

Rangeland ecosystem services: shifting focus from supply to reconciling supply and demand

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Ecosystem services have been extensively studied in recent decades. Most of the thousands of scholarly papers published on the subject have focused on describing the production, spatial extent, and valuation of such services. Human reliance on ecosystem services is a function of ecosystems' capacity to supply and societal demand for these benefits. However, considerably more attention has been devoted to the supply side than to the demand for them. Sustainable land management depends on reconciling supply of and demand for ecosystem services among different stakeholders. The emphasis is now shifting from the supply of ecosystem services to attaining a balance between supply and demand. Here, we illustrate the demand for rangeland ecosystem services, describe current changes in societal demand, and present a specific provisioning service to exemplify the dynamic nature of reconciling ecosystem-service supply and demand.

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The concept of ecosystem services – the benefits that society receives from ecosystems (Daily 1997) – has been the subject of considerable attention in recent years, but most studies to date have focused on the supply (Sala and Paruelo 1997; Havstad *et al.* 2007; Carpenter *et al.* 2009; Raudsepp-Hearne *et al.* 2010) and valuation (Costanza *et al.* 1997; Gómez-Baggethun *et al.* 2010) of such services. However, human use of ecosystem services depends on both the capacity of the landscape to supply, and on societal demand for, these resources (Tallis and Polasky 2011).

In a nutshell:

- The value of rangelands depends on both their ability to supply ecosystem services and society's demand for such services
- Traditional research on ecosystem services has focused on the capacity of ecosystems to supply services, but recent emphasis has shifted to ensuring that supply meets or exceeds demand
- Societal demand for ecosystem services provided by rangelands has diversified in the past decades, transitioning from demand primarily for provisioning services to now commonly including regulating and cultural services
- Demand depends on income, place of residence, and level of education – variables that are under constant and rapid change
- Land-use decisions reflect balances between the supply of ecosystem services and multiple demands by stakeholders, weighted by their political power

Human demand is related to the social beneficiaries, and represents the other side of the ecosystem-services equation. Demand for specific ecosystem services varies among stakeholders (the individuals or groups who benefit from and/or have an active or passive influence on the delivery of these services; Lamarque *et al.* 2011). The demand may be described by the location, type, and intensity of requirement for services. Only a few studies have addressed the demand for ecosystem services besides provisioning services, and these have focused mainly on the perception of ecosystem services by different stakeholders (de Chazal *et al.* 2008; Quétier *et al.* 2010; Martín-López *et al.* 2012). Stakeholders vary in both their demand for and valuation of different ecosystems services.

A new approach is to shift attention from supply and focus on demand relative to the available supply. This transition is important because a major focus of land management is implementing practices to ensure that supply meets or exceeds demand. Ecosystem services, such as clean drinking water, are provided regardless of whether those specific services are used, and demand for ecosystem services may also exist independently of the supply. Demand and supply can also overlap, resulting in use of that ecosystem service by society (Table 1).

Rangelands are defined as “the land on which the potential native vegetation is predominately grasses, grass-like plants, forbs or shrubs” (Kauffman and Pyke 2001). Rangelands produce a great variety of ecosystem services, including the provisioning of food and fiber, carbon sequestration, maintenance of biodiversity (conservation), and recreation (Sala and Paruelo 1997). Globally, rangelands occupy approximately 54% of terrestrial ecosystems and sustain 30% of the world's population (Reynolds *et al.* 2007; Estell *et al.* 2012), including a variety of stakeholders (eg farmers, tourists, conservation-

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ists). As such, rangelands are among the more interesting systems in which to analyze the balances between supply and demand of various ecosystem services.

In this article, we (1) characterize the demand for rangeland ecosystem services; (2) evaluate changes in the types and quantities of services required, and how these are affected by socioeconomic characteristics; (3) use a specific provisioning service as an example of the dynamic nature of reconciling supply and demand; and (4) describe land use as a function of ecosystem-service supply and demand, and the political influence of the stakeholders, given that different stakeholders differentially affect societal decisions.

■ Supply and demand for ecosystem services

Substantial variation in supply and demand has been observed within and between the four different types of ecosystem services (provisioning, supporting, regulating, and cultural, as defined by the Millennium Ecosystem Assessment [MA 2005]; see also Table 1). Provisioning services are the products – such as food, fiber, fuel, and fresh water – obtained from ecosystems. The relationship

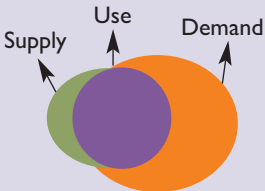
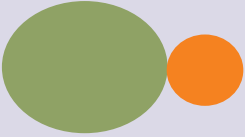


between supply and demand for provisioning services varies by region and by the specific products (Tilman *et al.* 2011). Demand for some provisioning services – most notably fresh water and specific foods – often (and increasingly) surpasses supply (Table 1).

Supporting services – including biodiversity and nutrient cycling – are essential to other ecosystem services, influencing the supply of provisioning, regulating, and cultural services (Vitousek *et al.* 1986; MA 2005). At the global scale, the supply of supporting services is higher than the demand, and human use does not apply because, by definition, supporting services are not directly used by people (Table 1).

Regulating services are the benefits that stem from regulating ecosystem processes, such as climate regulation, air-quality maintenance, water purification, and erosion control. The demand for these services is higher than the supply, meaning that use is typically equivalent with supply (Table 1); for example, the amount of carbon sequestered to offset atmospheric greenhouse-gas emissions does not match current emission levels.

Cultural services – including cultural diversity, spiritual and religious values, knowledge systems, and recreation –

Table 1. Hypotheses about ecosystem-service supply (green), use (purple), and demand (orange) for the four classes defined by the Millennium Ecosystem Assessment (MA 2005)

Ecosystem-service type	Supply	Use and value*	Demand
Provisioning 	Production of forage (kg dry matter yr ⁻¹ ha ⁻¹)	Livestock production (kg meat yr ⁻¹ ha ⁻¹); value of livestock production (\$ per ha)	Livestock production to satisfy human food demand (kg meat yr ⁻¹ ha ⁻¹)
	Water supply for irrigation (water yield, mm yr ⁻¹ ha ⁻¹)	Water used for irrigation (mm yr ⁻¹ ha ⁻¹); additional crop productivity due to irrigation (\$ per ha)	Estimated irrigation needed for forage production (mm yr ⁻¹ ha ⁻¹)
Supporting 	Habitat quality – habitat rarity (score 0–5)	Non-consumptive value	Desired habitat quality
	Biodiversity (number of species per ha; number of species with conservation value per ha)	Non-consumptive value	Biodiversity under pristine conditions (number of species per ha)
Regulating 	Carbon sequestration and storage (kg C ha ⁻¹)	Carbon sequestration (kg C ha ⁻¹ , ie supply); social cost of carbon and value of avoided damage (\$ per Mg of C); market price for carbon	Carbon storage and sequestration to compensate carbon emissions and regulate climate
Cultural 	Recreation and ecotourism	Services co-produced by ecosystems and people, such as art inspired by nature; value is based on the value of the experiences	Demand varies among stakeholders (see Figure 3)

Notes: *The value of the ecosystem service refers to the social value, ie the total value it offers to society, as opposed to the value it offers to the owner of the service-providing land. Modified from data in Carpenter *et al.* (2009). Examples of supply, use, value, and demand are given as they apply to rangeland ecosystems.

are the non-material benefits that humans obtain from ecosystems. For some services (eg aesthetic value), the potential and realized supply are indistinguishable; for others (eg recreation), we speculate that demand exceeds supply in some regions of the world, while the opposite may be true elsewhere (Table 1).

The supply of and demand for ecosystem services vary between spatial scales. Some ecosystem services are delivered at the local scale (eg pollination, soil fertility) whereas others are global (eg carbon storage); spatial mismatches between those who control the provision of ecosystem services (eg supply of drinking water in an agricultural area) and those who benefit from the services (eg inhabitants of a small town in the watershed) may also occur. In addition, some ecosystem components are multifaceted, in that they encompass more than one type of ecosystem service. Water in arid regions, for example, is a supporting service (water controls primary productivity and forage production), provisioning service (as drinking water or for use in irrigation), and regulating service (the water cycle is tightly linked with climate regulation). Finally, many ecosystem services produce multiple, intertwined values (Bennett *et al.* 2009); some may provide benefits to a multitude of stakeholders, whereas others may benefit only a few.

■ Quantifying demand for ecosystem services

Demand for ecosystem services has received less attention than estimates of supply and is typically determined by estimating the depletion of a service, particularly in food production (Tilman *et al.* 2011). Surveys of stakeholder preferences through questionnaires and interviews are one common approach for assessing the level of demand for different ecosystem services. Social surveys typically explore social preferences and perceptions of ecosystem services (Lamarque *et al.* 2011; Martín-López *et al.* 2012), allowing respondents to identify services spontaneously; alternatively, ranking exercises present a list of services that respondents are asked to arrange by perceived value (Lamarque *et al.* 2011). During social surveys, more “visible” or “obvious” services, such as recreation, aesthetics, and natural hazards regulation, are commonly identified, while ranking exercises allow more “invisible” services, such as pollination and soil fertility, to emerge (Lamarque *et al.* 2011). An additional approach for identifying preferences for ecosystem services is to use non-market valuations, such as “willingness to pay” for maintaining ecosystem services.

■ Demand for ecosystem services from rangelands

Rangelands include prairies, marshes, tundra, wet meadows, savannas, shrubland steppe, chaparral, desert grasslands, and woodlands (Kauffman and Pyke 2001), and produce a wide diversity of provisioning, supporting, regulating, and cultural services (Sala and Paruelo 1997). As

such, rangelands are ideal for analyzing the balance between supply and demand for different types of services. In contrast, hyperarid ecosystems provide supporting, cultural, and regulating services but few, if any, provisioning services, and humid ecosystems are generally transformed into crop- and wood-production landscapes at the expense of cultural (including recreation) services. Rangelands, on the other hand, offer a wide variety of ecosystem services that are valuable to many different stakeholders. In addition, rangelands are broadly threatened ecosystems and are often undervalued as providers of ecosystem services. For instance, in a study of sociocultural preferences toward services delivered by different types of ecosystems, rivers and streams, drylands, and urban systems scored significantly lower than forests, wetlands, and coasts in terms of their capacity to supply services (Martín-López *et al.* 2012). Some semi-arid ecosystems are particularly susceptible to overexploitation because of recent increases in intensive agriculture and tourism (Castro *et al.* 2011). In some areas, society perceives nature conservation as a threat to human development (Tschakert 2007). Although stakeholder perceptions of ecosystem services have been formally assessed in studies, only a subset of these have concentrated on rangeland settings (Zhen *et al.* 2010; Castro *et al.* 2011).

Beneficiaries of rangeland ecosystem services include individuals, commercial entities, and the public sector. In addition, beneficiaries may be grouped across local, regional, and global scales (Newcome *et al.* 2005). For instance, US rangelands are an amalgamation of public and private ownership; approximately 50% of the lands contained within the 14 western US states are publically owned lands administered by federal, state, and local governments (Havstad *et al.* 2007). Such a complex landscape of jurisdictions, property rights, legal responsibilities, management objectives, strategic plans, and fiscal constraints highlights the issue of trade-offs between different uses. If people’s known preferences for services can be expressed accurately using comparable metrics, then decision making would be, at least conceptually, straightforward and would involve a simple cost–benefit calculation (Carpenter *et al.* 2009).

We identified the beneficiaries or stakeholders and the main ecosystem services valued by each of these groups for rangelands (WebTable 1). Demand may differ even among similar groups, for instance between farmers and land tenants. While both farmers and land tenants demand forage supply for livestock production, farmers also demand regulating services to sustain forage production over the long term, whereas tenants are focused on the short-term benefits of forage production (WebTable 1). Similarly, among tourists, we can distinguish between the demands of passive nature tourists (visitors who do not partake in recreational activities but stay in hotels close to natural areas) and active nature tourists (visitors who actively engage in recreational activities, such as backpackers, photographers,

birders and other wildlife observers, hunters, equestrians, mountain bikers, climbers, and hikers; WebTable 1). Active tourists and environmentally aware local residents were found to have a comparatively high level of understanding regarding the delivery of ecosystem services, including recreational and aesthetic factors, but also air quality, water quality, and biodiversity conservation (Castro *et al.* 2011). In contrast, local workers – who were the least environmentally aware group examined by Castro *et al.* (2011) – perceived mostly cultural services and those provisioning services related to altered ecosystems (eg agriculture and forest products) as having the highest values.

As demonstrated above, the demand for ecosystem services is complex and the classification of service beneficiaries, who often vary in their ecosystem-service preferences, can be a useful tool for identifying potential trade-offs and for balancing multiple, often conflicting, demands for services. The issue of motorized recreation on public lands serves as an example, as it demonstrates the need for trade-offs between stakeholders who want motorized access rights and stakeholders who are more interested in the protection of wilderness areas (BLM 2014). Legal precedents, user rights, land impacts, and concerns about the future form the basis of opposing positions and the conflicts that arise. Comparisons of the demand for ecosystem services should enable a better understanding of the trade-offs among different activities and help establish management priorities.

■ Recent changes in demand for rangeland ecosystem services

The provision of goods such as food, fiber, and wood has long been recognized as the primary value of rangelands (Havstad *et al.* 2007). A strong historical emphasis on provisioning services in land-use planning is likely related to their tangible societal value. However, a shift has recently occurred in the societal demand for ecosystem services from rangelands. By studying sociocultural preferences toward ecosystem services delivered by different arid and semi-arid ecosystems, Martín-López *et al.* (2012) determined that people now value regulating and cultural services more than provisioning services. Carbon sequestration, for example, is a service for which demand is increasing because of growing concerns about climate change, and a service that rangelands have considerable potential to supply (Poulter *et al.* 2014). Similarly, the conservation value of rangelands has increased as extinction threats become more conspicuous, while soil erosion and nutrient retention are gaining in importance in light of an increasing awareness of large-scale conversion of grasslands to croplands and grassland degradation. Evidence of the impact of plant cover on air temperature and regional climate has focused attention on the effects of arid ecosystems on the amelioration of weather. Although fuel-wood production is not in very high

demand in North America, it is critical in parts of the world where this is the main source of energy. Finally, the values of tourism, recreation, and other cultural services are increasing.

As negative environmental impacts of human activities become more prevalent, individual perceptions of the value of certain services, such as air and water quality, and the importance of conserving biodiversity, are changing. For instance, in a survey conducted in Spain that included randomly selected individuals over 18 years old, and covering a wide range of ecosystem services beneficiaries such as local inhabitants, visitors, and environmental technical experts, the social perception of regulating services was found to be the most prominent (44% of total respondents), followed by cultural (33%) and provisioning services (23%) (Martín-López *et al.* 2012). When respondents were asked to identify the relative importance of particular services, more than 40% identified air purification, the intrinsic value of biodiversity, and nature-based tourism as the most important services (Martín-López *et al.* 2012). Fewer respondents recognized the role of ecosystems as providers of forage for cattle (23% of respondents) or hunting as a recreational activity (11%). While important to some stakeholders, livestock grazing now competes with alternative ecosystem services, given that other industries and the general public view public lands primarily as sources of conventional and renewable energy, and as locations for outdoor recreational opportunities (BLM 2014). Demand for tourism and recreation increased over the same time period, as determined by the growing number of visitors, hunters, and wildlife-watchers in the public lands and national parks of the arid states of the American West (Figure 1; Cordell 2012). National trends reflect the shift in public perception; data collected via the US Department of Agriculture's National Survey on Recreation and the Environment (NSRE) revealed that there is an increasing demand for recreational uses of public lands in the US. For all lands managed by the Bureau of Land Management (BLM), the number of visitors who participate in recreational activities increased by approximately 17% (from about 77 to 90 million individuals) between 1996 and 2011 (BLM 2014). Particularly in the western US, participation rates increased for a range of activities, including bicycling (31% to 43%), day hiking (23% to 46%), and backpacking (9% to 16%), between 1982/1983 and 2000/2001 (NSRE 2002). In addition, the demand for recreation services increased between 2000 and 2010, as can be seen by the changes in participation in hunting and other wildlife-related recreation (Figure 1). The relative importance of provisioning versus regulating and supporting services has shifted in recent decades, as demand for recreation services increased (Figures 1 and 2).

Changes in the relative demand for provisioning versus recreational services in the ten most arid US states

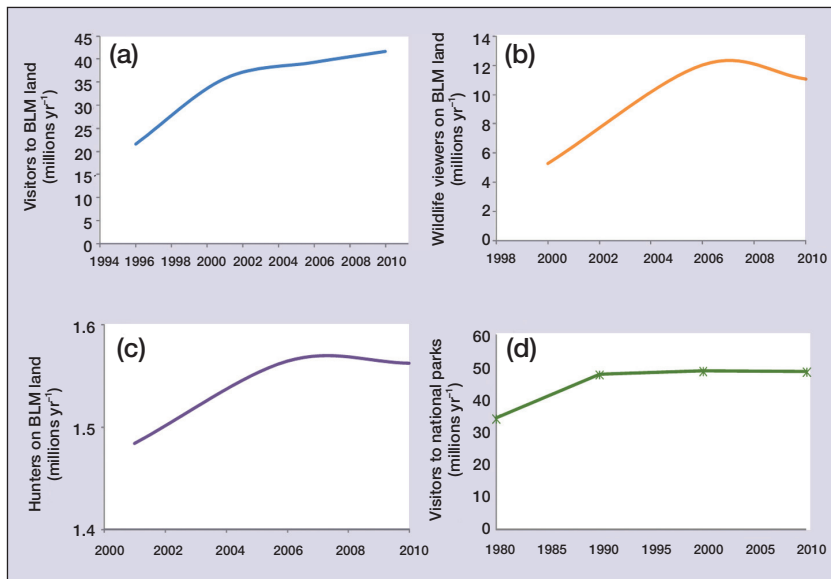


Figure 1. Changes in recreational use patterns in selected US public lands through time: (a) total number of visitors to areas administered by the Bureau of Land Management (BLM) for recreational purposes, regardless of duration; (b) total annual wildlife viewers visiting BLM-administered lands; (c) total number of hunters per year on BLM-administered lands; (d) total numbers of visitors to national parks each year. Data source: www.blm.gov/public_land_statistics/index.htm

(Arizona, Colorado, Nevada, Utah, Wyoming, New Mexico, Montana, Idaho, South Dakota, and North Dakota) may be explained in part by the uneven distribution of humans between urban and non-urban areas. Population increases during recent years were concentrated in urban areas, whereas non-metro areas (ie locations with 2500 to 20 000 people that are either adjacent to or isolated from a metropolis) and rural areas experienced lower rates of growth (WebFigure 1). Populations in rural areas have declined in some arid states. Indeed, most people in western US states now live in urban areas that are surrounded by great expanses of public land that can satisfy their broad demand for services. Although some western US cities have been among the nation's fastest growing over the past several decades (www.census.gov), the region still encompasses large amounts of open land with very low human population densities.

■ Livestock forage: a dynamic example of supply and demand

As shown in Table 1, the global demand for and use of provisioning services, especially with regard to water and forage for livestock, meets or exceeds the supply of these services. Clearly, at local, regional, national, and global scales, increasing pressures are being placed on provisioning services. A well-documented example is the demand for livestock forage. Globally, the number of cattle, sheep, and goats increased by over 601 million individuals from 1979 to 2009, representing an addition of ~1.6 million livestock animals per month over 30 years (Estell *et al.* 2012). Projections indicate that the quantity of livestock,

and the resulting demand for forage, will continue to rise at a similar rate in the future; according to the UN Food and Agricultural Organization, by the year 2030, 3.2 billion tons of extra forage will be required annually to feed the additional 830 million cattle, sheep, and goats on the planet (FAO 2003, 2009).

These increasing demands are not evenly distributed across the globe. Anadón *et al.* (2014) showed that social demand for livestock production – as a provisioning service of arid grasslands experiencing shrub encroachment – differed between North and South America. In semi-arid and subhumid regions, woody vegetation had a greater effect on livestock production in South America as compared with that in North America (Anadón *et al.* 2014). The authors attributed the discrepancy between the two continents to a disparity in demand for ecosystem services, with ecosystems in developing countries mainly valued for livestock production

whereas other services, such as recreation and hunting, might be in greater demand in developed countries (Anadón *et al.* 2014).

In North America, and specifically in the US, demand for livestock forage has decreased in recent decades. Livestock abundance in North America declined by 14% between 1979 and 2009, leading to falling demand for the supply of forage from BLM-administered public lands in the western US (Figure 2). In terms of animal unit months (AUMs) billed annually on all BLM grazing-district lands, forage demand has declined by 48%, from nearly 15 million AUMs in the late 1940s to 7.83 million AUMs in 2011 (Figure 2a). In recent years, the BLM has reported available forage in terms of both the number of AUMs available for lease (the supply) and the actual billed use (the demand) for those AUMs. During the past decade, for the BLM lands in the Las Cruces District Office surrounding the Jornada Basin in southern New Mexico, annual forage use has averaged only about two-thirds of the supply (Figure 2b), which is about the same for all BLM land in the western US (Figure 2c). There are numerous reasons for this disparity between supply and demand, including voluntary livestock reductions due to prolonged drought and the presence of fewer livestock and livestock operations. In the US, decreasing domestic demand for forage is mirrored by increasing international exports of forage crops (including alfalfa hay; Figure 2d). This “globalization” of supply to satisfy worldwide demand involves multiple provisioning services: not only forage but also the water and fuel required for production and export (US Trade Online 2014).

Drivers of demand for ecosystem services

The interest that individuals have in ecosystem services is dependent on factors such as income, gender, culture, and geographic location (MA 2005). Likewise, Martín-López *et al.* (2012) showed that the pattern of sociocultural preferences toward ecosystem services varied considerably among respondents, depending on their level of formal education, gender, place of residence (ie urban versus rural), age, and reported behavior toward the environment. For instance, provisioning services were more highly valued by rural inhabitants, by the elderly (> 70 years old), and by those with a lower level of formal education. Even though people living in urban areas increasingly rely on essential provisioning services such as food production, these services are less highly valued by urban residents (Martín-López *et al.* 2012).

The major determinants of demand for ecosystem services in rangelands are monthly income, level of education (from traditional ecological knowledge to formal education), and place of residence (position on the rural–urban continuum). We hypothesized changes in the relative demand for the four types of ecosystem services with different levels of income and education and place of residence (Figure 3). Consumption patterns change as per capita income grows (Tilman *et al.* 2011), shifting from basic needs to luxury goods and services that improve the quality of life. Businesses respond to these changing demands by producing an evolving mix of products. In addition, as incomes rise, the demand for non-agricultural goods and services increases disproportionately (Nelson *et al.* 2005). Producers respond by devoting relatively more resources to industry and service activities than to agriculture, and as a result, the share of agricultural output in total economic activity falls. Conversely, the shift to a more diverse diet – in particular to higher rates of animal-based (including fish-based) protein consumption – slows the shift in demand away from agriculture and other provisioning services (Nelson *et al.* 2005).

Urbanization also affects the demand for ecosystem services. Rural communities are more likely to consume locally produced food, and are more often directly involved in agricultural practices and the food production process as compared with urban communities. Individuals that live in rural areas and derive their income from agricultural activities are more aware of regulating services, such as pest control or pollination, than are urbanites. Urban consumers, on the other hand, are more likely to prefer meals that are easy and quick to prepare, and to purchase them from restaurants or supermarkets, making the connection between provisioning and

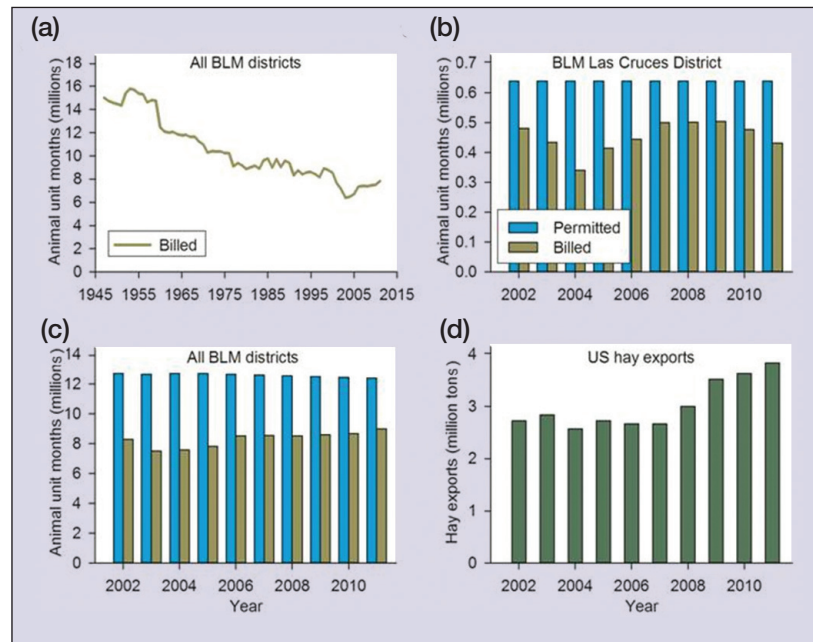


Figure 2. Actual billed demand for livestock forage from public land administered by the BLM in terms of animal unit months (AUMs), or the amount of forage needed to sustain one cow and its calf, one horse, or five sheep or goats for a month (a) from 1947 through 2011 for BLM Grazing District Lands in the US (BLM 2014); the authorized supply of and actual billed demand for AUMs in (b) the BLM Las Cruces, New Mexico, District between 2002 and 2011 (from Estell *et al.* 2014) and (c) all BLM lands across the western US during the period 2002–2011 (BLM 2014). (d) Alfalfa hay tonnage exported from all US ports to all other continents between 2002 and 2011 (USA Trade Online 2014).

regulating services much less apparent. Urban residents depend on ecosystem services that are generated far away from cities and of which they are largely unaware. On the other hand, urban dwellers typically have a higher per capita income, demand more cultural and recreational services, and put greater emphasis on environmental quality related to regulating services and cultural experiences (Figure 3). In addition, several indirect factors, such as the growing awareness of environmental problems and improvements in both education and environmental regulations, may influence changes in the demand for ecosystem services as per capita income increases.

This analysis may apply to other ecosystems as well; for example, as with rangelands, coastal ecosystems supply numerous and relatively evenly distributed ecosystem services. More extreme ecosystems, such as hyper-arid regions or the deep sea, produce relatively few provisioning services. At the other extreme, the most productive ecosystems produce a small variety of ecosystem services because they have already been transformed to produce specific goods (eg crops) at the expense of cultural and regulating services.

Implications for decision making

Decisions regarding land use have major consequences for the sustainable use of rangelands worldwide. Here, we

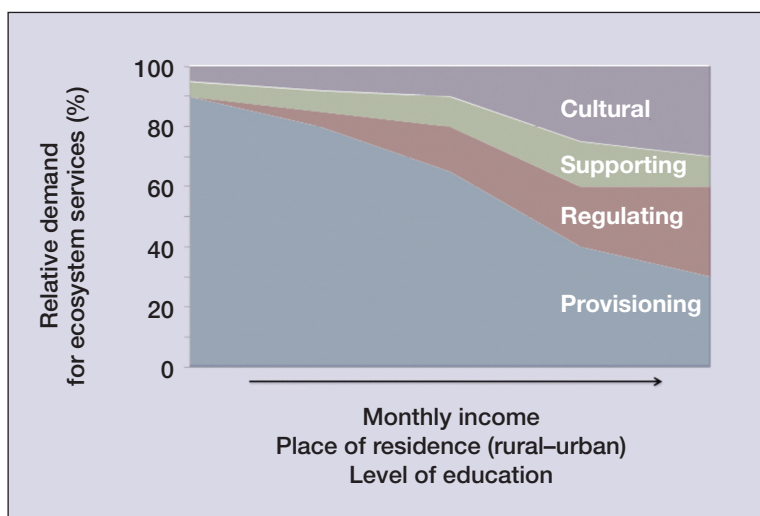


Figure 3. Hypothesized relative demand for the four ecosystem-service classes based on three main drivers: average monthly income, place of residence (the rural–urban continuum), and level of education.

propose a conceptual framework of the determinants of decision making, where “land use” involves all decisions about the use of rangelands (including whether land is grazed and [if so] at what stocking rate, as well as whether invasive species are controlled). The fate of a piece of land depends on the sum of the ecosystem services that it can supply and the stakeholders’ demands for all those services. The requirements of each stakeholder are further shaped by the amount of political influence they have. Decision making for land use includes reconciling supply and demand for ecosystem services. For example, a hypothetical piece of land that has the potential to produce clean water would not be managed to maximize this service if there were no stakeholders interested in drinking clean water.

This framework can be synthesized in the form of equation 1 below:

$$\text{Land use} = f \left[\sum_{j=1}^n (ES_j \text{ Supply}), \left(\sum_{i=1}^m (ES_j \text{ Demand}_{\text{stakeholder } i} * \text{Political Power}_{\text{stakeholder } i}) \right) \right] \quad \text{Eq 1}$$

Ecosystem-service (ES) supply is the amount of each j ecosystem service sum across services. Ecosystem-service demand is the demand for each ecosystem service j by each individual stakeholder i weighed by the political power of each stakeholder i .

This conceptual framework could serve to guide future research and the decision-making process regarding land use in rangeland systems. Analysis of the different components in Equation 1 may draw attention to information gaps and areas where research will have maximum impact; for example, current understanding of ecosystem-service supply is far more developed than that of demand. Finally, this conceptual framework could serve as a starting point for evidence-based, transparent negotiations among stakeholders.

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