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Using Ecological Site Information to Improve Landscape Management for Ecosystem Services

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On the Ground

- Ecological sites and their component state-and-transition models are valuable tools for predicting the effects of climatic and management changes on a variety of ecosystem services.
- Site-specific information must be able to be both refined to finer scales to account for spatiotemporal variability within a mapped site and expanded to include interactions with other sites in the landscape to identify priorities and account for integrative disturbances and ecosystem services such as wildlife habitat, hydrology, fire, insect outbreak and invasive species.
- Ecological site groups, spatially contiguous and behaviorally similar, are an important level in the land hierarchy to organize and interpret information.

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People, and their societies, have a complicated relationship with land. The unofficial patron saint of ecologists, Aldo Leopold, in "The Sand County Almanac," traced the modern human relationship with land from a purely economic to an ecologically based approach, culminating in his "Land Ethic."[1] In this ground-breaking and influential essay, Leopold proposed that "a land ethic changes the role of *Homo sapiens* from conqueror of the land-community to plain member and citizen of it." The main idea embodied in this essay was that good land management was an individual and community responsibility that transcended pure economics. While Leopold focused primarily on the cooperative nature of the human relationship to land, a secondary, but just as important, part of the essay was that "The land ethic simply enlarges the boundaries of the community to include soils, waters, plants and animals, or collectively, the land."

Whether explicitly stated or not, "The Land Ethic" has become the basis for most modern conservation efforts, both through the ideas of *sustainability* as an individual and collective ethical commitment, but also in the inclusion of diversity in products and processes that go beyond commodities.[2] It has provided a foundation for the ideas of ecosystem services by expanding the benefits of nature to human communities.[3] By going beyond the traditional provisioning (food, fuel, fiber) services to also include regulating (control of climate and disease), supporting (nutrient cycles, pollination), and cultural (aesthetics, recreation, spiritual) services, the modern ecosystem services approach is both a way to incentivize more sustainable management and to communicate to humans their connection to the natural world.[4] While a reasonable argument could be made that Leopold did not have the "commodification of nature" in mind, there is no doubt about the connections.

One clear benefit of an ecosystem services approach to land management is the realization that there are no nonworking lands. Everything is managed to achieve some sort of societal benefit. Even "wildlands" have guidance for management (Wilderness Act of 1964). In most cases, the luxury of managing land for a single commodity output is not available. Even the most intensively farmed croplands have to be managed to ensure some level of sustainable yield. At the other end of the spectrum, completely protected lands require some kind of extensive management and are frequently surrounded by lands managed at different degrees of intensity (e.g., the Greater Yellowstone Ecosystem).

Thus, the ecosystem services model has expanded to include virtually all types of land and land management. The idea that all land is, to some degree, working land and requires at least strategic management is pretty easy for practicing rangeland managers to accept; the expansion to products and processes beyond immediately marketable commodities is

more difficult. Making those connections more tangible and transparent is what Ecological Sites are for. In this issue, multiple papers (*see Salley et al., Karl and Talbot, Bestelmeyer et al., this issue*) address the framework for connecting ecological process and pattern, while others (the case studies) provide interpretations of those patterns and processes to address emerging conservation issues. The purpose of this paper is to explicitly define the necessary requirements of a system that provides those tangible and transparent connections so that scientists, managers, policymakers, and an interested public can see specifically how landscapes can be managed to achieve a range of objectives. The fact that there is frequently an overwhelming lack of agreement on what those services should be is not considered in this paper, but there are techniques and proven applications for making those decisions as well.[5]

For ecosystem services to provide an incentive for land managers to adopt improved practices, there has to be some motivation. For the purposes of this discussion, we will rule out regulations and legal pressure as incentives. In the voluntary realm, if the ecosystem service has a well-developed market (i.e., beef, wool, fuel), relationships between land manager actions and price are relatively reliable. While government conservation programs track payments and activities closely, there is a decided lack of standardized methodology for determining the relationship between landowner actions and the resulting non-commodity ecosystem services.

In this paper, we propose that ecological sites and their supporting information can be the basis for developing more quantitative and transparent relationships between incentives, whether public or private, land owners actions, ecological processes, and, ultimately, ecosystem services. This is not a new issue. DeGroot et al.[6] provides a comprehensive list of 23 different ecosystem services, but also points out that a standardized methodology to account for these benefits, assess tradeoffs, and provide a basis for markets is lacking. Recent critiques of ecosystem service markets are evidence that more specificity in definitions and rules, as well as in project level applications, could be improved, especially in terms of improving links to land management and science.[7]

A Systematic Approach to Ecological Sites for Ecosystem Services

We believe that there are three principles that a systematic approach to ecological site information should follow to ensure transparency, accuracy, and consistency.

Account for Everything, Including Interactions

A consistent hurdle in the development of a framework that will increase the use of ecosystem services to broaden incentives for management action is the inability to integrate across scales. While some land units (and landowners) may opt to manage for a particular ecosystem service (say, water quality), others within the same watershed or basin may focus their management efforts on production of commodity grains. The grain producers, depending upon where their land is located within the watershed, may or may not have influence on water quality. These complex, spatially explicit relationships require baseline information and models that can integrate across multiple spatial scales to insure cost-effective policy implementation.[8] In this special issue of *Rangelands*, the case study by Spiegal et al. similarly identifies critical landscape components (ecological site groups) that should be the focus of management for an endangered species, but also acknowledges the important context of surrounding sites. The selection of critical sites for either water quality or habitat management is impossible without knowledge of the interactions among sites and how the ecological process(es) of interest integrate those sites. Incomplete or inconsistent information about ecological sites within a landscape makes it difficult to predict across scales, and more importantly, to convince, through various incentives, land managers of their role in managing landscapes for ecosystem service goals.

Ecological sites (especially in the United States), as a derivative of the modern soil survey approach, have suffered from the tendency of mappers to view landscapes as collections of polygons. This approach has led to an overemphasis on what makes soils/sites different and how can they be distinguished, described, and archived in a defensible manner. The outcome has been the overemphasis on some sites, based on areal extent, productivity or accessibility, and an underemphasis on interactions among sites. The map-making approach has also led to a fixation on differentiating the polygons, both spatially and in terms of describing their inherent properties (*see Karl and Talbot, this issue*). These point and polygon scale rules for differentiating pieces of land have made the bookkeeping and programmatic parts of conservation easier, but treating the landscape as a collection of non-interacting polygons has not contributed greatly to more stable, diverse, and productive landscapes.[9]

Provide Compatible, Consistent Information, Including Tradeoffs

The father of modern soil conservation, Hugh Hammond Bennett, founded an entire movement based on some key social and ecological principles. His central belief, "use every acre within its capability and treat it according to its needs," provided the basis for a variety of soil and land classification schemes, as well as a conservation philosophy.[i] Our expanding expectations of what ecosystem services we require from land, as well as our evolving understanding of ecosystem function, has moved us away from a precise definition of "best use" of Bennett's early 20th century to a more modern, multidimensional approach to both what we expect from working lands and how we treat them.[10]

The idea of multiple potential stable states, multiple unidirectional pathways, and multiple ecosystem services has had a profound effect on all land management, but especially rangelands. Managing land without intensive inputs requires a much more refined and nuanced understanding of ecological processes, especially how extensive management practices and ecological processes can interact over relatively minor changes

[i] Read more about Hugh Bennett at http://www.nrcs.usda.gov/wps/portal/nrcs/detail/nc/newsroom/features/?cid=nrcs142p2_046733.