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Biodiversity as a facet of rangeland research

William C. Krueger
Departments of Rangeland Resources, Oregon State University, Corvallis

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William C. Krueger
Professor and Head
Department of Rangeland Resources
Oregon State University
Corvallis, OR 97331

Abstract

Biodiversity is only partially a scientific issue. Philosophical and political value systems drive much of the debate and action. Better science would, however, help expose much of what is presently intuitive but may be false. A topic upon which range scientists have much to contribute is how plant diversity relates to successional status of woodlands, grasslands, shrub steppe, and deserts. Correspondence of vegetational change to animal habitats and soil erosion follows. Closer monitoring of large blocks of land under multiple use could lead to a blending of research with management. Definitive understanding of mechanisms will, however, require well-designed manipulated experiments with adequate controls maintained over longer time spans than has been the case in the past.

There are many facets to the concept of biological diversity that relate to range management. These include ethics, aesthetics, economics, values, politics, and ecological science. Managers must deal with both the abstract and unmeasurable facets of biological diversity, such as ethics, at the same time that they make decisions based on measurable ecological effects.

Much of the published information regarding biological diversity is speculative. For example, Paulson (1992) suggests that "the constant diminution of neotropical forest habitats will surely cause declines in populations of eastern migrants if it has not done so already." The purpose of many writings is presumably to support the opinions or value systems of the author. Ecocentric views dominate the literature and place high value on biodiversity as a right unto itself. Conversely, anthropocentric views, though less common in the biodiversity literature, promote biodiversity as a good to serve the interests of mankind. These views contribute to the politics of biodiversity that promote a variety of actions based on philosophy that sometimes masquerades as science. To a large degree, the current biodiversity debate is a political struggle with its basis in philosophy.

Despite the highly politicized atmosphere promoting biodiversity, there is a scientific component; and rangeland research has and should increasingly contribute to understanding the concepts embodied in the scientific portion of the biodiversity debate. West (1993) and the papers in this volume present an excellent review of the biodiversity of rangelands. They point out the varied reasons biodiversity should be of concern from ethical to ecological perspectives. The papers in this volume have added substantially to Cooperrider's (1990) treatise on rangeland biodiversity, which emphasized management, awareness, and governmental programs.

[1]See, however, Moir and Bonham, this volume.

The limited research, or interpretation of research, in the context of current theories of biological diversity results in a conservative view of ecological robustness in terms of diversity. As research continues, and even as old data sets are reevaluated, the importance of various components of diversity will be clarified. At the same time, we will be clarifying ecological theory as the framework within which we understand interaction of organisms and their environment.[1]

ASSUMPTIONS

The prevailing view of succession in our discipline is that succession is linear with given end points. To the extent that this is valid, we can show the orderly change in species abundance; and we can relate the changing diversity of increasers, invaders, decreasers, and various biological-diversity indices to what we call range condition. To the extent that linearity is not the principal mode of succession and that rangelands function more like a state and transition model, traditional measures of biological diversity will not necessarily reflect potential change.

We assume that high genetic diversity will lead to highly stable populations. Though the logic is clear, the experimental evidence is lacking.[2] Species richness is the aspect of diversity most often measured. Is this because it is the most meaningful attribute of diversity or simply because it is easily measured? We assume animal preference for specific sites or ecological structure is a measure of habitat requirements. So many ideas are seductive in their logic that most of us accept them with little question. Yet as we study nature, we discover that natural systems are more complex than we imagined; feedback and compensatory mechanisms add incredible stability to processes, and often our assumptions are invalid.

[2]See McArthur and Tausch, this volume.

RESEARCH AREAS

THRESHOLDS

Sustainability or stability of ecosystems is often our goal, and research should be conducted to define how ecological structure and processes relate to sustainability. Stability needs to be defined in spatial and temporal terms that may include significant fluctuation. For example, stability of a shrub-steppe ecosystem may require periodic fire and wide fluctuations in density and cover of shrubs. To prevent the fluctuation of shrub density may force the ecosystem across a threshold into a new state because of soil loss due to an excessive shrub component and limited herbaceous layer. Thus, stability of the site and its original soil is lost; similarly, the vegetation is not sustainable.

We need to understand clearly ecological threshold levels where induced or natural stresses cause permanent change in an ecological state and consequently in biodiversity. These processes will most likely be complex with a myriad of interactions as redundancy and compensation act to prevent a change in state.

SPECIES

Much is written about species in the biodiversity literature. Keystone species are those that have a disproportionate influence on ecosystem function or structure in relation to their abundance (Westman 1990). Other species' roles include critical-link species that play a crucial role in ecosystem function. West (1993) gives a thorough discussion of species roles in ecosystem stability, but West and Whitford have revisited that topic again in this volume and point out that much more definitive work remains to be done on this very important topic.

The role of rangeland species needs careful study to determine the extent to which one species can substitute for another. What are the keystone and other critical species, if any? Are species groups more important than individuals? Under what circumstances can alien species substitute for native species and maintain ecological processes?

The literature and especially the files of range scientists are rich with data on species abundance on the same and similar sites as well as under the same or similar management. A new analysis and interpretation of these data could help in understanding many questions about the role and substitutability of species in evaluating biological diversity. This analysis might also help define the data quality needed to make valid inferences about changes in biological diversity.

SPECIES GROUPINGS AND ENVIRONMENT

Communities, ecosystems, landscapes, and regions are increasingly broad groupings of organisms and their environment. Interaction of a multitude of species, soils, weather patterns, aspects, elevations, and land use results in significant spatial and temporal variation. A logical, though largely assumed, deduction is that biodiversity buffers changes at all levels under great annual variation and decidual, centennial, and millennial extremes.

Management at all scales depends on understanding the nature of ecosystem structure and function under natural and induced stresses and the interrelationships of different ecosystems at landscape and regional scales as they relate to biological diversity. Little work has been done on rangeland systems at landscape and regional scales. Consequently, the current approach is to assume theory developed on isolated and mesic ecosystems is applicable to rangeland systems in drier environs. This assumption is likely to prove incorrect as information is gathered. As West (1993) indicated, the best way to maintain biological diversity at all scales is to maintain ecosystem integrity. Sustaining this integrity especially means maintaining soil characteristics and ecosystem processes.

Determining when a change in ecosystem state is inevitable due to stresses like species invasions, weather changes, pollution, or other factors is important. If we can predict the inevitability of changes, we can learn to manage the new ecosystem, landscape, or region and not expend energy in futile attempts to change natural or irreversible processes.

It may be feasible to maintain a sustainable ecosystem by focusing management on maintenance of ecological processes with little concern for biological diversity. In this case, ecosystem function would be the key to maintaining a healthy and sustainable landscape and region. To the extent species can substitute or compensate for one another, this becomes a feasible option.

These topics require long-term study. In most cases, at least a decade is required to even experience a normal amount of variability in weather. It is unusual for management to be sustained unchanged for this long, and other natural events will also vary. We need to look at ways of objectively measuring factors we believe to be important today in evaluating biological diversity and sustainability. At the same time, we must maintain flexibility in experimental design to add factors as our vision improves and as we change levels or practices of management in response to ecological change. The statistical considerations of work on this scale will require intense scrutiny of assumptions in the analyses. Modeling will be a major tool used to develop theory in these areas. However, some level of empirical validation will be necessary to accept output of theoretical models. State and federal experimental ranges are important sources of long-term databases where treatments have been maintained for long periods. There is no substitute for long-term empirical data sets that incorporate large-scale landscapes and actual responses to environmental variation. The temptation to make sweeping assumptions will be great and needs to be resisted as much as possible. Once we accept an assumption and it becomes a component of our landscape paradigm, it is difficult to accept an alternative explanation of a phenomenon. For example, if we believe protection from all disturbances will yield a climax of a specific type in the sagebrush steppe, we miss the opportunity to understand that the vigor in ecological processes and soil building may *depend* upon disturbance. If we believe maximum species diversity is the measure of health, we may overlook the possibility that fewer species in specific functional groups may be more important to maintain the functioning of the system than high-species richness.

Because so little is known about sustainability, we need to keep our minds ready to accept results of objective science as it develops. A major part of every landscape or regional-level study should be to recognize and evaluate the assumptions and the quality of the data collected. Once this is accomplished and standards for biological diversity measures are defined, we can develop effective monitoring procedures.

CONCLUSION

Biological diversity has been a central theme in range science since the discipline was first organized. Current ideas and theory in a variety of ecological subdisciplines are emphasizing the need to preserve diversity for many reasons. The importance of preserving diversity is especially applicable in the extreme cases where ecosystems or species are minimized unnecessarily. Also, considering the broad scale, the interrelationships of all levels of ecological organization are intuitively important.

At the operational level, where species, communities, ecosystems, landscapes, and regions interact under normal circumstances, the predictability of science is limited. The details of ecosystem management from soils to species, guilds, functional groups, and processes are largely based on experience and theory. Using the ideas generated by current understanding of biological diversity, the range research community can add substance by addressing these ecological issues in a new way and at new scales to define procedures that will improve landscape management.

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