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Viewpoint: Trend assessment by similarity—a demonstration

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Abstract

Methodology for assessing trend in range condition is still evolving. This paper demonstrates use of Dice's community similarity coefficient, 2a/(2a + b + c), with communities present at 3 times and a notional community as a goal. Coefficients range from 0 (indicating a complete lack of similarity) to 1 (indicating complete similarity). Similarity is classed as low (0 - 0.25), moderate (0.26 - 0.50), high (0.51 - 0.75), or full (0.76 - 1). Study of time-goal coefficent graphs is suggested for deciding whether trend is up, down, or static. Defining goals and lack of statistical tests are major limitations. The goal concept and use of data standardization are discussed.

Key Words: change, intercepts, management goals, resource values, standardization

Change is a reality of life on the range. Although modern range managers may use data derived from geographic information systems and satellite imagery, the traditional job of assessing trend in range condition remains. But there is no common agreement on the best way to approach the task. Like others, the approach suggested in this paper has its problems, and methodology is still developing.

Methods of analysis based on classification and ordination are being developed (Foran et al. 1986, Hacker 1983, Ratliff and Westfall 1989). Such approaches frequently involve computer programs and complex calculations that require specialized training. The basics involve computing resemblance functions—single values expressing how 2 samples resemble each other or are dissimilar (Ludwig and Reynolds 1988). Such functions integrate differences between samples that are expressed individually by multiple variables.

Coefficients of community similarity are resemblance functions. They express how nearly 2 communities resemble each other. Some are relatively easy to compute and understand and appear to offer a comparatively simple approach to trend assessment. The objectives of this paper are to demonstrate and to stimulate research on the use of such a coefficient for that purpose.

Similarity

Community similarity is frequently used in plant ecology to compare different stands. The coefficients of Dice, Jaccard, and Ochiai are recommended when species presence-absence data are used (Janson and Vegelius 1981, Ludwig and Reynolds 1988). However, species quantities may also be used (Mueller-Dombois and Ellenberg 1974). A coefficient of 0 indicates complete lack of similarity (there are no common species or values), and a coefficient of 1 indicates complete similarity (all species or values are common). Both extremes are unlikely, especially when a specific site is monitored over long time periods.

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Goal Concept

The potential natural community (PNC), the highest development attainable under present environmental conditions without human interference (RISC 1983), may be the goal for a particular site. Like climax, however, PNC assumes succession and suffers from ambiguity in defining stages to a stable end state (Smith 1989).

As with the climax and PNC concepts, defining goals for different sites will stimulate debate. Nevertheless, management must have a goal; otherwise it is without direction. A goal is the standard, reference, or benchmark of comparison for communities present at different times; it is a community having desired characteristics. Whatever the goal, it must be defined by the variables used in assessing the actual community and be within reach of management.

A goal may thus be the PNC or a community of high value to a specific animal species, or aesthetics, or watershed protection, or forage production, or some combination of resource products. While not ecologically desirable perhaps, the goal conceivably may be a low successional but stable community. Such a community may be desired or at least needed for specific products, or it may be accepted as a goal because management cannot effect change to a more desired state without a major input of off site resources.

Trends

Trend is directional change (RISC 1983) and will indicate whether the goal is being approached. Coefficients of community similarity can be used to place stands along a single axis. Over time, therefore, the positions of the communities present on a site will indicate trend relative to the goal. For example, the axis may represent a sere with climax or PNC being the desired end point. In that case the degree of similarity to PNC indicates the ecological status of the present community (RISC 1983). As suggested, the desired end point or goal can relate to a resource value. In that case the degree of similarity indicates the status of the present community relative to that desired for producing a given product or mix of products.

The communities present at successive times of assessment may be judged against the goal by using time-goal similarities; they may be judged against each other by using time-time similarities. Time-time similarity coefficients aid understanding of fluctuations and assessment of trends indicated by time-goal similarities.

Methods

Community Similarity

Coefficients indicate the proportional amounts of similarity between communities, and those of Dice, Jaccard, or Ochiai will serve equally well. That of Dice [$D = 2a/(2a + b + c)$] is used because of its mathematical equivalence to Sorensen's coefficient, which is better known (Wolda 1981). I prefer Dice's formulation to Sorensen's because the factors (a, b, and c) refer to cells of a 2×2 table, as common in enumeration statistics. Factor values may be numbers of species. When they are species quantities, however, "a" is the sum of the values common to both communities, i.e., the smaller of each pair.

Four equally proportioned similarity classes were suggested for judging the status of a community relative to the PNC (RISC 1983): early seral (0 - 0.25), midseral (0.26 - 0.50), late seral (0.51 - 0.75), and PNC (0.76 - 1). As a convenience, I used those proportions. In order to avoid confusion with successional terms, however, I have called the respective similarity classes **low, moderate, high,** and **full.**

Data

I selected 3 data sets obtained at 5-year intervals by a modified line intercept technique. The plot was a belt transect 30.5 m long and 127 cm wide on the Harvey Valley grazing allotment of the Lassen National Forest, California. Plant species intercepts were measured on 100 line segments centered on and set perpendicular to the belt center. Total length of line measured each time was, therefore, 127 m.

Goal

For purposes of demonstrating the use of community similarity I took as my goal a notional community composed largely of silver sagebrush (*Artemisia cana* Pursh.) and Nevada bluegrass (*Poa nevadensis* Vasey ex Scribn.), with lesser amounts of other perennial grasses. Total live plant cover (60%) was represented by 76.2 m of intercept on the transect. Composition of the live plant cover was silver sagebrush (50%), meadow barley (*Hordeum brachyantherum* Nevskii.) (5%), mat muhly (*Muhlenbergia richardsonis* Trin.) (5%), Nevada bluegrass (30%), and bottlebrush squirreltail (*Sitanion hystrix* [Nutt.] J.G. (Sm.) (10%). Black sagebrush (*Artemisia arbuscula* Nutt.), basin sagebrush (*A. tridentata* Nutt.), cheat grass (*Bromus tectorum* L.), and perennial and annual forbs were not desired, although for a specific objective they may have been.

When the goal can be well defined and a site has the potential to reach the goal, a narrow range of values (0.91 to 1.0, for example) may be required for accepting full community similarity.

Standardization

Large quantities or dominance of a species (relative to others) at each measurement can mask the influence of important but relatively small changes in other species. To avoid or reduce the risk of such affects, each row of data were transformed (standardized) by dividing all intercepts of a species by the largest (Ludwig and Reynolds 1988). In order to maintain the original relationships, i.e., the relation between amounts of species "s" at time 1 and species "s" at time 2, standardization was across all times and included the goal. Values for all variables then ranged from 0.0 to 1.0.

Results and Discussion

Community Similarity

An intercept is the distance occupied by a plant along a line. The sum of intercepts for a species on a given length of line may be used to compute its percent cover or composition or both. Here intercepts and their standardized values (Table 1) are used directly in computing community similarity.

With abundant silver sagebrush and annual forbs, similarity was high for the times 1 and 2 communities, full for times 1 and 3, but only moderate for times 2 and 3 (Table 2). That effect was due to the intercepts of silver sagebrush. Between times 1 and 2 there was a marked decrease in silver sagebrush (the result of herbicide spraying) and annual forbs increased. The rapid recovery of silver sagebrush by time 3 brought its intercept to within 13% of that at time 1, but it was twice that at time 2. Annual forbs had virtually vanished along with meadow barley by time 3, but the increase in silver sagebrush counteracted their loss.

Much ground must be captured by perennial grasses in order to reach the goal. Temporary perturbations, such as that caused by herbicide, may be needed to advance the site toward the goal—to break a state of suspended succession (Laycock 1989).

With the overriding influences of silver sagebrush and annual forbs removed by data standardization (Table 1), the picture of trend was more clear. While it may not always happen, the coefficients of community similarity were in the order expected for a gradually improving resource (Table 2).

Data sets may contain a mixture of different kinds of quantitative variables (species composition, herbage production, soil properties, surface conditions, and plant heights, for example). Through data standardization techniques those variables necessary for valid assessments of trend for different resource values can be incorporated into the coefficient of community similarity. Of course, only variables included at time 1 may be used in computing the similarities of that community and those of subsequent times.

Assessment

How large a difference between coefficients of community similarity is necessary to declare a significant trend? Given a large number of samples, "D" is approximately normally distributed, and when it is used to examine ecological association of 2 species, a

Table 1. Species characteristics used to calculate coefficients of community similarity for time-time and time-goal comparisons, Harvey Valley grazing allotment, Lassen National Forest, California.

	Characteristic							
	Intercepts[1]				Standardized[2]			
	Time				Time			
Species	1	2	3	Goal	1	2	3	Goal
	cm				Proportion			
Annual forbs	1,309	2,365	3		0.553	1.000	0.001	
Basin sagebrush	64				1.000			
Black sagebrush	39				1.000			
Bottlebrush squirreltail	17	32	104	762	0.022	0.042	0.136	1.000
Cheat grass	3				1.000			
Mat muhly		9	3	381		0.024	0.008	1.000
Meadow barley	32	25		381	0.084	0.066		1.000
Nevada bluegrass		4	5	2,286		0.002	0.002	1.000
Silver sagebrush	5,276	2,290	4,600	3,810	1.000	0.434	0.872	0.722
Totals	6,740	4,725	4,715	7,620	4.659	1.568	1.019	4.722

[1]Total transect length was 12,700 cm measured on 100 line segments.
[2]Intercepts/greatest intercept for the species.

Table 2. Factor values and community similarity coefficients (D) for time-time and time-goal comparisons, Harvey Valley grazing allotment, Lassen National Forest, California.

		Comparisons					
		Time-Time			Time-Goal		
Characteristic	Factor	1–2	1–3	2–3	1–G	2–G	3–G
Species intercepts	a	3,641	4,620	2,332	3,859	2,360	3,922
	b	1,084	95	2,383	3,761	5,260	3,698
	c	3,099	2,120	2,393	2,881	2,365	793
	D =	0.64	0.81	0.49	0.54	0.38	0.64
Standardized data	a	1.075	0.895	0.487	0.828	0.568	0.869
	b	0.493	0.124	0.532	3.894	4.154	3.853
	c	3.584	3.764	1.081	3.831	1.000	0.150
	D =	0.345	0.315	0.376	0.177	0.181	0.303

confidence interval can be computed (Janson and Vegelius 1981). Most range related monitoring, however, involves only 1 transect or at best a nonrandom cluster of 3 per site. Because there is 1 replication per time a variance cannot be computed, and statistical tests of change in community similarity are not available. The decision criterion must, therefore, be arbitrary.

Trend can be represented by the change of site (community) position in ordination space through time (Foran et al. 1986). Though less rigorous, trend can also be assessed by observing a graph of the coefficients of each time with the goal or goals (Fig. 1).

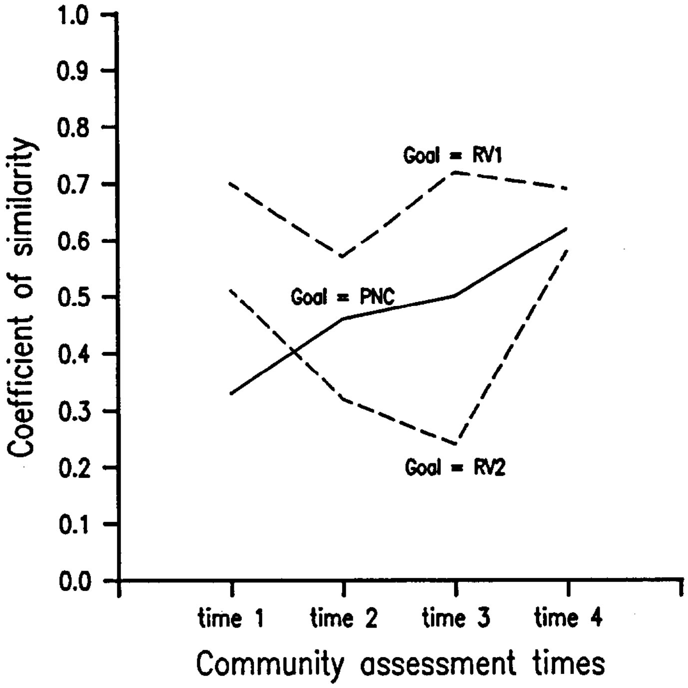

Fig. 1. Coefficients of community similarity for 3 hypothetical goals (2 resource values, RV1 & RV2, and the potential natural community [PNC]) with the communities present at 4 times of assessment.

A basically flat line (or trajectory) indicates little or no change in the community on the site; hence, trend is static. Sharp changes indicate rapid change in the community. Rising lines indicate trend toward the goal, while falling lines indicate trend away from the goal.

Defining the goals for different sites and lack of statistical tests of change are seen as the principal drawbacks to using community similarity in trend assessment. Working together range managers, ecologists, and others can set the goals and work out appropriate analyses. Doing so requires a willingness to get on with the job.

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