

**IS THE RANGE CONDITION CONCEPT COMPATIBLE
WITH ECOSYSTEM DYNAMICS?**

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IS THE RANGE CONDITION CONCEPT COMPATIBLE WITH ECOSYSTEM DYNAMICS?

**A SYMPOSIUM ORGANIZED BY TONY SVEJCAR AND JOEL BROWN
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IS THE RANGE CONDITION CONCEPT COMPATIBLE WITH ECOSYSTEM DYNAMICS?

An Introduction to the Symposium

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The practice of range management is among the oldest of human endeavors, however, our profession is relatively young. If our profession intends to guide the practice of range management it must be from a sound philosophical and technical basis. Often unstated, the range condition model has provided that philosophical and technical basis.

The objective of this symposium is to examine the validity of our principles and, if needed, propose new ones. This should not be interpreted as a weakness, far from it. This is the mark of a robust, responsive group and is the very basis for progress. Real progress generally requires realistic self examination and a clear vision of a goal. We have to know where we are and where we want to go. If we examine the range condition model and its assumptions, it may help us see where we are. I will leave it to our speakers to provide the vision (and the direction).

Some of the limiting assumptions are imposed by the fact that this model was developed fifty years ago. We simply know things now that we did not then. Others were explicitly stated by Dr. Dykesterhuis when he wrote the classic papers describing the model.

Limitations that have emerged in the time since development are technical in nature:

1. It is a plant community measurement. Many of the products of rangelands are measured at a higher level of organization.
2. It is a climax-based succussional model. That model lacks supporting evidence to be universally applied.

Assumptions attached to the model by Dr. Dykesterhuis generally refer to appropriate use:

1. It is a system for evaluating forage production on land used as range. There are many values of rangeland that may not be correlated with forage production and livestock grazing.
2. It is a tool for communication between field workers and land managers. It was never intended to be a means of communication between institutions and the public or a mechanism for policy formulation. These assumptions do not lessen the validity of the model, they limit the utility. We need a new paradigm that allows for the incorporation of new knowledge and philosophies.

As we seek new philosophical and technical organizing principles to carry our profession into the future, we should recall a quote from Dr. Dykesterhuis, "continued developments and refinements of this approach appear probable if founded on ecological principles". I will now ask our speakers to tell us what those ecological principles are and what those developments may be.

NON-LINEAR DYNAMICS IN GRAZED ECOSYSTEMS: THRESHOLDS, MULTIPLE STEADY STATES AND POSITIVE FEEDBACKS

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The works of Schimper, Warming, Cowles, Gleason and Clements published at the turn of the 20th century heralded the emergence of the science of ecology. However, the currently recognized sub-disciplines of ecology were not formulated until the 1950s and it was not until the International Biological Program (IBP) in the 1960s and '70s that the basic principles of ecology received rigorous testing and evaluation. Even then, the focus of the IBP was primarily on abiotic factors; plant-animal interactions and population biology were largely ignored until the mid-70s and 1980s. Ecology is thus a young science and the basic tenets of the rangeland condition and trend concepts were largely developed when that science was in its infancy.

In recent decades, several ecological paradigms have been rightfully questioned. There is considerable debate as to what forces drive succession (Connell and Slatyer 1977, MacMahon 1981, Westoby et al 1989) and the importance of resource availability (Chapin 1980, Chapin et al. 1987), competition (Schoener 1983, Connell 1983, Fowler 1986) and disturbance (Huston 1979, Pickett and White 1985, Rykiel 1985, Collins 1987, Milchunas et al. 1988) in determining community composition. There is also a substantial body of "theory" on ecosystem stability (e.g. capacity to resist change or recover from disturbance), and positive (self-reinforcing) and negative (homeostatic) feedbacks, most of which has been developed since the 1960s. These concepts help explain why the pathway(s) of succession following removal of grazers are often not a simple reversal of the pathway of retrogression (hysteresis effect) and why the dynamics of change are often abrupt and non-linear rather than gradual and continuous. In addition, range sites are embedded within landscapes and an understanding of their dynamics may be contingent upon a knowledge of the extent of interactions with other landscape components. We will review and illustrate these concepts with examples from rangeland ecosystems.

The notion of single equilibrium communities that progress steadily toward or away from climax depending on grazing pressure does not apply in many rangeland systems. Examples of the importance of stochastic events in shaping the path of succession, alternative steady states, and discontinuous and irreversible transitions are abundant (see Westoby et al. 1989). The rate and path of succession will vary, depending on the life history traits of the new vegetation, the mobility and availability of propagules, the extent of soil modification and climatic variables. If disturbance thresholds are exceeded, positive feedbacks can cause systems to shift to a new steady state which may persist regardless of subsequent grazing practices. Plant population parameters or other abiotic variables that might forecast impending transition thresholds must be identified and incorporated into management plans.

The range condition/trend concept has changed little since its inception, even though the basic science which underlies it has evolved substantially over the past 40 years. The range science profession is in a unique position to address both the basic and applied aspects of succession and disturbance theory in ecology. In the applications arena, our challenge is to incorporate key elements of autecology, population biology, ecosystem science and modelling to make the application of the condition and trend concept more robust and consistent with current ecological theory. Rangeland ecosystems are, in many cases, uniquely suited to testing and refining succession and disturbance theory at appropriate spatial and temporal scales (long-term manipulations over large land areas). As such the profession is in a position to contribute to the development and testing of basic tenets of relevant theory. In addition, the widespread availability of powerful and inexpensive computer hardware and software offers unprecedented opportunities for using multivariate analyses, geographic information systems and modelling to (1) more thoroughly analyze and explore existing databases of plant-soil-climate relationships in the context of disturbance and succession; and (2) adapt and apply sophisticated statistical and ecosystem models to local management situations.

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ALTERNATIVE RANGE CONDITION CONCEPTS AND MODELS FOR SAGEBRUSH GRASS RANGELAND

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Rangeland dominated by various subspecies of big sagebrush do not react as predicted by the current range condition model. The "climax" or "pristine" sagebrush-grass stand generally is presumed to have been an open stand of sagebrush with a productive herbaceous understory. The presently-used range condition model assumes that areas with thick stands of sagebrush will return to this condition if grazing is reduced or removed. This generally does not happen, thus frustrating managers.

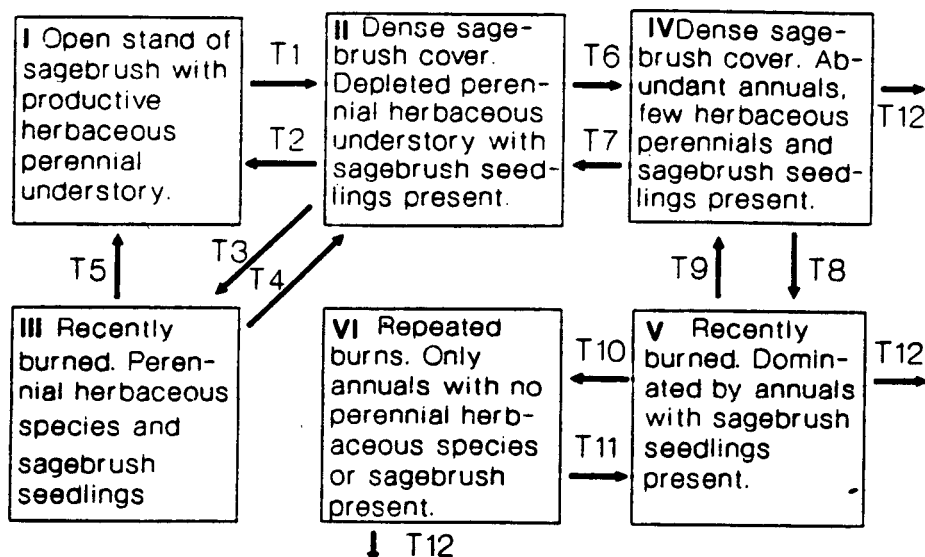
In reality, the pre-livestock condition probably was a mosaic of stands with varying amounts of sagebrush from thick stands in areas that had escaped fires for a long period of time to recently-burned areas with no mature sagebrush. Presently, there are large areas with thick stands of sagebrush, either because of heavy grazing in the last century or because of heavy grazing in the last century or because of lack of fire. These stands remain dominated by sagebrush for very long periods of time even where livestock grazing has been completely removed. Areas excluded from grazing for up to 45 years remain dominated by sagebrush and thus, show little or no improvement in range condition. This sagebrush-dominated community represents a stable state which resists changes toward a more open grass/sagebrush state caused by reduction or removal of livestock grazing. Some intervention, by man or nature, that removes the mature, dominant sagebrush plants is required to push the community out of this stable state.

A second stable state occurs in areas of southern Idaho and surrounding areas now dominated by cheatgrass brome. These areas originally were sagebrush-grass rangelands. Heavy grazing, repeated fires and the presence of highly adapted annuals caused this change. Large areas have few perennial grasses and no sagebrush close enough to provide seed. Fire frequency is now less than 5 years due to the flammability of cheatgrass. These frequent fires do not allow perennial grasses, sagebrush, or other shrubs to establish and set seed. Thus the cheatgrass communities are recognizable stable vegetation states where removal of grazing has little effect and where current range condition criteria do not apply.

One different way to consider range condition in the sagebrush-grass ecosystem is the "state-and-transition" model shown on the next page. The stable states (boxes) and transitions (arrows) represent the changes described above and may help managers to better understand range condition in sagebrush-grass communities. State I represents the concept of the "pristine" community, State II represents the sagebrush-dominated stable state and State VI represents the cheatgrass-dominated stable state described above. The implications of this and other alternative range condition models will be discussed.

STATE-AND-TRANSITION MODEL FOR A SAGEBRUSH GRASS ECOSYSTEM

(After Westoby, Walker and Noy-Meir, 1989)



State-and-transition diagram for sagebrush-grass vegetation.

Catalogue of Transitions

- Transition 1**—Heavy continued grazing. Rainfall conducive for sagebrush seedlings.
- Transition 2**—Difficult threshold to cross. Transitions usually will go through T3 and T5.
- Transition 3**—Fire kills sagebrush. Biological agents such as insects, disease or continued heavy browsing of the sagebrush by ungulates could have the same effect over a longer period of time. Perennial herbaceous species regain vigor.
- Transition 4**—Uncontrolled heavy grazing favors sagebrush and reduces perennial herbaceous vigor.
- Transition 5**—Light grazing allows herbaceous perennials to compete with sagebrush and to increase.

If climate is favorable for annuals such as cheatgrass, the following transitions may occur:

- Transition 6**—Continued heavy grazing favors annual grasses which replace perennials.
- Transition 7**—Difficult threshold to cross. Highly unlikely if annuals are adapted to area.
- Transition 8**—Burning removes adult sagebrush plants. Sagebrush in seed bank.
- Transition 9**—In absence of repeated fires, sagebrush seedlings mature and again dominate community.
- Transition 10**—Repeated burns kill sagebrush seedlings and remove seed source.
- Transition 11**—Difficult threshold to cross if large areas affected. Requires sagebrush seed source.
- Transition 12**—Intervention by man in form of seeding of adapted perennials.

THE EXTRAORDINARY CONCEPT OF MULTIPLE STEADY STATES: ANALYSIS FOR THE ORDINARY SCIENCE TO FOLLOW.

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For scientists, a paradigm is a common set of beliefs that give a central thrust to the work of a discipline. Range science is undergoing a paradigm shift - the paper by William Laycock at this symposium is a clear statement that the shift is well underway.

Thomas Kuhn (Structure of Scientific Revolutions) has pointed out that most of science, which he terms ordinary science, simply reinforces the existing paradigm. Paradigm shifts are so unusual that Kuhn terms such actions "Extraordinary science", and that is the reason that this symposium is so exciting.

The concept of multiple steady states in ecology is not really new, but its acceptance in mainstream range science is new. Individuals at obscure (to us) research laboratories, publishing in obscure (to us) journals such as Theoretical Biology, have presented models of ecological systems with two to many steady states for at least two decades. Graduate students, and others working on the fringe of range science, have not ignored this literature, but they have not yet managed to press their ideas into traditional range management. However, when the same ideas are presented by such a senior, distinguished and well recognized scientist as Bill Laycock at an opening day symposium for the annual SRM meeting, we can no longer ignore the obvious change that is upon us.

Paradigm shifts are painful, but necessary for a science to progress. Acceptance of a new paradigm should not imply criticism of the older paradigm - scientific thoughts are always transitory unless there is stagnation.

This presentation is based on the assumption that the extraordinary science that requires consideration of multiple steady states, rather than the traditional concept of single steady states for ecological systems that has dominated range management for most of this century, has now been accomplished. We must applaud Dr. Laycock and others who have helped to bring this about, and then we must move on to the ordinary science which will examine the new paradigm in great detail. This process will require many years and many graduate students. Eventually, we will all struggle to stay awake through yet another thesis defense on multiple steady states, and at some later time a new paradigm revolution will occur. Such is progress.

Now for the ordinary science. Popper's view of science is that it requires falsifiable hypotheses. For ordinary science (i.e., that which most of us can do) this is probably an adequate statement (any extraordinary scientists in the audience can take a nap during the rest of this presentation). Ordinary scientists are required to state and test hypotheses. For older folks, this used to mean that the appropriate statistical analyses could be found in Snedecor. For the late-middle aged the appropriate reference may be Cochran and Cox. For the increasingly younger set, it probably means using an analysis package such as BMDP, SPSS, SASS or GAUSS.

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Classical ordinary science does not involve "exploratory analysis", thus I will exclude from my remarks any analyses that purport to be statistical but do not involve the a priori statement of hypotheses. If we are ordinary and scientist, we must have testable hypotheses. If we are really ordinary, we should also have statements in our reports like $p < .05$. When we reach $p < .01$, we are probably ready for the next paradigm shift.

This self-imposed ban on exploratory analyses limits the use of multivariable techniques such as principal components analyses, factor analyses and discriminant analyses, and spatial techniques such as spatial autoregression. However, it would be acceptable to use such analyses with one set of data, and hypothesize that the resultant multipliers apply to another set of data. Even with this use, one must be imaginative in developing valid statements of probability appropriate to these analyses.

Study of multiple steady state systems may involve a space-for-time trade off, i.e., using ecological relationships displayed in space as a surrogate for ecological relationships displayed in time as at this SRM meeting examines this possibility in detail. If ecological boundaries are dynamic, then it may not be discernable whether a phenomena is occurring in space or in time. "When the moving ecotone reaches an observer" might be the same question as "when a moving observer reaches the ecotone". This suggests that spatial analysis techniques used by geographers might be useful. However, most of these analyses are exploratory and do not qualify as science that uses hypothesis statements. An exception is the 1990 book on spatial data analysis by Robert Haining (Cambridge U. Press), as he makes very strong statements about the need to properly use hypotheses.

Let us look at the simplest model of multiple steady states, i.e., a fold catastrophe. (A drawing of a fold is simple, it is only the proof that it is the simplest multiple steady state model that is difficult). In this model, the response to some extreme value of a control variable has a single stable steady state. In between there is a zone where either state can be considered a stable steady state (along with some unstable steady states).

If we would sample for some measurement variable along the control axis, we would expect to find a low variance at the two extremes of the fold and a high variance in the middle zone. In fact, the high variance might obscure the fact that there are steady states of any kind, and we might assume that we have chaos.

Although the high variance across the mid-range of the control variable appears to be obvious, the tricky part is that we are really sampling for one variable at one extreme and another variable at the other extreme. We might be measuring mostly grass species at one end and mostly shrub species at the other end. To reduce this to a single variable that will indicate the mid-range, we need to find an acceptable index.

The index question alone should allow us a decade or so of theses. Let us view the zone of multiple steady states as an ecotone. A single index should be low (or high) on each side of the ecotone, and the reverse in the ecotone itself. Some nominees include species richness indices, patch connectivity, diversity indices, fractal dimensions, phase

transition parameters, discontinuity detection algorithms, edge detection algorithms, changes in spatial autocorrelations, and others. The important thing is that the analysis should illuminate the ecotone as the focus of the analysis, rather than being merely the common edge of two adjacent communities or ecoregions. As an example, a fractal dimension computed for an ecotone should be high (approaching 2), and a fractal dimension computed for the adjacent single steady state communities should be low (approaching 1).

The procedure is simple in concept: (1) find an interesting ecotone, such as a riparian/upland transition, a woodland/grassland transition, a C3/C4 transition, etc. Then (2) hypothesize that a given index will clearly and unambiguously discriminate between the ecotone and the surrounding "single steady-state" communities. After a few hundred theses and dissertations examine this question over a wide variety of ecotones, we should begin to agree that some indices are more consistent than others and thus are more useful as ecological change detection procedures.

A suitable index also will allow tests of the hypotheses that the ecosystem under study has properties of hysteresis, i.e., that the response of a system to a control or treatment variable is different when the variable is changed in one direction as contrasted to a change in the opposite direction. This is a very important point for range management, as it says that we cannot restore range condition simply by ceasing to do those things that caused the decline. As an example, assume that the control variable under study is the beginning date of grazing. A rangeland with a history of early grazing, moving to later grazing, would have a different equilibrium than a rangeland with a history of late grazing, moving to earlier grazing, even though the current grazing date is the same.

We will probably see many workers using space-for-time trade offs to examine the property of hysteresis, rather than waiting for the response to occur in time. However, this does have some dangers, and certainly it would be more convincing to be able to induce hysteresis experimentally.

Let us now move on to the next most complex multiple steady state model - the cusp catastrophe. This model is much like the fold, but involves an additional dimension with an additional control variable. This second control is sometimes called the "slow control", as contrasted to the control of the fold catastrophe which is the "fast control". Viewed from on edge, the cusp model appears to be simply a fold model. However, viewed from above, some new insights appear. A point of bifurcation, not seen in the fold model, is the most obvious property. The good news here is that the existence of the bifurcation can be statistically inferred from an analysis of variance, testing the mean square of the slow control X fast control interaction. The bad news is that one of the treatment variables is slow, which may mean a longer time will be required for the response equilibrium to develop.

The cusp model also may alleviate the concerns of those who are unwilling to depart from the earlier paradigm that time and succession will cure all ills. Whereas the fold model requires a "jump", i.e., and outside influence, to move from one steady state to another, the cusp model allows a "smooth return" along the slow control that does not require an outside influence.

There is some other news, both good and bad. Most of the analyses of multiple

analyses. It is safe to forecast that the ordinary science of multiple steady state systems will make extensive use of these technologies. The bad news here is that most of the current GIS techniques are at best false 3-D, sometimes called 2 1/2 D. Although such systems portray x, y and z coordinates, only one z value can be displayed for each x, y pair. (Figures for fold and cusp surfaces can be displayed with such software only if turned on edge so that it appears that there is only one z value for each x, y pair). However, by definition multiple steady state models have more than one z value for each x, y pair, and this requires more expensive true 3-D software.

IS THE ECOLOGICAL RANGE CONDITION CONCEPT USEFUL IN GOOD MANAGEMENT OF RANGELANDS?

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Theories of ecological function and ecosystem dynamics are widely varied and all are useful in expanding our knowledge and understanding.

The ecological range condition concept has evolved over many years as a working tool for field people. The major development and application procedures, used by the SCS, were made by SCS range conservationists.

SCS uses the range condition concept to explain to land managers how grazing or other uses may effect the plant community. The precise composition of any part of a range site is not normally recorded or needed. Although secondary plant succession does not follow a single pathway we have found that professional range conservationists are capable of explaining to the land user the expected changes resulting from a given management scheme. Few if any of our clientele are concerned about specific pathways of secondary succession. They are interested in attaining a stable plant community that will meet their objectives.

Since SCS is not a land management agency we do not make land use/management decisions. Our authority is to provide technical assistance to non-federal land owners and managers. Under special agreement we occasionally provide assistance on other lands.

In order to strengthen the application of sound resource management the SCS has recently developed a planning system that fully recognizes 5 resource bases. These are soil, water, air, plant, and animal. Since we have determined that scientific knowledge does not exist to precisely define a conservation treatment threshold we have instead developed Quality Criteria for each of the land uses for each of the resource bases. This systems approach will reinforce the application of ecological range management assistance provided by the Soil Conservation Service.

THE RECENT EVOLUTION OF RANGELAND CONDITION DETERMINATION IN THE FOREST SERVICE

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The concepts of defining rangeland condition in the Forest Service have evolved and changed over the last 10 years. These changes are the result of the application of ecosystem concepts and principles to rangeland management, and the realization that rangeland management is more than just livestock grazing. Many of the changes have been accelerated as a result of the development and implementation of integrated management prescriptions in Forest Plans and the requirements of NEPA.

The most important change has resulted from taking an ecosystem approach to management in which all the component parts of the ecosystem are taken into account, including how the components interact and function together.

The second most important change is the incorporation of the concept of managing by objective and identifying a desired future condition of the rangeland ecosystem. The desired future condition reflects the objective and provides the means to measure progress toward achieving it. Desired future condition is composed of the desired soil condition, desired future vegetation, and the desired condition of other relevant rangeland resources such as riparian areas, fish habitat, and wildlife cover. Desired soil condition is the soil condition which meets forest plan or other management objectives for maintaining soil quality, soil productivity potential, and hydrologic function. Desired future vegetation is the composition and structural characteristics of the plant community on a site or an ecological unit which meets forest plan or other management objectives.

Resource value ratings define the desired future condition and the relationships of that condition to existing conditions for all relevant rangeland resources. Indicators which reflect the results of management actions in the shortest time frames are chosen for the relevant rangeland resources and resource value ratings are established for them to measure progress toward achieving the desired future condition.

In the aggregate, rangeland condition is that state or condition of all relevant rangeland resources in relation to the desired future condition. Satisfactory condition is achieved if we are at the desired future condition or making satisfactory progress towards achieving the desired future condition.

INCORPORATING NEW SUCCESSIONAL THEORY INTO THE RANGELAND MANAGEMENT PROGRAM OF THE BUREAU OF LAND MANAGEMENT

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The Bureau of Land Management (BLM) currently uses ecological site classification and inventory to determine site potential and assist range condition. The approach is based on the successional theory of Clements (1916), as applied to rangelands by Dyksterhuis (1949), and further refined by the Soil Conservation Service (1976). Important assumptions of the approach include: 1) that each ecological site has only one climax, stable state plant community; 2) that secondary succession is simply the reverse of retrogression and proceeds through a series of predictable seral communities; 3) that pioneer species facilitate the invasion and establishment of later seral species; 4) that succession proceeds in a steady, continuous fashion; and 5) that climate remains relatively stable, at least over periods of many decades to hundreds of years. All of these assumptions are severely challenged by current successional theory (see, for example, Connell and Slatyer 1977; Noble 1986; Noble and Slatyer 1980; MacMahon 1980; Niering 1987; Cattelino et al. 1979; Smith 1988 and 1989; Glenn-Lewin 1980; Holling 1973; Walker et al. 1981; Westoby et al. 1989; Friedel 1991; Laycock 1991; and Svejcar and Brown 1991)

The BLM depends upon standard ecological site descriptions developed by the Soil Conservation Service. These descriptions provide a list of the plant species found in the climax community and the relative contribution of each species to the total amount of above-ground biomass produced annually (relative yield). Plant attributes other than relative yield, such as cover and structure, may also be described but in practice usually are not. Seral communities may also be characterized in the site descriptions, but for the most part are not, often because they are poorly understood.

The challenge for BLM in the 1990's will be to incorporate current successional theory into its existing procedures and to establish new procedures where necessary. Fortunately, the concept of ecological site classification is sound and much of the information collected to date will remain useful. Changes in implementation of the concept are, however, necessary. Standard ecological site descriptions must be developed that recognize the potential for multiple stable state communities. Complete characterizations of each of these communities must be provided, along with details on the factors required to change from one stable state community to another. This can be best accomplished by incorporating the state-and-

¹The views expressed by the author do not necessarily reflect the official views of the Bureau of Land Management.

state-and-transition model of Westoby et al. (1989; see also the discussions of Friedel 1991 and Laycock 1991). Although site descriptions should discuss the relative value of each community for site protection and particular uses, they should make no conjectures as to the position of the community on an assumed sere.

Site descriptions should also incorporate data on plant attributes other than relative yield. As a minimum, additional data should be provided for each community on relative cover of each species (by stratum) and vegetation structure.

Once such site descriptions are available they will prove invaluable to the land manager in determining which of the several communities that may occupy a given site will best meet the objectives of land use plans. This plant community then becomes the desired plant community (DPC) for that site. Progress toward achieving the DPC can then be assessed by measuring the appropriate plant attributes at different times and comparing the results the results to the site description of that community.

Incorporating these modifications into ecological site classification will require a major change in the way the Bureau assesses range condition. The current procedure, in which the range condition of an ecological site is determined by comparing its existing plant community to the one potential (climax) community, will no longer be workable. The solution to this problem was recently provided by the Society for Range Management's Task Group on Unity in Concepts and Terminology (1991). The Task Group recommended that range condition be determined by assessing the effectiveness of present vegetation in protecting an ecological site from accelerated erosion. The assessment is called the site conservation rating. The point at which accelerated erosion begins is called the site conservation threshold (SCT). Sites rated below the SCT are in unsatisfactory condition, while those above the SCT are satisfactory. Trend is determined by comparing site conservation ratings at different points in time.

One other area of rangeland management requires increased attention. Until now, most research and application has been applied to individual ecological sites, with little consideration for how adjacent sites interact in the landscape. The ecological site classification itself is a single-level system, making it extremely difficult to agglomerate sites into higher level units for large scale planning. The Bureau's Resource Management Plans often cover geographic areas ranging from hundreds of thousands to millions of acres. These plans require that decisions be made on broad units of land such as watersheds. Sound decisions require knowledge of the interrelationships of ecological sites to one another within these broad landscape units and the ability to lump similar sites together for the purpose of determining desired vegetation over large segments of land. Research and development is necessary to improve the Bureau's ability to accomplish this.

The Bureau is already moving to incorporate or at least consider most of the changes discussed above. It has developed draft manual guidance on implementing the DPC concept and has put the process to work at several places in the West. It has indicated its

willingness to adopt the site conservation rating but has not yet officially done so. Finally, it has designated a task force to recommend changes to its ecological site classification and inventory methodology.

These changes, though necessary, will not come about easily. Perhaps the biggest obstacle to their implementation is our lack of knowledge. We need to know a lot more about the states and transitions for most ecological sites. Site Conservation Thresholds have not been determined for most sites, and in many cases additional research will be required. The need for more research into the interrelationships of ecological sites in the landscape has already been discussed.

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Symposium Summary

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The symposium opened with an introduction by my co-organizer, Joel Brown. In his discussion, Joel cited several informative quotes from Dyksterhuis, one of which made the point that rangeland assessment should be founded in ecological principles. Following the introduction were 3 papers from representatives of the research community that dealt with historical changes in ecological thinking, and some alternatives to range condition models. The second set of three papers were by representatives of the USDA- Soil Conservation Service, USDA-Forest Service, and USDI-Bureau of Land Management. These papers addressed the question of how the various agencies might change range assessment practices in response to changes in ecological thinking. I'll summarize the papers very briefly.

In their presentation, Steve Archer and Fred Smeins discussed some of the historical changes in ecological thinking, and made the point that steady progress toward a single equilibrium community does not occur in many rangeland ecosystems. They introduce the idea of steady states and mention that the range condition and trend concept has changed little since its inception, even though the basic science that underlies it has evolved substantially over the past 40 years. Bill Laycock presented a formal state and transition model for the sagebrush steppe. The model seems relatively easy to understand and sets realistic limits on what can, or cannot be accomplished with grazing management. Don Jameson discussed extraordinary concepts, paradigm shifts and various folds and cusps. The paper was enjoyable to read, but I felt rather subordinate in my understanding of spatial analysis. Fortunately for all of us, the professions of range management and arid land ecology have an excellent mix of extra - to subordinate thinkers, and with enough interaction we may all be able to understand how these analyses can be used.

From the Soil Conservation Service perspective, Harlan DeGarmo felt that range conservationists could use the current range condition system to explain rangeland response to management, and that the SCS clientele is not concerned about successional pathways. The SCS recently developed a planning system that recognized 5 resource bases: soil, water, air, plant, and animal. "Quality Criteria" are to be used to assess the impact of land uses on each of the resource bases.

Robert Williamson and Edward Schlatterer cite a shift in management strategies within the Forest Service. The shift is toward application of an ecosystem approach, managing by objective, and defining a desired future condition. The desired future condition should reflect the objective and allow a means of measuring progress toward the objective. Although not mentioned in this paper, Edward Schlatterer (USDA- Forest Service General Technical Report INT - 257, 1989) discussed some of the problems encountered using conventional plant classification guides to assist in ecosystem management. The full citation appears in the pertinent literature section.

John Willoughby made a number of critical points in terms of Bureau of Land Management rangeland assessment: 1) the information collected using ecological site classifications will be useful even if multiple steady state rather than linear succession models are used, 2) site descriptions should include plant data other than just relative yield to be useful, 3) the BLM has developed a manual for applying the desired plant community concept and is currently testing the concept in the field, and 4) at some point we must begin to think about entire landscapes and not just individual sites in developing management plans.

This is not the first symposium dealing with range condition, and certainly won't be the last. The intent of the symposium was to encourage interaction among individuals from science or management backgrounds. There is nothing wrong with occasionally stepping back and taking a good long look at what we are doing. If everything is fine we can proceed with confidence, but if things are not fine we should consider changes in direction. I certainly agree with Dyksterhuis, that rangeland assessment needs to be based on sound ecological principles. The question becomes, how do we best apply the principles of current ecological thinking? Is the state-and-transition model appropriate; should site conservation thresholds be used (as proposed by the SRM Unity in Concepts and Terminology Committee), or is the classical range condition concept still okay? We tried without success to attract a speaker from Australia. Their perspective is of great interest because the Australians have abandoned range condition and trend in favor of opportunistic management (see Westoby et al. 1989). Using Don Jameson's approach, I think we can say the Australians have already suffered through their paradigm shift; the question remains, how will those of us in North America assess rangelands in the 1990's?

Pertinent References

Laurenroth, W.K. and W.A. Laycock. 1989. Secondary succession and the evaluation of rangeland condition. Westview Press, Boulder, CO.

The listed authors are actually editors, and the book contains seven chapters by various authors. As with the present symposium, there are chapters by representatives of the SCS, BLM, Forest Service and by several researchers (including one from Australia).

Schlatterer, E.F. 1989. Toward a user-friendly ecosystem: myth or mirth? p. 223-227. In D.E. Ferguson, P. Morgan, and F.D. Johnson (eds.) Proceedings - Land classifications based on vegetation: applications for resource management. USDA Forest Service Gen. Tech. Rep. INT 257 Intermountain Forest and Range Experiment Station, Ogden, UT.

This article provides an interesting discussion of how multiple steady states within a given habitat type can cause difficulty in the use of vegetation classification guides.

Westoby, M., B. Walker, and I. Noy-Meir. 1989. Opportunistic management for rangelands not at equilibrium. J. Range Manage. 42:266-274.

This article basically introduced the concept of using multiple steady state models for managing rangelands.

Billings, W.D. 1990. Bromus tectorum, a biotic cause of ecosystem impoverishment in the Great Basin. In G.M. Woodwell (ed.). The earth in transition: patterns and process of biotic impoverishment. Cambridge Univ. Press, N.Y.

Dr. Billings makes the case that cheatgrass is a "threat to large, integrated, and operational ecosystems" in the Great Basin. This chapter documents the changes a single chance introduction can have on plant communities.

Friedel, M.H. 1991. Range condition assessment and the concept of thresholds: a viewpoint. J. Range Manage. 44:422-426.

A quote from the conclusions pretty well summarizes the article: "I have put forth the possibility of focusing on the thresholds of change from one domain or state to another. I propose that range does not necessarily deteriorate linearly as grazing pressure increases. Instead, it may retain the capacity to recover up to a critical point, beyond which it cannot readily return to its former state".

Laycock, W.A. 1991. Stable states and thresholds of range condition on North American rangeland: a viewpoint, *J. Range Manage.* 44:427-433.

Dr. Laycock presents a state and transition model (see his abstract in the proceedings) and a thorough discussion of steady states and thresholds.

Sprugel, D.C. 1991. Disturbance, equilibrium, and environmental variability: what is "natural" vegetation in a changing environment. *Biological Conservation* 58:1-18.

This article deals with the concept of non-equilibrium in plant communities. To quote from the abstract, "Where an equilibrium does not exist, defining the 'natural' vegetation becomes much more challenging, because the vegetation in any given area would not be stable over long periods of time even without man's influence. In many areas it may be unrealistic to try to define the natural vegetation for a site: one must recognize that there are often several communities that could be the 'natural' vegetation for any given site at any given time". Examples from several ecosystems are given.

Svejcar, T. and J.R. Brown. 1991. Failures in the assumptions of the condition and trend concept for management of natural ecosystems. *Rangelands* 13:165-167

This brief article covers climatic drift, species invasions, and how these factors can influence rangeland assessment.

Scanlan, J.C. and S. Archer. 1991. Simulated dynamics of succession in a North American subtropical Prosopis savanna. *J. Vegetation Science* 2:624-634

These authors present a state and transition model for mesquite savannas in south Texas.

Society for Range Management Task Group on Unity in Concepts and Terminology. 1991. New directions in range condition assessment. Report to the Board of Directors, Society for Range Management, Denver, CO.

The task group was chaired by Lamar Smith from University of Arizona and included representatives from Federal land management agencies, research and ranching. The report suggested that the Society for Range Management adopt the following seven recommendations:

- 1) "rangeland should be classified by ecological sites as a basis for rangeland inventories, assessments, and extrapolation of research and management experience",
- 2) "management objectives should be defined in terms of a Desired Plant Community (DPC) for each ecological site",
- 3) "effectiveness of present vegetation in protecting the site against accelerated erosion by water and/or wind should be assessed independently of the

use of the site. This assessment should be called a Site Conservation Rating (SCR). The SCR at which accelerated erosion begins should be called the Site Conservation Threshold (SCT). Any site rated below the SCT would be in unsatisfactory condition, and those above it, satisfactory".

- 4) "the SRM glossary should be revised to make it consistent with the definitions of terms related to the topic of range assessment developed by the Task Group",
- 5) "SRM, through its Board of Directors and Executive Vice President, should serve as a catalyst to establish a permanent interagency working group".
- 6) "the SRM Board of Directors should provide an effective educational program to ensure understanding by SRM members, agencies and others of the principles and terms described in this Task Group report", and
- 7) "SRM leadership should encourage NSF, ARS, CSRS, USFS, BLM, SCS, EPA and other research and funding agencies to support basic and applied research which would provide the theoretical basis for the principle of sustainability as is implied in the term Site Conservation Threshold".

The report contains background material, discussion of basic concepts, terminology, and future actions of the Task Group.