960). And density, although a stable vegetation parameter, is often difficult and time consuming to measure, especially when plants reproduce vegetatively (Strickler and Stearns 1963). In contrast to these other parameters, perennial plant frequencies are simple to obtain, objective, and relatively stable from season to season and year to year (Hyder et al. 1966, Mueller-Dombois and Ellenburg 1974).

Frequency is based on presence or absence of a species in a given number of repeatedly placed small quadrats. A species' frequency is the percentage of quadrats in which it occurs, varying from 0 to 100%. Because frequency is simple to obtain, objective, and relatively stable from season to season and year to year, frequency sampling is advantageous for monitoring changes in species composition. But as mentioned above, species composition based on frequency is not equivalent to composition by yield or cover—the inputs needed to use many current range condition guides. Frequency sampling can be used to monitor changes of individual species, but there is presently no way to describe these changes in terms of range condition classes. Development of condition guides based on frequency data would preclude the need to use 2 different sampling methods, 1 for monitoring changes of particular species and an additional method for classifying a site's range condition.

Study Area

During the summers of 1982 and 1983, 18 dry mountain meadow sites were sampled within 6 USFS grazing allotments in central Idaho. Study sites were located on 3 national forests and 4 different ranger districts: Lowman and Cascade Districts on the Boise National Forest, McCall District on the Payette National Forest, and Stanely Zone of the Sawtooth National Recreation Area on the Sawtooth National Forest. Study sites ranged in elevation from 1,920 to 2,135 m (6,300 to 7,000 ft), and annual precipitation varied from 500 to 1,020 mm (20–40 in) with approximately 70% occurring as snow. Central Idaho's dry meadow vegetation is a complex mixture of graminoids and forbs. Common species include sedge (*Carex* spp. L.), timber oatgrass (*Danthonia intermedia* Vasey), tufted hairgrass (*Deschampsia caespitosa* (L.) Beauv.), western yarrow (*Achillea millefolium* L.) and mountain dandelion (*Agoseris glauca* (Pursh.) Raf.). It must be kept in mind that a dry meadow is a distinct vegetation type, different from a mountain grassland or open conifer type. Meadows, as defined in this study, are characterized by predominantly herbaceous vegetation, low-lying topography, and a relatively high water table. Whereas wet meadows remain wet or moist throughout the year, dry meadows are moist in the spring but usually become dry by midsummer.

Methods

Of 18 sites sampled, 6 sites were sampled in each of 3 condition classes—good, fair, and poor—as determined by USFS range analysis and trend study records. USFS (Region 4) range condition estimates are based on 2 vegetation factors, vegetal composition and plant production, and 2 soil factors, ground cover and soil erosion. These factors are measured, evaluated against optimal standards outlined in the Range Analysis Handbook (USDA 1981), and tabulated into 2 scores—a vegetation condition rating and a soil condition rating. The lower of the 2 scores is used as the overall range condition rating and is described by condition classes: excellent, good, fair, poor, and very poor. In this study, the vegetation condition rating was the lower of the 2 scores on all sites sampled. Therefore, throughout this study range condition is equated with vegetation condition. Of the 5 USFS range condition classes, only 3 were sampled. Excellent and very poor condition classes were not represented because too few sites in these condition classes were found within this vegetation type.

A 30.5×30.5-m (100×100-ft) macroplot was established on each study site. This macroplot consisted of 5 parallel 30.5-m transect lines spaced 7.6 m (25 ft) apart. A 30.5-m transect was used because this was the length chosen by the USFS (Region 4) for their updated range trend analysis procedures (USDA 1981). Vegetation was sampled within a nested frequency quadrat that had several smaller plot sizes contained (nested) within 1 frame. This quadrat was placed at 1.5-m (5-ft) intervals along the 5 transects, resulting in 100 quadrats per site. One hundred quadrats adequately sampled most of the common species at $\propto = .20 \pm 10\%$. This sampling intensity was considered the maximum practical amount for land management personnel; additional plots or transects would be time prohibitive.

Data for nested plots of 5 sizes were simultaneously recorded, and rooted frequency of occurrence within each quadrat was recorded by species. A plant was considered present if any portion was rooted within the quadrat (Greig-Smith 1983). Plot sizes were 5×5 cm, 10×10 cm, 25×25 cm, 25×50 cm, and 50×50 cm. Data were analyzed to assess appropriateness of the different quadrat sizes. The smallest quadrat that sampled a site's most abundant species at 63–86% frequency was considered the proper size (Curtis and McIntosh 1950). The 10×10-cm quadrat met this criterion on the majority of study sites. The 3 larger plot sizes were valuable in measuring widely-spaced, broadleaved perennial forbs. The 5×5-cm quadrat was considered too small for frequency sampling most dry mountain meadows.

Once vegetation was sampled, percent species composition was determined for each plot size by dividing number of occurrences for each species by total number of occurrences in the sample (USDA 1981). Since the 10×10-cm quadrat was selected as most appropriate, its composition estimates were used for initial data analysis. Percent composition of each species was tabulated according to the species' desirability rating—desirable, intermediate, or least desirable (USDA 1981). As mentioned above, these categories developed by the USFS are approximately equivalent to the decreaser, increaser, and invader groupings used by other agencies. Desirability ratings were then totalled, thus providing relative frequency percent composition for each desirability category.

Discriminant analysis procedures in SAS (Helwig and Council 1979) were then used to classify sites into range condition classes based on their frequency data. This method of analysis was chosen for its relative simplicity and repeatability between workers. Discriminant analysis is a multivariate statistical procedure that attempts to predict group membership based on one or several predictor variables. This is accomplished by finding that combination of predictor variables that maximizes the differences among the groups. To begin separating condition classes based on frequency data, 2 numeric variables were chosen, the relative frequency percent of desirables and of intermediates. Of the 3 potential variables—desirables, intermediates, and least desirables—any 2 were acceptable. This was because the 3 values add up to 100% and knowing any 2 also provides the third value. The percentages of desirables and intermediates were selected because these are the 2 values used in the current USFS (Region 4) range condition method. In the existing procedure the percent desirables and intermediates, based on yield, are located in a chart that provides a vegetal composition rating. USFS personnel are thus accustomed to using these 2 values.

To begin the analysis, the percentages of desirables and intermediates were standardized to have a mean of 0 and a standard deviation of 1. This was to facilitate later comparisons. Procedures in SAS then developed a classification equation for each of the 3 range condition classes. These equations followed the form

$$S_j = c_{jo} + c_{j1}y_1 + c_{j2}y_1$$

where y_1 and y_2 were the percentages of desirable and intermediate species, respectively. The coefficients (c_j) in these equations were weighted to characterize the condition classes as statistically distinct as possible based on the desirability percentages. Each site then received a classification score (S_j) for each condition class.

The site was classified into the condition class for which it had the highest classification score. Accuracy was evaluated by comparing the known classification groupings to the condition class groupings derived from discriminant analysis (Tabachnick and Fidell 1983).

Thus far the analysis has considered only data from a single plot size. Other frequency sampling research, however, has demonstrated that summation of frequencies from several plot sizes improved frequency sampling's ability to detect changes in species composition (Smith 1982). Based on this information, summed standardized frequency values were used to determine whether this would improve frequency sampling's ability to classify range condition. Data analysis continued by summing frequencies of 4 plot sizes—10×10 cm, 25×25 cm, 25×50 cm, and 50×50 cm. A species' frequency could now total 400% compared to 100% with only a single plot size. Once summed, percent composition was again determined by dividing number of occurrences for each species by total number of occurrences of all species in the sample. These new species composition figures were totalled according to desirability rating and also tested with discriminant analysis.

Results and Discussion

When using statistical methods to develop ecological models or guides, numerous choices must be made concerning which variables to include. These choices can be based partially on statistics, but decisions must be tempered by a researcher's field experience and the anticipated applications of the model or guide.

In this study the 2 variables chosen were the relative frequency percent of desirable and intermediate species. Relative frequencies were used to facilitate constructing a scorecard suitable for inclusion in a handbook. Total frequencies, as opposed to relative frequencies, did not supply the endpoints necessary to build a scorecard to cover all possible combinations. Relative frequency percent composition of indicator species was not used because there is no species that occurs on all dry mountain meadow sites. It should be noted that frequencies of all species sampled were included in the relative frequency composition estimates. Composition estimates are thus influenced by total number of species identified, and different persons with varying plant identification skills could obtain slightly different composition estimates. But the condition guides developed by this study were developed from data sampled at a species identification level consistent with most USFS range technicians. Because of this, results obtained are believed to be highly repeatable among the people expected to use these condition guides.

Standardized classification equations based on 10×10-cm quadrat data are shown in Table 1. Since desirable and intermediate

Table 1. Standardized classification equations based on 10×10-cm quadrat data for classifying study sites into range condition classes.

Condition class	Classification Equations
Good	$S_g = -1.38325 + 2.72326y_1 + 1.51771y_2$
Fair	$S_f = -0.01313 - 0.08634y_1 - 0.18689y_2$
Poor	$S_p = -1.26108 - 2.63695y_1 - 1.33081y_2$

y_1 = standardized percent relative frequencies of desirables.
y_2 = standardized percent relative frequencies of intermediates.

values were initially standardized, resulting coefficients in the classification equations can be compared. The coefficients show the relationship between percentage of desirable and intermediate species on a site and the site's condition class. Good condition sites are characterized by high percentages of desirable and intermediate species; few least desirables are present. In contrast, poor condition sites have fewer desirables and intermediates and more least desirables. The coefficients reflected this relationship. Coefficients for good condition sites were positive, whereas coefficients for poor condition sites were negative. Coefficients for fair condition sites approximated the midpoint between the poor and good condition values.

Classification equations based on 10×10-cm quadrat data correctly classified 15 of 18 sites examined, or 83% (Table 2). All good

Table 2. Site comparison of range condition classification based on 10×10-cm quadrat frequency data.

Site Name	% Composition D[1]	I	L	Actual Condition Class	Classified by Frequency
Cache Creek	77	13	10	Good	Good
Elk Meadow	62	33	5	Good	Good
Hartley Meadow	56	41	3	Good	Good
Poker Meadow	75	8	17	Good	Good
Sater Meadow	49	44	7	Good	Good
Stanfield Meadow	57	33	10	Good	Good
Bearskin Meadow	56	7	37	Fair	Fair
Corduroy Meadow (a)	47	38	15	Fair	Fair
Dead Cow Meadow	52	24	24	Fair	Fair
Pen Basin	67	11	22	Fair	Fair
Pole Creek	46	25	29	Fair	Fair
Stanley Creek	40	29	31	Fair	Poor*
Ayers Meadow	18	12	70	Poor	Poor
Big Meadow	54	8	38	Poor	Fair*
Bruce Meadow	43	19	38	Poor	Poor
Corduroy Meadow (b)	36	43	21	Poor	Fair*
Little East Fork	40	28	32	Poor	Poor
Tyndall Meadow	39	22	39	Poor	Poor
Accuracy					83%

* = Misclassified sites.
D[1] = Desirables, I = Intermediates, L = Least Desirables

condition sites were classified correctly; the error was encountered between fair and poor condition sites. No fair or poor condition sites were placed into the good condition class. An analysis of desirable and intermediate percentages shows that differences between poor and fair sites were not as distinct as between good and fair sites (Table 2). Misclassification of 2 sites, Corduroy Meadow (b) and Big Meadow, can be attributed to their relatively desirable species composition yet low herbage production in relation to assumed site potential. As explained earlier, current USFS (Region 4) condition classification guidelines combine vegetal composition and site productivity into a single score. This makes it difficult for our classification scheme based solely on vegetal composition to correctly classify sites where low productivity offsets relatively desirable species composition. We are unable to explain misclassification of the Stanley Creek site.

The summation technique formulated a second set of similar standardization classification equations. Identical relationships existed between coefficients in these equations as discussed in reference to the 10×10-cm quadrat equations in Table 1. Classification equations formulated by summation also correctly classified 15 of 18 sites. The 3 sites misclassified were Corduroy Meadow (b), Stanley Creek, and Bruce Meadow (Table 3). Corduroy Meadow (b) and Stanley Creek were also misclassified by the single plot size data. Reasons for this technique misclassifying the Bruce Meadow site are unclear.

Classification results were considered sufficiently accurate to warrant development of range condition guides. Using nonstandardized classification equations developed from the 10×10-cm quadrat data, a classification score was calculated for each possible combination of desirable and intermediate percentages. This resulted in the condition guide shown in Figure 1. This chart can be used with relative frequency data from a 10×10-cm quadrat to estimate range condition. Begin by locating percent desirables on the left scale and percent intermediates on the bottom scale. Point of interception of the 2 lines gives the range condition rating. The range condition estimate is thus made from the relationship of

Table 3. Site comparison of range condition classification based on summation frequency data.

Site Name	% Composition D[1]	I	L	Actual Condition Class	Classified by Frequency
Cache Creek	67	18	15	Good	Good
Elk Meadow	57	35	8	Good	Good
Hartley Meadow	64	23	13	Good	Good
Poker Meadow	64	16	20	Good	Good
Sater Meadow	48	41	11	Good	Good
Stanfield Meadow	50	35	15	Good	Good
Bearskin Meadow	54	10	36	Fair	Fair
Corduroy Meadow (a)	48	35	17	Fair	Fair
Dead Cow Meadow	47	22	31	Fair	Fair
Pen Basin	57	16	27	Fair	Fair
Pole Creek	49	23	28	Fair	Fair
Stanley Creek	38	31	31	Fair	Poor*
Ayers Meadow	34	15	51	Poor	Poor
Big Meadow	52	5	43	Poor	Poor
Bruce Meadow	49	18	33	Poor	Fair*
Corduroy Meadow (b)	37	42	21	Poor	Fair*
Little East Fork	39	29	32	Poor	Poor
Tyndall Meadow	45	19	36	Poor	Poor
Accuracy					83%

* = Misclassified sites.
D[1] = Desirables, I = Intermediates, L = Least Desirables

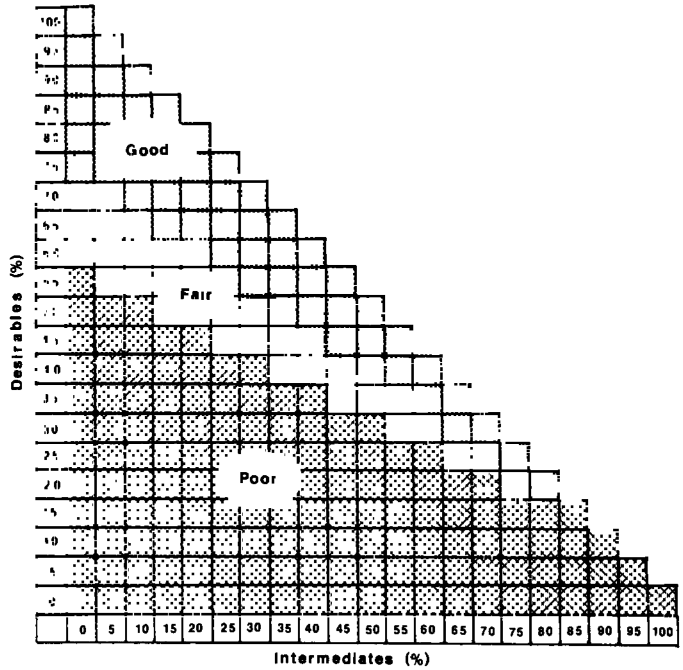

Fig. 1. *Range condition classification guide for use with relative frequency data from a 10×10-cm quadrat.*

desirables to intermediates, and not the amount of a single group. This explains the wide limits for desirables and intermediates in each condition class. A similar condition guide was formulated using non-standardized classification equations developed from the summed data. This guide can be used to estimate range condition with frequency data from 4 summed plot sizes: 10×10 cm, 25×25 cm, 25×50 cm, and 50×50 cm. Since sites in excellent and very poor condition were not sampled, these condition classes could not be included in these guides. This is not to suggest that these classes do not exist. Excellent and very poor condition classes would be shown in the extreme top and lower left sections, respectively, of Figure 1. The exact division, however, between these and the other condition classes is not known.

Summary and Conclusions

Range condition can be estimated with frequency data. This study developed 2 range condition guides for mountain meadows, 1 based on a single plot size and a second guide based on summation of 4 plot sizes. Both guides were equally accurate, correctly classifying 83% of sites examined. Since no increase in accuracy was experienced with summation, this additional effort does not appear necessary. However, if data are to be summed for monitoring changes of individual species as recommended by Smith (1982), it seems only logical to use the same data for range condition classification.

Because frequency is affected by plant size, plant distribution, and plant density (Kershaw 1973), relationships between frequency and range condition are specific to individual areas and vegetation types. This study was conducted in dry mountain meadows of central Idaho and so the condition guides presented here are specific for this area and this vegetation type. However, the procedure used here to develop these guides should be useful in any area and in any vegetation type. The level at which future guides need to be developed will depend on the variability present within each particular vegetation type. Vegetation within the meadows sampled in this study was fairly homogeneous despite occurring over a large geographical area. More variable vegetation types may require more localized sampling. Also, the existing USFS vegetation type classification system is not as refined as some systems used elsewhere (e.g., range site, habitat type). If a more complex classification system were used to subdivide dry mountain meadows, for example, frequency-condition relationships should correlate even more closely.

The procedure developed by this study involved accumulating frequency data on sites where condition class was already known. Discriminant analysis was then used to develop classification equations that maximized the distance between condition classes based on frequency data. Consequently, these condition guides do not represent a new classification system. Any possible deficiencies in the present USFS condition standards still exist. The guides presented here merely relate frequency data to the current standards, enabling land managers to estimate range condition by frequency sampling.

Finally, our procedure is not limited to relating frequency data to range condition only as condition is determined by current USFS (Region 4) methodology. There is no apparent reason why discriminant analysis cannot be used to relate frequency data to range condition, regardless of the criteria presently used to determine vegetation condition. Individuals or agencies currently using other plant community characteristics to classify condition, such as cover or density, should also be able to use our procedure to develop their own range condition guides based on frequency data. However, because frequency characterizes only vegetation, this procedure cannot be used to relate frequency to range condition based on nonvegetation attributes such as soil stability or percent ground cover.

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