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Ecological services to and from rangelands of the United States

Kris M. Havstad^{a,*}, Debra P.C. Peters^a, Rhonda Skaggs^b, Joel Brown^c,
Brandon Bestelmeyer^a, Ed Fredrickson^a, Jeffrey Herrick^a, Jack Wright^d

^aUnited States Department of Agriculture, Agricultural Research Service, Jornada Experimental Range, Las Cruces, New Mexico, USA

^bDepartment of Agricultural Economics and Agricultural Business, New Mexico State University, Las Cruces, New Mexico, USA

^cUnited States Department of Agriculture, Natural Resources Conservation Service, Jornada Experimental Range, Las Cruces, New Mexico, USA

^dDepartment of Geography, New Mexico State University, Las Cruces, New Mexico, USA

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ABSTRACT

The over 300 million ha of public and private rangelands in the United States are characterized by low and variable precipitation, nutrient-poor soils, and high spatial and temporal variability in plant production. This land type has provided a variety of goods and services, with the provisioning of food and fiber dominating through much of the 20th century. More recently, food production from a rangeland-based livestock industry is often pressured for a variety of reasons, including poor economic returns, increased regulations, an aging rural population, and increasingly diverse interests of land owners. A shift to other provisioning, regulating, cultural, and supporting services is occurring with important implications for carbon sequestration, biodiversity, and conservation incentives. There are numerous goods and services possible from rangelands that can supply societal demands such as clean water and a safe food supply. The use of ecologically-based principles of land management remains at the core of the ability of private land owners and public land managers to provide these existing and emerging services. We suggest that expectations need to be based on a thorough understanding of the diverse potentials of these lands and their inherent limits. A critical provisioning service to rangelands will be management practices that either maintain ecological functions or that restore functions to systems that have been substantially degraded over past decades. With proper incentives and economic benefits, rangelands, in the U.S. or globally, can be expected to provide these historical and more unique goods and services in a sustainable fashion, albeit in different proportions than in the past.

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1. Introduction

Rangeland is a type of land found predominantly in arid and semi-arid regions that is managed as a natural ecosystem supporting indigenous vegetation, predominately grasses, grass-like plants, forbs, or shrubs (Stoddart et al., 1975). In the United States, there are approximately 308 m ha of rangeland, about 31% of the total land area. This land type

provides a multitude of goods and services not only to rural populations, but also to tens of millions of people in large urban areas located within or among rangelands. These services include food, fiber, clean water, recreational space, minerals, religious sites, and sources of natural medicines. The purposes of this paper are to: (1) describe the salient features of these lands, (2) characterize their present ownership and traditional services, (3) examine key emerging goods

* Corresponding author.

E-mail address: khavstad@nmsu.edu (K.M. Havstad).

URL: <http://usda-ars.nmsu.edu> (K.M. Havstad).

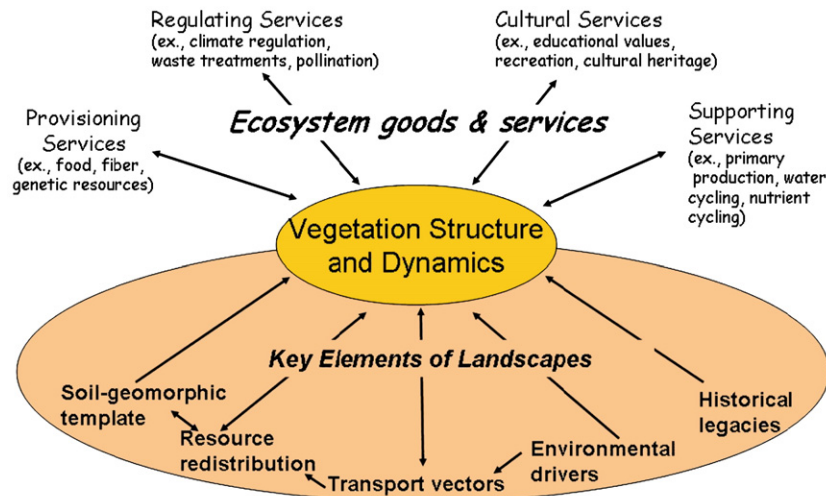


Fig. 1 – Five key elements of rangeland landscapes interact to determine vegetation structure and dynamics with resulting effects on ecosystem goods and services: (1) historical legacies of past climate, disturbances, and human activities, (2) environmental drivers, (3) transport vectors, such as the run-on and run-off of water during extreme rain events, (4) redistribution of resources, such as soil, nutrients, and seeds, (5) the soil-geomorphic template (after Peters et al., 2006).

and services that rangelands may provide, and (4) detail necessary steps, including incentives, required for a sustained delivery of any rangeland-based goods and services.

1.1. Important characteristics of rangelands

Rangelands are characterized by four important features which strongly influence their ability to provide goods and services. First, most rangelands are limited by water and nutrients, primarily nitrogen (N) (Hooper and Johnson, 1999). Long-term average annual precipitation is low and variable (300–500 mm/yr for semi-arid regions and <300 mm/yr for arid regions), and evaporative demand is high, often at least 95% of annual rainfall (Nicholson, 1999). Water limitation is further compounded by, and often coupled with, nutrient-poor soils. For example, N content of arid rangeland soils is often only 0.1% (Gallardo and Schlesinger, 1992), and net primary production from US rangeland averages ca. 160 g/m²/yr (Huenneke and Schlesinger, 2006).

Second, tremendous temporal and spatial variability in production characterizes these ecological systems (Lieth, 1975). Seasonal and annual variation in production is a widely recognized feature given that failure to adjust management in response to extremely low production during drought was a major contributor to land degradation in the US at the end of the 19th century (Wootton, 1908; Fredrickson et al., 1998). Given the tremendous heterogeneity in soils, landforms, and climate that occur across these landscapes, spatial variation in productivity can also be substantial (Herbel and Gibbens, 1996). Collectively, spatial and temporal variation has resulted in reports of 10-fold differences in production across years within a site and across sites within years (Ludwig, 1987).

Third, U.S. rangelands are an amalgamation of public and private ownership. For example, approximately 50% of the lands in the 14 western states are in public ownership that spans federal, state, and local governments, and a multitude of agencies and departments within those governments. In

turn, these public lands indirectly influence management of private lands (Dale et al., 2000). The resulting diversity in jurisdictions, property rights, legal responsibilities, management objectives, strategic plans, and fiscal constraints has been constraining cohesive management for over two centuries. This aspect of the complexity of these landscapes is increasingly central to any discussion about the realistic capacity for rangelands to provide goods and services on a sustained basis.

Fourth, rangelands are uniquely coupled systems of both people and nature, and are commonly viewed as both complex and adaptive (Walker and Janssen, 2002). This uniqueness stems from the overriding importance of inherent ecological constraints in the management of rangelands. Dale et al. (2000) described five key ecological principles that should underlie the management of these natural landscapes: 1) processes occur within a temporal setting, 2) species can have strong effects on processes, 3) sites have unique organisms, abiotic conditions, and ecological processes, 4) disturbances are important events, and 5) landscapes affect the structure and function of local ecosystems. We have integrated these principles and complexities into a conceptual framework containing five interacting elements that both characterize the dynamic nature of rangelands and their capacity to provide goods and services, as described by the Millennium Ecosystem Assessment (2005; see Fig. 1).

Each element of our framework can directly or indirectly influence ecosystem structure and dynamics with consequences for ecological goods and services. The relative importance of these elements to ecosystem goods and services can vary in both time and space for the same system as well as among systems. In rangelands, provisioning services include food, fiber, and genetic resources, regulating services include water and air quality, cultural services include educational values and recreation, and supporting services include primary production, water and nutrient cycling.

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