Successional Theory and the Desired Plant Community Approach

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The Bureau of Land Management (BLM) has been considering use of a Desired Plant Community (DPC) approach as the basis for managing and evaluating BLM-administered lands. Concern has been raised that this approach may not be scientifically sound or that it may be inappropriately used by managers to justify unacceptable rangeland conditions. The BLM currently evaluates rangeland condition and trend based on the successional concept that plant communities progress toward a species composition similar to undisturbed communities if environmental conditions remain the same and if disturbance is reduced or eliminated. This successional concept was influenced greatly by successional theories developed by Frederick E. Clements in the early 1900s.

The Clementsian-based successional theory as a model for vegetation change is inconsistent with current ecological thought regarding succession on many rangelands. Smith (1988) and Laycock (1991) referenced a number of ecologists who have suggested that traditional theories of plant succession leading to a climatic climax are scientifically inadequate for semiarid and arid rangeland ecosystems. There is not yet an agreement as to an alternative theory that may be considered appropriate; however, theories involving multiple steady states and state-and-transition processes appear to be gaining acceptance.

The purpose of this paper is to briefly describe current concepts of vegetation dynamics in semiarid communities relative to traditional theory and to try to place the Desired Plant Community approach into the context of current theories. Knowledge gaps and the potential of this approach for vegetation management and evaluation will also be discussed.

Current Concepts: Vegetation Dynamics of Semiarid Communities

Forecasts of the likelihood that a site will successfully recover after a disturbance are based on models of vegetation dynamics for similar sites. Much of our current basis for judging rangeland dynamics is based on the theory, as described by Clements, that a successional trajectory will lead to a single stable plant community, climax or potential natural community, provided that severe disturbances are eliminated. This concept is widely taught and is presented in currently used textbooks of rangeland management (e.g., Stoddart et al. 1975, Heady 1975, Holechek et al. 1989).

The traditional rangeland dynamics model used in determining condition classes in the United States was developed by Dyksterhuis (1949, 1958), was based on the Clementsian successional theories, and was accepted by federal land management agencies in the late 1960s. This successional approach for defining rangeland condition classes was strongly criticized because it did not accurately reflect the health of grazed rangeland. For example, the species composition of shrub-steppe communities grazed by cattle declines in herbaceous plants as woody plants dominate the site. Once woody plants become dense, the elimination of livestock grazing will not be sufficient to allow herbaceous plants to fully recover to their previous levels in the community. On some sites, woody plants replace herbaceous plants regardless of the livestock grazing because suppression of fires allows the more competitive woody species to dominate. Because of several problems associated with inaccurate condition classes formulated from the traditional rangeland succession model, the Rangeland Inventory Standardization Committee (1983) recommended using a potential natural community (PNC) rather than climax as the basis for comparison. This approach compares current vegetation to the potential community the site can accommodate while considering past modifications of the site. Thus, a site may develop into one of many potential communities depending on the type and severity of the disturbance on the site. Yet, this approach retains the concept of a single steady state that the community will achieve if disturbances are eliminated. The Potential Natural Community approach currently is being used by several federal land management agencies, including the BLM, to describe rangeland condition.

Regardless of the traditional condition class approach chosen, both are strongly rooted in the Clementsian theory that succession is a predictable, linear, bi-directional process. In other words, succession progresses towards a climax or potential community if disturbances are eliminated and regresses from the climax or potential community if disturbances continue. The traditional rangeland succession model and the Potential Natural Com-

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munity model have largely been accepted for rangeland management because of the desire to find a single objective standard for assessing the impacts of grazing animals (Smith 1988).

Alternative theories of vegetation dynamics take an individual species approach to the development of communities based on the early work of Gleason (1926). These alternatives rely on the species' life-history, on the interactions among the individuals that constitute the population, and on the interactions between the individual and its environment. Disturbance becomes a part of the ecosystem and several stable communities have the potential to develop after disturbances are eliminated or reduced. The nature, frequency, and intensity of the disturbance differentially impact each plant species, therefore the community formed after a disturbance depends on the abilities of the species to survive the disturbance or to replace themselves through reproduction after the disturbance. The likelihood of a species surviving or replacing itself after a disturbance depends on the species germination characteristics, competitive ability, growth, phenology, and on its genetic variability and plasticity related to the myriad of environmental factors it may face. In short, forecasting the dynamics of a community following a disturbance requires the knowledge of the physiological and demographic responses of the individuals that constitute the interacting populations of species that form the community.

The individualistic approach to vegetation dynamics recognizes that more than one potential community can result following a disturbance. Acceptance of this idea has led to the recognition that multiple stable states or communities may exist for any given site (Holling 1973, May 1977, Walker et al. 1981). In a recent review of rangeland successional models, Westoby et al. (1989) outlined the limitations and exceptions to the traditional approach that have led them to advocate that many stable plant communities have the potential to exist on any given landscape. They have proposed an alternative state-and-transition model for describing rangelands and for applying management prescriptions. States are relatively stable assemblages of species that develop on a site depending on the timing, intensity, and severity of disturbances. Transitions, also referred to as thresholds (c.f., Friedel 1991), are actions that result in new states (communities) of species assemblages. Transitions are characterized by the following: (1) unpredictable natural events, such as fires or changing climatic conditions, or human-induced uses of the ecosystem, such as farming or grazing; and (2) changes in states are not reversible on a practicable management time scale without human intervention (e.g., artificial restoration).

The state-and-transition model appears to be appropriate for semiarid communities of North America (Laycock 1991), Australia, and South Africa (Westoby et al. 1989). This approach has been successfully applied to arid and semiarid rangelands where the interaction between different types of disturbance and climate can lead to alternative stable plant communities. Within the western United States, Laycock (1991) proposed a state-and-transition model for the sagebrush-steppe ecosystem that combines transitions resulting from grazing, fire, and climatic conditions that result in the development of six relatively stable communities.

The Desired Plant Community Concept

The philosophical concepts which form the basis of rangeland condition assessment are now in a period of considerable ferment and change. Rangelands often suffer degradation because of their relatively low production per unit area, some traditional management practices, and because of the erratic climatic influences which drive their biological productivity. It is very important to have objective methods to assess their productivity and the effectiveness of management applied to the lands (Foran et al. 1986).

The Society for Range Management formed a Task Group in 1989 on Unity in Concepts and Terminology which has recommended that objectives for multiple use management on rangelands be defined in terms of a Desired Plant Community (DPC) for each ecological site (Task Group on Unity in Concepts and Terminology 1991). These same recommendations are applicable to ecosystem management that is being advocated by the federal land management agencies in the USA. The recommendation was approved by the Board of Directors, Society for Range Management, in July 1991. Of the several plant communities that are capable of occupying an ecological site[1], the Desired Plant Community is defined as the one that has been identified through a management plan to best meet the plan's objectives for the site. It is selected to meet the needs and values of people who have legitimate interests in land management. The value of the concept is that the desired community is clearly defined in terms of human values, including economic and social considerations, and not in terms of a "pristine" condition which may or may not have existed at some arbitrary time in the past. Vegetation management status should be reported in terms of similarity to (i.e., condition) and trend toward or away from the selected community. The SRM Task Group recommended that the effectiveness of a vegetative community in protecting the site against accelerated erosion be assessed independently of the use of the site. This assessment should be called a Site Conservation Rating (SCR). The point at which an unacceptable level of erosion begins should be called the Site Conservation Threshold (SCT). Sites with erosion in excess of the threshold would be assigned a Site Conservation Rating of "unsustainable" or "unprotected" and those with lower rates of

[1]Ecological Site is defined as a kind of land with specific physical characteristics which differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and its response to management. The ecological site concept is and will remain a useful tool for assessing the productive capability of ecosystems. Ecological sites should be the basis for classification of rangelands for the purposes of inventory, assessment, and extrapolation of management practices.

erosion would be assigned a rating of "sustainable" or "protected." Any community with plant cover that is capable of maintaining lower erosion rates than the threshold would be a candidate for the Desired Plant Community at the site. The Desired Plant Community could include introduced plant species. Any plant community that results in erosion in excess of the threshold level is undesirable and should not be selected.

A site where erosion exceeds the threshold may, through management, improve and reach a satisfactory condition. However, if erosion remains in excess of the threshold long enough, presumably the site will lose a significant part of its former productivity and become, for practical purposes, a new ecological site. In that case, a new Site Conservation Threshold and new array of possible Desired Plant Communities must be defined.

It must be understood that Site Conservation Threshold has not yet been defined for any given site, with the exception of some preliminary work by the Soil Conservation Service in Arizona. It is at this time merely a proposal. We must learn how to define it and how to identify the parameters to measure or estimate it. The threshold, and the parameters used to measure it, would be specific to the ecological site. Initially, Site Conservation Ratings will be developed for communities on specific sites by individuals with sufficient experience at these sites and communities to know what community attributes offer protection against accelerated erosion.

Smith (1987) and others have recommended that rangeland managers take the responsibility to decide the type of vegetation which most closely meets management goals (including the fundamental goal of site protection) and use that vegetation type as their standard for condition (Smith 1988). In the Desired Plant Community approach, condition would be based on those attributes pertinent to projected uses of the land. Factors other than potentially narrowly defined management objectives should be considered. An example would be the potential for weeds, particularly noxious weeds, to invade a community that otherwise satisfies management objectives. Given more than one option, the community with the lower potential for noxious weed invasion would be selected.

A concern with the Desired Plant Community approach to rangeland monitoring is that it may lead to moving targets as the values of society and managers change over time. Another concern is that agencies may attempt to use the approach to coverup the lack of improved rangeland condition. However, rangeland condition and trend are interpretations of field data characterizing attributes of the plant/soil system. The monitoring data collected should provide a record of trends in these attributes even though the values placed on them may change over time (Smith 1988).

The Desired Plant Community approach appears to be compatible with the concepts of multiple steady states and state-and-transition models and should be seriously considered as a method for addressing multiple use and ecosystem management objectives. Basic and applied research will be needed to provide the theoretical basis for the principle of "sustainability" as is implied in the term "Site Conservation Threshold", and to develop practical procedures for application.

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