The Science and Practice of Landscape Stewardship

Edited by

CLAUDIA BIELING

Institute of Social Sciences in Agriculture, University of Hohenheim, Stuttgart, Germany

TOBIAS PLIENINGER

Department of Geosciences and Natural Resource Management, University of Copenhagen, Denmark

CAMBRIDGE
UNIVERSITY PRESS

15 Landscape Stewardship for Rangelands

Lynn Huntsinger and Nathan F. Sayre

Introduction

Rangelands encompass between one-third and one-half of the ice-free land on Earth (Fig. 15.1). They are lands on which the vegetation is predominantly grasses, grass-like plants, forbs, or shrubs suitable for grazing or browsing; grasslands, steppe, tundra, scrublands and savannas are all considered rangelands (Booker et al. 2013) and provide multiple environmental benefits. Hunting, trekking, camping, birdwatching, water collection, mushroom and herb collection, livestock grazing, firewood and wood production – some or all of these things typically occur on rangelands. Species important to crop pollination rely on the vegetation of surrounding rangelands (Chaplin-Kramer et al. 2011). The extensive, semi-natural character of many rangelands makes them a good buffer between preserves and urban areas; studies have found that their esthetic values are reflected in the enhanced value of residential properties bordering them (Caparros et al. 2013). Rangelands store an estimated 30 per cent of the world's terrestrial carbon (Booker et al. 2013) and are important watersheds (Cao et al. 2013, Caparros et al. 2013). They support more herbivore biomass than any other terrestrial habitat (Frank et al. 1998) and include many of the world's biodiversity hotspots (Veldman et al. 2015).

Because rangeland ecosystem services and the herbivores that characterise rangeland systems often depend on rangeland extensiveness and connectivity, sustaining rangeland landscapes is a multi-dimensional project requiring attention to social and ecological processes across multiple spatial and temporal scales (Huntsinger and Oviedo 2014). Rangelands worldwide are imperiled by fragmentation – not only ecological and physical but also social and political – and preventing, minimising and coping with fragmentation is a focal concern of rangeland landscape stewardship regardless of land tenure type (Behnke 2008, Hobbs et al. 2008, Reid et al. 2014). The innovative approaches and connections needed to rebuild and sustain landscape-level stewardship of rangelands increasingly originate among grassroots stakeholder groups.

Rangelands have co-evolved, over millions of years, with complex regimes of climate, fire, vegetation and soils interacting with the herbivory of everything from microbes to large mammals (Veldman et al. 2015). Grasses and other rangeland plants are thus adapted to some loss of their above ground parts, whether by fire, grazing or periodic drought. Many rangeland herbivores, typically ungulates, migrate or move long distances to cope with low or erratic forage and water supplies, drought, flooding

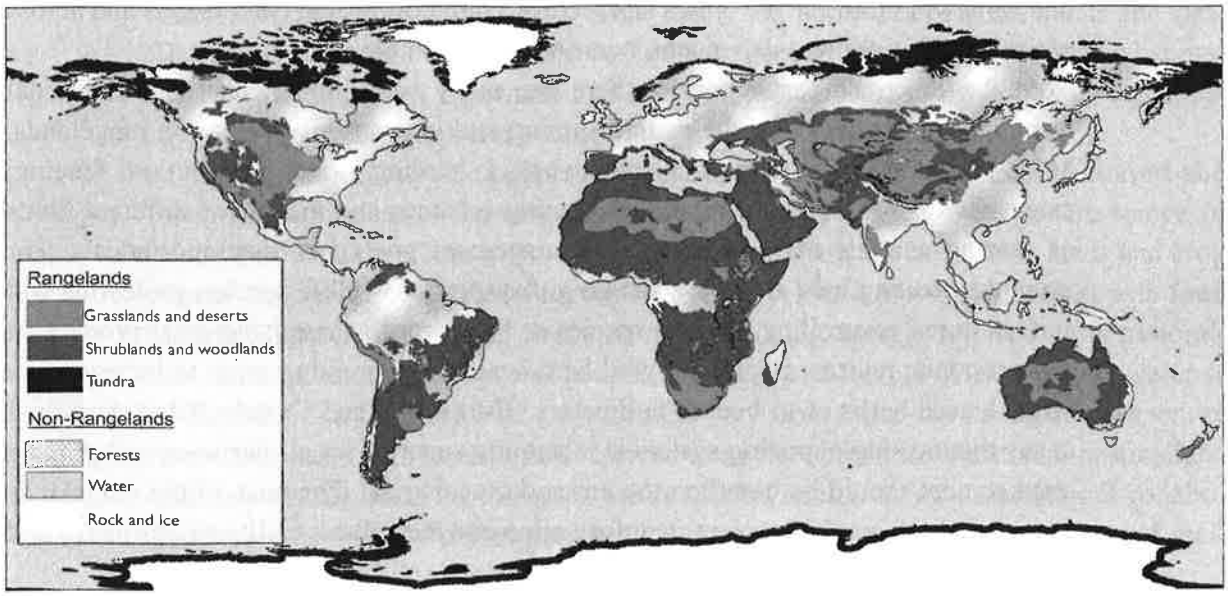

Figure 15.1 Natural distribution of the world's rangelands. Rangelands on productive soil with favourable climatic regimes, such as the tallgrass prairies of central North America (light grey), have been converted on a massive scale to crop production. At a smaller scale, arid areas accessible to water sources are vulnerable to cultivation, tree planting, and water diversion. Source: Information & Education and Remote Sensing & GIS committees of the Society for Range Management.

or extreme cold. Humans have long influenced these patterns, through burning, hunting, water diversion and beginning roughly twelve thousand years ago, domestication of grazing animals.

Rangelands are the ultimate 'peripheral' lands. Changing technologies for crop production, mineral extraction and water delivery have supported conversion of rangelands throughout the world. The rangelands that remain have been spared conversion to more intensive uses because they are generally unsuited for such uses – geographically remote and economically, politically and ecologically marginal (Sayre et al. 2013). Widely considered to be of lower conservation priority than forests (Veldman et al. 2015), rangelands enjoy relatively little protection from expanding urbanisation and development. Cultures that rely on rangeland grazing for sustenance most often are in the minority in their respective countries and are changing too, as market, political and demographic forces act to fragment traditional institutions and communities.

Many problems in rangeland stewardship stem from mismatches between the large scale of critical ecological processes and the much smaller scales at which management, ownership, jurisdiction and governance operate. Scientists, too, have historically assumed linearity across scales – extrapolating from plots and pastures to landscapes by simple multiplication – neglecting the non-linear feedbacks and complexities that are central to newer scientific understandings of rangelands. Attention to scale in framing and analysing problems and solutions is important to both ecological and social analysis. It is also critical to developing conservation approaches (Huntsinger and Oviedo 2014). Although different processes may dominate at different scales, actions taken at

one scale will influence the others and feedbacks among system components and across scales are often context-dependent, non-linear and complex.

At the ranch or pasture scale, there are many well-known new and traditional techniques for influencing the pattern, timing and intensity of grazing on rangelands. Management of wildlife populations, livestock herding, water distribution, fencing, extensive, high intensity or rotational grazing schemes and the use of different kinds of grazing animals may all be used. Management goals can vary enormously: For example, creating bare areas or short grass for specific wildlife species, protecting soil carbon stores, controlling invasive species or fire hazard, maximising grass production and economic returns, improving wild herd health or supressing grass to increase rare broad-leaved herbs or to benefit pollinators (Huntsinger and Oviedo 2014). Suffice it to say that no single grazing system is inherently superior for all purposes and grazing management should be based on the particular ecological dynamics of the rangelands in question, the available scientific information and the values, traditions, resources and economies of the people involved.

Our focus here is on the landscape scale, at which rangeland stewardship entails integration of and across smaller scales and situating rangeland systems in relation to surrounding landscapes and economies in ways that enhance the stability of rangelands and the sustainability of the diverse benefits they provide. While institutional and governmental ownerships and some large private properties may encompass entire landscapes in the ecological sense, our premise is that landscape stewardship most often involves finding ways to build bridges across social, political and ecological jurisdictions. We discuss the following four major characteristics of rangeland systems that have profound implications for landscape stewardship:

(1) Rangelands are usually low in vegetative productivity or net primary production (NPP) and vegetation is low in nutrient density
(2) On most rangelands, the quantity and quality of vegetation production vary widely over space and time
(3) Especially in arid areas, many factors controlling the quality and productivity of rangeland vegetation are abiotic and out of the control of the manager and
(4) When used for producing livestock, returns per unit area from rangeland grazing are low compared to uses such as crop production and mining and generally derive from the low cost of husbandry and forage production.

It should be noted at the outset that all of these factors are likely to be influenced by climate change; in some rangelands these changes are already evident (Seeger and Vecchi 2010). Here we explain the significance of each of the four and discuss how grassroots efforts fit them to local landscapes.

Low Productivity and Nutritional Quality

Using large land areas to acquire sufficient nutrition from land of low productivity is characteristic of rangeland use by grazing animals. Ungulates (the herbivorous hooved

mammals, including sheep, goats, cattle, deer, elk, horses, camels, elephants and similar grazers) can move large distances and can convert fibrous, low protein and sometimes toxic rangeland vegetation into balanced proteins and energy rich fats digestible by predators, scavengers and people.

Hunting is one way that people make use of the capacity of ungulates to convert and concentrate nutrients from rangelands. Domestication offers a more secure source of 'food on the hoof' (Clutton-Brock 1989). Livestock can use non-arable lands and crop waste, concentrating nutrients harvested from vast areas, providing farmers with food and fertiliser. Those rearing livestock on rangelands, loosely referred to as pastoralists, have cultural traditions and practices that support the use of extensive rangelands (Fernandez and Le Febre 2006). Pastoralists vary from those that have exclusive tenure over large rangeland areas, often referred to as 'ranchers', to 'traditional pastoralists' that rely mostly on lands in shared forms of land tenure. Cross-jurisdictional collaboration, rentals or government permits, use of unclaimed lands or various forms of reciprocity may be used to increase access to rangelands.

For traditional pastoral communities, sharing rangelands helps increase the amount of land and the diversity of habitats and water sources available to each animal. Communal or collective access rules may control use of a commons. In other cases, rangelands are an open access resource, where herds may be controlled by periodic droughts, winters of exceptional cold or restrictions based on ownership, kinship or religious connections (Fernandez-Gimenez and Le Febre 2006, Moritz et al. 2013).

Both communal and open access tenure systems may be sustainable, but central governments and development agencies may view them as inherently prone to overgrazing and degradation due to the 'tragedy of the commons' (Hardin 1968). Two common policy 'solutions' have thus been widely applied: State acquisition and management and division into individually owned private parcels. The United States and Australia combine the two by retaining state ownership and regulation of some rangelands but dividing and fencing them into fixed allotments for lease of grazing rights to ranchers. Division of rangelands has been attempted through privatisation in Africa and long-term contracting of individual parcels to households in China. In fact, using land in common does not itself lead to resource degradation and breaking up shared lands does not itself prevent resource degradation (Ostrom 1990). Governance is more important. Different forms of governance may co-exist or overlap in pastoral areas and may govern different resources on the same land or different rangelands used by the same pastoralist (Starrs 1998). As examples, on Spain's private rangelands, the local community may have rights to hunt or gather; US ranchers with private rangelands may graze government lands during some times of year.

At the landscape scale, wild herbivores may also use rangelands of differing governance and management (Fig. 15.2). Growing protected elephant populations in Kenya's Amboseli Park frequently forage in neighbouring pastoral areas, coming into conflict with Maasai pastoralists and farmers (Thompson 2002). Parks and preserves may not include the full ranges of the large ungulates they protect, as with Yellowstone National Park's bison. Bison must leave the Park to use vital wintering areas, causing conflicts with nearby landowners. Some wild ungulate populations may outgrow the available

Figure 15.2 Newly refurbished sections of fence along the US border with Mexico can be a barrier to large ungulates, an example of how international politics can translate to rangeland fragmentation. Photo: Lynn Huntsinger.

space even if the initial protected area includes their full range and yet control plans are seldom in place. Landscape stewardship must consider how different rangeland land uses affect one another and seek to minimise conflict while sustaining the viability of the desired land uses.

Key Areas

Small portions of a rangeland landscape may be 'key areas' of disproportionate importance to herbivores or livestock production, including travel routes, areas of exceptional forage growth and quality, sheltered areas and breeding or birthing areas. Key areas are often the most threatened by competing uses: In arid lands, meadows near water may be converted for cultivation or used for tree plantations, for example. Key areas may also be the first to suffer from over use. For example, Patagonian riparian habitats called *mallines* are key grazing resources for sheep and wildlife. They have lost productivity because of improper grazing management and sustainability of the system depends on their recovery (Utrilla et al. 2005). The development of wells and stock ponds can create key areas for wildlife and livestock, leading to increased use of nearby rangelands. In a synergistic relationship, key areas for sub-Saharan wild ungulates are created by

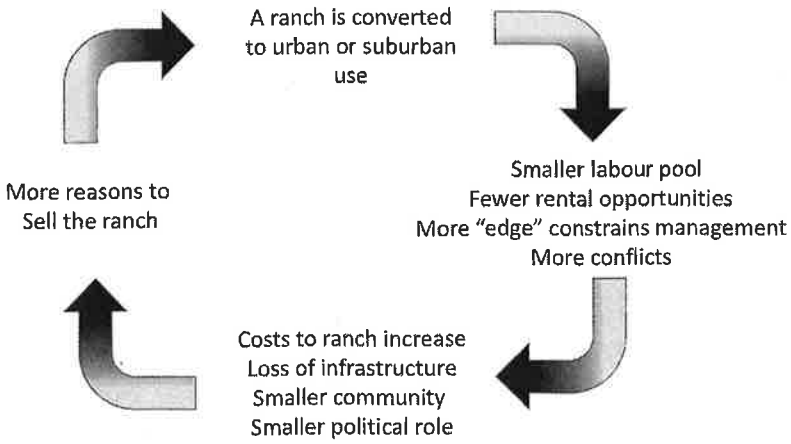

Figure 15.3 Rangeland landscape change feedback loop. When a ranch is lost, rangeland for livestock husbandry shrinks as does the local labour pool, the political influence of the grazing community and the support for markets, feed stores, veterinary services and slaughterhouses. Source: Huntsinger 2009

temporary livestock corrals because lush plant growth is fed by the manure left behind (Porensky and Veblen 2015). Key areas, as well as the extent and productivity of rangelands, are important considerations in sustainable stewardship.

Critical Mass for Pastoral Communities

Sustained pastoralism not only requires extensive rangeland, but a community to share labour, knowledge, equipment and facilities and to provide mutual support and political voice in what pastoralists often see as a relatively unfriendly outside world. Even when pastoralists own enough private land to support their herds, veterinary services, packing facilities and local markets require a 'critical mass' of livestock producers to operate (Liffmann et al. 2000). Loss of infrastructure, neighbours and rangelands makes it harder for pastoralists to persist (Fig. 15.3).

In scenic or peri-metropolitan areas, a feedback loop of increasing land conversion has been described for private ranches in the United States (Huntsinger 2009): the urban agricultural 'edge' expands, leading to greater conflicts with new, amenity seeking residents and higher prices for ranch lands. The probability that more ranches will be sold increases, approaching a hypothesised 'tipping point' where the community is simply too small to be tenable (Liffman et al. 2000) and the landscape shifts from rangeland to urban.

Variable and Unpredictable Production in Space and Time

Forage production reflects rainfall and temperature patterns and extremes of precipitation and temperature may be unpredictable (Vetter 2005). Mobility, including migration, is an adaptation by ungulates to a low, patchy and dispersed distribution of nutrients that

Figure 15.4 Summer pasture and horse milking, Xinjiang Province, China, the most enjoyed time of year for many families. Only during this time is horse milk made into a fermented drink, called Kumiss, that is shared by family and guests. Photo: Lynn Huntsinger.

is heterogeneous in time and space (Behnke et al. 1993). Grazers need to move to access vegetation and water across elevational and other gradients or to escape severe weather conditions such as drought. They may migrate long distances irregularly or regularly or with the seasons. Nomadic herders have traditionally moved their herds to match the seasonal resource availability with the nutritional and reproductive status of their animals (Fernandez-Gimenez 2002). On large ranches, animals may be herded from one pasture to another seasonally or based on various management goals. The native peoples of the American Great Plains followed bison migrations.

Transhumance, cycling from one rangeland type to another to take advantage of seasonal variations in forage, is common among pastoralists (Fernandez-Gimenez and Le Febre 2006, Huntsinger et al. 2010a). Households may send members or paid herders to manage herds in summer pastures or they may move with the herd (Fig. 15.4). For example, Alpine farmers often send stock from private paddocks to community owned mountain meadows in summer, typically watched by herders hired by the community (Netting 1981, Bunce et al. 2001). In the United States, ranching families may have mountain cabins where they or their paid cowhands stay to watch the herd in the summer. Private land, rented private land, land owned by one or more government agencies and off rangeland feed sources may be used over the year.

Many development programmes have promoted or required sedentarisation of pastoralists on the grounds that this provides better access to schools, employment and medical facilities (Fig. 15.5). Division or privatisation of rangelands often accompanies

Figure 15.5 Settlement houses in Qinghai, China. Herders have been settled as part of government development programmes. The loss of mobility has affected environmental conditions and household economies and significantly changed social relationships in pastoralist communities. Photo: Lynn Huntsinger.

sedentarisation efforts, increasing costs to pastoral families for fencing, labour and supplemental feed, while curtailing overall economies of scale (Williams 1996, Li and Huntsinger 2011). Common results include overuse of pastures near settlements, underuse or neglect of distant pastures and overuse of groundwater to irrigate crops for supplemental feed (Fan et al. 2014). Individual parcels may be unable to provide adequate year round resources and fences inhibit migrations and may undermine community cohesion and capacity for sharing labour. Various forms of re-aggregation may be pursued, including collaborative land sharing, rentals and purchase of rangelands by those able to persist from those who cannot. Fences may also restrict wild ungulates.

One challenge to mobility is managing the spread of diseases and invasive species. For example, in the arid rangelands of the US Intermountain West, transmission of disease between domestic and wild sheep is a persistent problem (Huntsinger et al. 2012). Managing diseases across jurisdictional boundaries is also an important consideration (Cumming et al. 2015). Finally, ungulates can carry seeds long distances in their digestive systems and fur. Unfortunately, regulations for prevention of disease and species transfer may preclude migrations. Quarantining new animals and limiting introductions may be an alternative viable approach to control.

Abiotic Factors Are a Major Influence on Rangeland Vegetation

Abiotic factors such as weather, temperatures, soil structure, topography, erosion, fire and water table depth are often the dominant drivers of rangeland productivity and species composition, such that vegetation change may be unpredictable and beyond management control. Achieving an equilibrium between forage and grazing animals by establishing a fixed herd or population size (carrying capacity) may not be possible (Behnke 1993, Sayre 2008). Scientists characterise such systems as fitting a 'non-equilibrium' model (Vetter 2005) of vegetation dynamics. Management of domestic or wild ungulates must be flexible and adaptive to respond to unpredictable change in available forage and weather.

Reciprocal social relations and mobility help pastoralists cope with variable conditions (Bennett et al. 1968, Ellickson 1986, Fernandez-Gimenez and Le Febre 2006, Reid et al. 2014). 'Fuzzy boundaries,' or the ability to graze more or different areas when needed, including 'reserve areas' during drought, may be part of pastoral practice. Pastoralists gain access to emergency pastures, transportation, or other key productive resources in exchange for reciprocal resource access privileges, labour, goods, bureaucratic or market access, or other social or political favours (Fernandez-Gimenez 2002, Fernandez-Gimenez and Le Febre 2006, McAllister et al. 2006). In Inner Mongolia, for example, traditionally a village could come to another village's rangelands during a drought or exceptional cold, provided that the favour was returned when needed (Li and Huntsinger 2011). Even in countries where large private properties are the norm, landowners may share rangelands with neighbours when the need arises.

Fire is an abiotic factor that can be managed and used to improve forage and reduce woody vegetation and weeds. For example, tens of millions of American bison once grazed the prairies of the Midwestern United States. By setting fires, the native inhabitants helped prevent the encroachment of woody plants (Anderson 1990, Allen and Palmer 2011) and stimulated fresh regrowth that attracted herds. This landscape stewardship was deeply entwined with the needs and behaviour of bison in interaction with the grassland (Commerford et al. 2016).

As rangeland is fragmented and reduced, substitutes become more important. Feeding, water transport or development and selling animals, among other strategies, are used to buffer drought or unusual cold. Government programmes providing subsidies, supplies or feed during emergencies may also be used – but all come at a cost and increase the energy inputs needed to produce livestock products.

Low Costs and Few Inputs Make Low Returns Per Unit Area Economical

Rangelands are by definition dominated by native or naturalised vegetation (Fig. 15.6) that grows without irrigation or other inputs. Low returns per unit area from grazing can therefore be economical. Many attempts to intensify production fail because the environment precludes much increase in productivity and improvement costs therefore cannot be recouped. For example, in China, shifting croplands from collective management to household control brought huge increases in production and in the

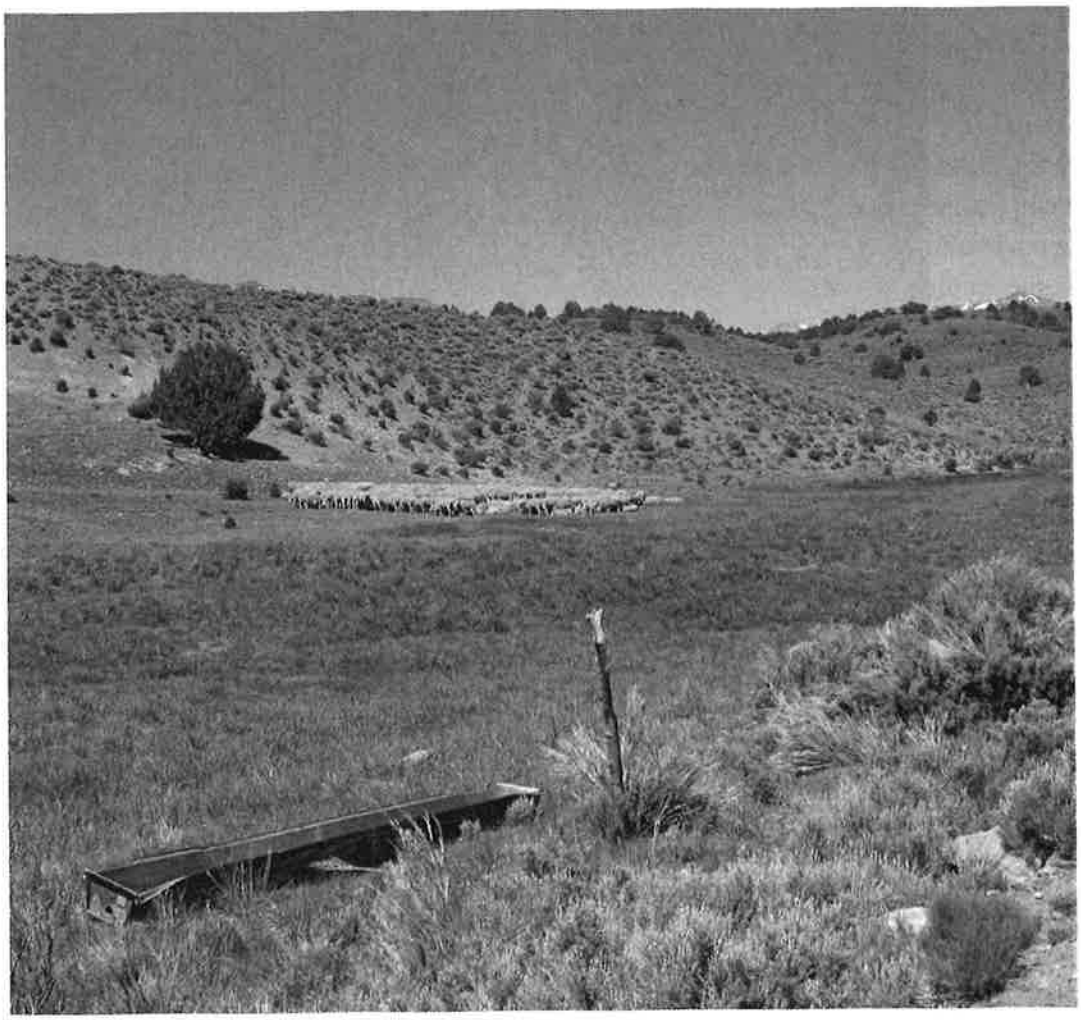

Figure 15.6 In the arid US Intermountain West, approximately 6–10 ha of sagebrush steppe (pictured) is needed to support a sheep for a year (Huntsinger and Starrs 2006). Key areas like this green meadow are a critical source of higher quality forage for wildlife and livestock. Photo: Lynn Huntsinger.

diversity of crops produced with increased owner investment in technology. But efforts to 'improve' rangeland livestock production on the model of farming or agronomy have met with little success in China or elsewhere (Stokes et al. 2006, Li et al. 2007, Cao et al. 2013, Li et al. 2015). The costs of 'green revolution' technologies such as irrigation, improved plant genetics, seeding, fertilisation or cultivation are usually prohibitively high relative to marginal returns. In general, this approach has exacerbated environmental problems and poverty (Gongbuzeren et al. 2015).

On the other hand, rangelands are amenable to multifunctional management (Sayre et al. 2012). Diversification of the goods and services produced can reduce rangeland fragmentation by increasing income from e.g. hunting fees, agrotourism or payment for ecosystem service programmes that reward environmentally friendly practices. Rangeland-based livestock production may benefit from premiums for organic, grass fed or natural meats. Consumer interest in local production and direct marketing can also help rangeland producers to add value to their products. Access to diverse and

Figure 15.7 Fragmentation and landscape patterns influence wild and domestic ungulate safety and movements. Photo: Lynn Huntsinger.

niche markets, processing facilities for livestock and animal products and non-market income streams, environmental subsidies and cost sharing programmes, are best provided at the landscape scale. Creating positive feedbacks between economic and ecological diversity should be the ultimate goal.

Range livestock production is directly dependent on biodiversity at multiple spatial and temporal scales as rangeland production is generated and regenerated on site rather than supported by imported, often non-renewable, inputs (Kremen et al. 2012, Kremen and Miles 2012). This does not mean that livestock cannot cause ecological damage and there are trade-offs and synergies in managing landscapes for livestock and ecosystem services like wildlife habitat (Niamir-Fuller et al. 2012). Yet even where non-native or invasive plants have encroached on or replaced native species, rangelands retain high levels of plant diversity compared with croplands or plantation forests and rangelands that have never been plowed retain much of their soil and microbial diversity (Havstad and Peters 1999). Wild ungulates and livestock both need large land areas, travel corridors, water, key areas and seasonal grazing areas (Fig. 15.7).

Conflicts are more likely at the plant community scale. Landscape configurations can help reduce conflicts and maximise synergies with other uses – for example, providing for space to move livestock out of wildlife breeding areas during the breeding season if needed or enough buffer area to use controlled burning to improve forage for livestock and wild ungulates.

Livestock and wild ungulates may graze the understory of orchards, savannas, woodlands and forests, as well as forest meadows and clearings as part of agro-sylvo-pastoral production systems or to reduce fire hazard. On the Iberian Peninsula for example, oaks, livestock, wildlife and crops are husbanded in a system known as *dehesa* in Spain, producing a diverse array of products (Campos et al. 2013). Dehesa is also one of the most fire-resistant landscapes in the Iberian Peninsula, where climate change, abundant plant growth and dry, hot, summers foster wildfire. The interactions among large herbivores, forest growth and fire are complex and depend on site environmental conditions, grazing management and the relative palatability of forest species (Shannon et al. 2011). Single use management can lead not only to environmental problems, but also to degradation of the diverse ecosystem services from rangelands. For example, tree planting is a common approach to sequestering carbon, but on rangelands, may reduce biodiversity (Veldman et al. 2016), increase fire hazard and provide no benefit for carbon sequestration (Naudts et al. 2016). Planting open forests that provide forage for grazing animals and consist of more deciduous and broadleaved vegetation may be preferable and is a form of diversified management.

Because of the diverse benefits they produce for society and the limited income stream generated by rangeland livestock production alone, the future of most rangelands lies not in intensive single purpose management but in the continued provision of multiple ecosystem goods and services. Diversified management can also increase the perceived value of rangelands to society.

Importance of Proximate Communities

Drawing on outside sources of income may be the most common form of diversification in rangeland livestock production (Sayre et al. 2013). Industrialised livestock production based on low cost and often subsidised energy and chemical inputs competes with rangeland-based production, lowering prices. Rising populations in some pastoral regions mean less rangeland per person. Young people migrate away when local economies do not support supplemental income or alternative careers, leading to land abandonment. To maintain or increase living standards, pastoralists turn to supplemental sources of income. In the western United States, significant ranch household income comes from non-livestock sources including wage labour and rangeland prices often exceed their production value (Oviedo et al. 2012, Caparros et al. 2013). As early as 1969, Smith and Martin (1972) found ranchers in Arizona dependent on outside income and on local towns for jobs and business opportunities, a consideration for landscape planning.

Sustaining Rangeland Landscapes from the Grassroots

Innovative institutional arrangements are needed that facilitate new forms of mobility, maintain and encourage diversified use of rangeland and connect pastoralists to

larger-scale processes. While top-down governance and development programmes have had only limited success, there is evidence that in the complex rangeland context, bottom-up processes characterised by collaboration and communication with other stakeholders have found ways to adapt pastoralism to its changing context. NGOs, educational outreach programmes and government agencies have played varying roles, sometimes acting to facilitate the development of collaborative programmes. Bottom-up efforts foster the development of institutional arrangements built on adapting rather than supplanting traditional institutions. Restoring use of shared labour and use of larger and more varied land areas by pooling herds and opening fences has been undertaken by groups of householders in various parts of the world (Reid et al. 2014). For example, in China some communities are voluntarily managing their individual grazing areas as collective units. In South Africa, fences demarcating farm boundaries became a legal requirement in 1912; however, in the last two decades, there have been moves to dismantle fences to re-establish wildlife migration routes in several larger conservation landscapes (Cumming et al. 2015). In northwest Namibia, communities struggle to restore customary governance institutions (Bollig and Sweiger 2014). In Africa, community-based natural resource management programmes and safari enterprises that strengthen the value of wildlife to communities have had some success in encouraging the protection of elephants and other species (Fortmann 2005).

In the United States, even private ranches with extensive rangelands have found that working with fellow ranchers and conservation organisations has helped them build the social and economic connections needed to sustain their operations, including cooperative wildlife management, supporting local markets and processing infrastructure, encouraging cross boundary deliberate burning and working with complex mix of government agencies and policies. For example, Texas Wildlife Associations were originally created by state wildlife agencies to encourage ranchers to improve wildlife management on private lands. However, driven by rancher leadership, they have become a way to co-ordinate the management of wildlife across property lines, share knowledge and influence on the agencies that have authority over rangelands and wildlife (Huntsinger et al. 2014).

Pastoralists and pastoral institutions may be in a sense 'pre-adapted' to managing for diverse production and conservation values. Globally, motivations for rangeland animal husbandry often go beyond generating an income or subsistence and already include conservation values: Pastoralists value rearing livestock and stewarding rangelands as part of their culture and as consumers of ecosystem services (Oviedo et al. 2012). US ranchers are often described as seeking lifestyle and environmental benefits as much as profits. Appreciation of nature and landscape beauty, stewardship and caring for the land are among the reasons ranchers say they continue to ranch even when financial returns are marginal (Smith and Martin 1972, Caparros et al. 2013). Such goals often overlap with those sought from rangelands by the rest of society, such as living and working in a beautiful environment (Huntsinger et al. 2010b).

Working Landscapes in the United States

Community-based efforts led by ranchers have emerged as a successful and encouraging phenomenon in US rangeland conservation and are part of what has been termed the 'working landscape' movement. Groups seek to maintain access to rangelands and stabilise land tenure by promoting pastoral rangelands as providers of multiple ecosystem goods and services, such as water, carbon-sequestration, recreation, wildlife habitat, heritage values and scenery (Huntsinger and Sayre 2007, Huntsinger et al. 2014). Many include or co-operate with non-profit land trusts to prevent subdivision and development of private lands (Charnley et al. 2014) and a handful work closely with scientists to conduct research aimed at resolving acute management or regulatory problems (Huntsinger et al. 2014). Here we contrast two different organisations, the Malpai Borderlands Group and the California Rangeland Conservation Coalition, in two different regions to gain insight into how each alliance reflects both their unique political and ecological landscapes and the four characteristics of rangeland landscape stewardship. In both areas, ranches are large and privately owned, but ranchers found that they needed to work together to meet landscape-level goals.

Malpai Borderlands Group

The Malpai Borderlands Group (MBG) is a self-organised group of Arizona ranchers that began collaborating to facilitate controlled burning of their brush-invaded rangelands in 1991 (Sayre 2005). They developed connections to state and federal representatives of the land management agencies that control much of the grazing lands in their planning area, which comprises some eight hundred thousand acres of relatively unfragmented rangelands in southeastern Arizona and southwestern New Mexico (Malpai 2016). They were able to create a cross-ownership, landscape-level burn plan that facilitated burning and helped land management agencies to know where fires should be allowed to burn on private lands. Ownership of the semi-arid rangelands in the area is 59 per cent private, 11 per cent national forest, 7 per cent other federal and 23 per cent state land (Arizona and New Mexico). Ranchers may use lands in all four ownerships to meet their annual forage needs.

Eventually the group also became concerned about the growing demand for residential real estate that was driving the fragmentation of private rangelands. The group's goals grew to include resisting rangeland fragmentation by using 'conservation easements', a legal tool that removes development rights from the title to private parcels and transfers them to a conservation trust so that they cannot be used. Conservation easements are established voluntarily between a conservation organisation or government agency and a landowner. To motivate participating ranchers to set up conservation easements, access to a grass bank was provided for those who agreed to easements. A grass bank is basically an emergency reserve for use during drought or to enable conservation measures such as prescribed fire (Gripne 2005). For the MBG, the bank was a large ranch and conservation area owned by another NGO in the area.

One important innovation by the group is a clause in their conservation easements that allows for cancellation of the easement, if the associated federal or state grazing leases are lost through no fault of the rancher. Local land management agencies also see fragmentation and urban sprawl as threats to their management goals (e.g. fire control), so the clause gives the group a point of leverage in negotiations over possible changes in grazing policy. The large undeveloped ranches create a buffer around public lands (Talbert et al. 2007), reducing land-use conflict.

California Rangeland Conservation Coalition

The statewide California Rangeland Conservation Coalition (CRCC) is more a community of interest than representative of a specific group of people or geographic locale (California Rangeland Conservation Coalition 2016). In California's Mediterranean regions the challenges ranchers face in accessing rangelands are shaped by a higher level of fragmentation and diverse ownerships. Many ranchers around the state manage a complex portfolio of owned and leased lands, leasing not only from government agencies but also from private landowners who have retired from ranching, own land for investment or own land for non-ranching purposes. Ranchers are concerned about losing access to adequate rangeland; meanwhile, the conservation community is greatly concerned about the impacts of fragmentation on wildlife and other conservation values.

Responding to a history of polarisation over the impacts of livestock grazing, the CRCC originated in 2005 out of recognition that much habitat would be lost if the ranching and environmental communities did not work together to reduce the impacts of fragmentation. The CRCC is closely linked to the California Rangeland Trust, which partners with ranchers willing to establish a conservation easement to prevent development of their land. The group worked with an NGO to create a map of what they believed are the most important targets for establishing conservation easements within their scope of coverage in California (Huntsinger et al. 2014).

To help preserve access to rangelands, through conferences, workshops, websites and publications the CRCC promotes how livestock can be used to benefit a variety of endangered species and other wildlife (Huntsinger and Oviedo 2014). The Coalition seeks to inform the public, environmental consultants, managers and agencies that ranching is not only a preferred land use compared to development, but an essential resource management tool. They wrote a 'Rangeland Resolution' signed by over one hundred agricultural organisations, environmental groups and state and federal agencies. The signatories have pledged to work together to preserve and enhance California's rangeland for species of special concern, while supporting the long-term viability of the ranching industry.

Conclusions

Planning for rangeland landscapes can be clustered around the four rangeland characteristics presented in the introduction. First, the need for adequate rangeland area means

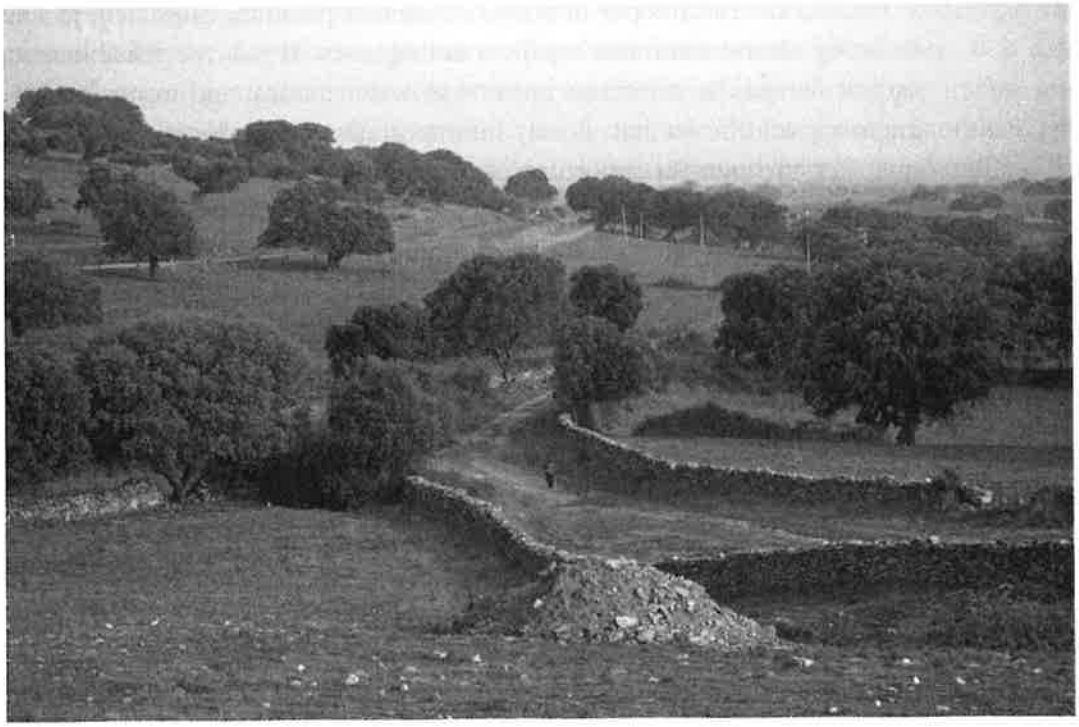

Figure 15.8 A traditional livestock trail winds through private lands in Spain. Lax enforcement of laws protecting them has led to loss from squatting and development. Shepherds and conservationists dedicated to restoring the *trashumancia* herd large numbers of sheep through Madrid each year to make the point that the lost trails and patterns of travel have cultural and ecological significance and should be restored. Drove roads that are used regularly are more likely to remain intact – shepherds in this case have a significant role in conserving these culturally significant landscape elements (Oteros-Rozas et al. 2013). Photo: Paul Starrs.

assessing the extent, quality and ownership of the rangelands available for grazing overall, at different seasons of the year and during drought. Key areas and resources must also be identified and protected. Land tenure, whether governmental, common or individual, should be stable to assure sufficient rangeland for the environmental, economic and social benefits of the rangelands.

Second, landscape planning must include consideration of mobility, including the travel corridors needed for animals to move between parcels, to carry out annual migrations or to migrate in response to weather conditions (Fig. 15.8). Livestock routes need protection. Together with the need for extensive lands, cross-jurisdictional planning and relationships with multiple stakeholders are often essential to maintaining adequate mobility.

Third, the unpredictability of rangeland forage production means that a wide range of weather driven scenarios have to be considered. There must be strategies for coping with a severe winter, drought or fire. These may include provision of feed, use of reserved grazing areas, reducing animal numbers, migration or in the case of livestock, transport to distant rangelands. Planning must incorporate landscape features that maximise flexibility and adaptive capacity (Oba et al. 2000).

Fourth, low returns per unit area mean that planning must help to keep costs low. Planning should minimise conflicts among uses. It may be feasible to use fences or natural features to minimise impacts to water quality and to encourage grazing that improves wildlife habitat. It may be important to consider if the communities nearby can offer employment opportunities to pastoralists, or if there will be conflicts between communities and wildlife or communities and typical livestock production practices. The number of pastoral households needed to support markets, processing facilities and veterinary services should be considered, as well as the costs of fragmentation and regulatory initiatives.

This chapter has illustrated how landscape stewardship for rangelands fits the characteristics of landscape stewardship as defined in this volume, from the perspective of the landscape-level ecological dynamics of rangeland systems. Each pastoral household has a unique configuration of available resources and constraints, depending on the types of land they have access to and who owns it, the amount of family labour available, the condition of the resources they use, their sources of outside income and capital and many other factors. Because of their semi-natural character and the ways that ecological, economic and social change are deeply interwoven, rangelands can be considered co-evolving social-ecological systems (Olsson et al. 2004, Folke et al. 2005, Ostrom et al. 2007). Conservation efforts must be attentive to multiple scales to avoid contradictory effects and undesirable feedbacks. Meaningful involvement of pastoralists in conservation of grazed rangelands is critical. Innovative institutions for governance and management, based on adapting traditional governance and practices, are emerging from grassroots groups. Grassroots groups reflect the motivations and activities that pastoralists themselves think are important, rather than those of people from outside. As such, they are more likely to attract participants from the community, despite the many competing demands on the time of pastoral producers.

Diversification of use is critical not only to sustaining and enhancing the many goods and services provided by rangelands, but also to creating additional income streams to support rangeland livelihoods. Market-based approaches, like carbon and water markets, sale of hunting opportunities, agrotourism, sale of the right to development rights to conservation organisations, mitigation markets and markets for 'green' rangeland products can help stabilise private rangelands. Government programmes such as land-use planning and payment for ecosystem services schemes can also help, as can efforts to integrate management of grazing and wildlife on government lands with the needs of integrated and proximate private ownerships.

Rangeland landscapes are characterised by multiple forms of land tenure and numerous agencies and programmes with responsibilities for various aspects of their use and management. Grassroots groups, conservation NGOs and agricultural extension programmes can co-ordinate the efforts of diverse interests, programmes and neighbouring landowners, while mediating relations among pastoralists, other rangeland users and government agencies. At the landscape scale, policy and planning should prioritise connectivity and mobility, relationships with proximate land uses, maintaining a critical mass of producers and buffering social and ecological systems against the inherent unpredictability of rangeland productivity.

Supporting grassroots and other collaborative efforts is critical to addressing the sustainability of dispersed and diverse rangeland resources and land uses. It is also critical to giving pastoralists a voice. Often a minority of the national population, and in many countries, ethnically a minority and economically marginal, pastoralists and the principles we have discussed here are not broadly understood. Interventions for improving environmental conditions, such as dividing common rangelands, imposing expensive technologies and reducing livestock numbers have often resulted in impoverishment for local communities and more environmental damage. Building on and adapting traditional institutions, as grassroots groups are inclined to do, may have a better chance of creating changes that benefit rangeland systems and of stimulating social learning.

Acknowledgements

We are thankful for the reviews and advice of Tobias Plieninger, Claudia Bieling, Elisa Oteros-Rozas and Kate Sherren. This work was supported by USDA National Institute of Food and Agriculture project CA-B-ECO-0117-MS and the University of California.

References

Allen, M. S. & Palmer, M. W. (2011). Fire history of a prairie/forest boundary: more than 250 years of frequent fire in a North American tallgrass prairie. *Journal of Vegetation Science*, **22**, 436–444.

Anderson, R. C. (1990). The historic role of fire in the North American grassland. In: *Fire in North American Tallgrass Prairies*, S. L. Collins and L. L. Wallace (eds.). Norman, OK: University of Oklahoma Press, pp. 8–18.

Behnke, R. (2008). The drivers of fragmentation in arid and semi-arid landscapes. In *Fragmentation in Semi-arid and Arid Landscapes: Consequences for Human and Natural Systems*, K. Galvin, R. Reid, R. Behnke & N. Hobbs (eds.). Dordrecht: Springer, pp. 305–340.

Behnke, R. H., Scoones I. & Kerven, C. (eds.) (1993). *Range Ecology at Disequilibrium: New Models of Natural Variability and Pastoral Adaptation of African Savannas*. London: Overseas Development Institute/International Institute for Environment and Development/ Commonwealth Secretariat.

Bennett, J. W. (1968). Reciprocal economic exchanges among North American agricultural operators. *Southwestern Journal of Anthropology*, **24**, 276–309.

Bollig, M. & Schwieger, D. A. M. (2014). Fragmentation, cooperation and power: institutional dynamics in natural resource governance in north-western Namibia. *Human Ecology*, **42**, 167–181.

Booker, K., Huntsinger, L., Bartolome, J. W., Sayre, N. F. & Stewart, W. (2013). What can ecological science tell us about opportunities for carbon sequestration on arid rangelands in the United States? *Global Environmental Change – Human and Policy Dimensions*, **23**, 240–251.

Bunce, R. G. H., Pérez-Soba, M., Jongman, R. H. G., Gómez Sal, A., Herzog, F. & Austad, I. (eds.) (2001). *Transhumance and Biodiversity in European Mountains, Report of the EU-FP5 Project Transhumount*. Wageningen: ALTERRA, Wageningen University and Research Center.

California Rangeland Conservation Coalition (2016). (http://carangeland.org/).

Campos, P., Huntsinger, L., Oviedo, J. L., Starrs, P. F., Díaz, M., Standiford, R. B. & Montero, G. (eds.). (2013). *Mediterranean Oak Woodland Working Landscapes: Dehesas of Spain and Ranchlands of California*. Dordrecht: Springer Landscape Series, pp. 353–388.

Cao, J., Yeh, E. T., Holden, N. M., Yang, Y. & Du, G. (2013). The effects of enclosures and land-use contracts on rangeland degradation on the Qinghai-Tibetan plateau. *Journal of Arid Environments*, **97**, 3–8.

Caparrós, A., Huntsinger, L., Oviedo, J. L., Plieninger, T. & Campos, P. (2013). Economics of ecosystem services, Chapter 12. In *Mediterranean Oak Woodland Working Landscapes: Dehesas of Spain and Ranchlands of California*, Campos, P., Huntsinger, L., Oviedo, J. L., Starrs, P. F., Díaz, M., Standiford, R. B. & Montero, G. (eds.). Dordrecht: Springer Landscape Series, pp. 353–388.

Chaplin-Kramer, R., Tuxen-Bettman, K. & Kremen, C. (2011). Value of wildland habitat for supplying pollination services to Californian agriculture. *Rangelands*, **33**, 33–41.

Charnley, S., Sheridan, T. E. & Nabhan, G. P. (eds.) (2014). *Stitching the West Back Together: Conservation of Working Landscapes*. Chicago, MI: University of Chicago Press.

Clutton-Brock, J. (1989). *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*. London/Boston: Unwin Hyman.

Commerford, J. L., Leys, B., Mueller, J. R. & McLauchlan, K. K. (2016). Great Plains vegetation dynamics in response to fire and climatic fluctuations during the Holocene at Fox Lake, Minnesota (USA). *Holocene*, **26**, 302–313.

Cumming, D. H. M., Osofsky, S. A., Atkinson, S. J. & Atkinson, M. W. (2015). Beyond fences: Wildlife, livestock and land use in Southern Africa. In *One Health: The Theory and Practice of Integrated Health Approaches*, J Zinsstag, E. Schelling, D. Waltner-Toews, M. Whittaker & M. Tanner. Wallingford: CABI, pp. 243–257.

Ellickson, R. C. (1986). Of coase and cattle: Dispute resolution among neighbors in Shasta County. *Stanford Law Review*, **38**, 623–687.

Fan, M. M., Li, W. J., Zhang, C. C. & Li, L. H. (2014). Impacts of nomad sedentarization on social and ecological systems at multiple scales in Xinjiang Uyghur Autonomous Region, China. *Ambio*, **43**, 673–686.

Fernandez-Gimenez, M. E. (2002). Spatial and social boundaries and the paradox of pastoral land tenure: Case study from postsocialist Mongolia. *Human Ecology*, **30**, 49–78.

Fernandez-Gimenez, M. E. & Le Febre, S. (2006). Mobility in pastoral systems: dynamic flux or downward trend? *International Journal of Sustainable Development and World Ecology*, **13**, 341–362.

Folke, C., Hahn, T., Olsson, P. & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources*, **30**, 441–473.

Fortmann, L. (2005). What we need is a community Bambi: The perils and possibilities of powerful symbols. In *Communities and Conservation: Histories and Politics of Community-Based Natural Resource Management*, J. P. Brosius, A. Lowehaupt Tsing & C. Zerner (eds.). Walnut Creek, CA: AltaMira Press, pp. 195–205.

Gongbuzeren, Li, Y. & Li, W. (2015). China's rangeland management policy debates: What have we learned? *Rangeland Ecology & Management*, **68**, 305–314.

Gripne, S. L. (2005). Grassbanks: Bartering for conservation. *Rangelands*, **27**, 24–28.

Hardin, G. (1968). The tragedy of the commons. *Science*, **162**, 1243–1248.

Havstad, K. M. & Peters, D. P. C. (1999). People and rangeland biodiversity – North America. *Proceedings of the Sixth International Rangeland Congress*, **2**, 634–638.

Hobbs, N. T., Galvin, K. A., Stokes, C. J., Lackett, J. M., Ash, A. J., Boone, R. B., Reid, R. S. & Thornton, P. K. (2008). Fragmentation of rangelands: Implications for humans, animals, and landscapes. *Global Environmental Change – Human and Policy Dimensions*, **18**, 776–785.

Huntsinger, L. (2009). Into the wild: Vegetation, alien plants, and familiar fire at the exurban frontier. In *The Planner's Guide to Natural Resource Conservation*, A. X. Esparza & G. McPherson (eds.). New York, NY: Springer, pp. 133–156.

Huntsinger, L., Forero, L. & Sulak, A. (2010a). Transhumance and pastoralist resilience in the western United States. *Pastoralism: Research, Policy, and Practice*, **1**, 1–15.

Huntsinger, L., Johnson, M., Stafford, M. & Fried, J. (2010b). Hardwood rangeland landowners in California from 1985 to 2004: Production, ecosystem services, and permanence. *Rangeland Ecology and Management*, **63**, 324–334.

Huntsinger, L. & Oviedo, J. L. (2014). Ecosystem services are social-ecological services in a traditional pastoral system: The case of California's Mediterranean rangelands. *Ecology and Society*, **19**, 8. (http://www.ecologyandsociety.org/vol19/iss1/art8/).

Huntsinger, L. & Sayre, N. E. (2007). Introduction: The working landscapes special issue. *Rangelands*, **23**, 9–13.

Huntsinger, L., Sayre, N. E. & Macauley, L. (2014). Ranchers, land tenure, and grass-roots governance: maintaining pastoralist use of rangelands in the U.S. in three different settings. In *The Governance of Rangelands: Collective Action for Sustainable Pastoralism*, J. Davies (ed.). New York, NY: Routledge, p. 298.

Huntsinger, L., Sayre, N. F. & Wulfhorst, J. D. (2012). Birds, beasts and bovines: Three cases of U.S. pastoralism and wildlife. *Pastoralism: Research, Policy, and Practice*, **2**, 1–28.

Huntsinger, L., & Starrs, P. F. (2006). Grazing in arid North America: A biogeographical approach. *Secheresse*, **17**, 219–233.

Kremen, C. & Miles, A. (2012). Ecosystem services in biologically diversified versus conventional farming systems: Benefits, externalities, and trade-offs. *Ecology and Society*, **17**, 40. (http://www.ecologyandsociety.org/vol17/iss4/art40/).

Kremen, C., Iles, A. & Bacon, C. (2012). Diversified farming systems: An agroecological, systems-based alternative to modern industrial agriculture. *Ecology and Society*, **17**, 44. (http://www.ecologyandsociety.org/vol17/iss4/art44/).

Li, W. J. & Huntsinger, L. (2011). China's grassland contract policy and its impacts on herder ability to benefit in Inner Mongolia: Tragic feedbacks. *Ecology and Society*, **16**, 1. (http://www.ecologyandsociety.org/vol16/iss2/art1/main.html).

Li, W. J. & Li, Y. (2012). Managing rangeland as a complex system: How government interventions decouple social systems from ecological systems. *Ecology and Society*, **17**, 9. (http://www.ecologyandsociety.org/vol17/iss1/art9/).

Li, W. J., Ali, S. H. & Zhang, Q. (2007). Property rights and grassland degradation: A study of the Xilingol Pasture, Inner Mongolia, China. *Journal of Environmental Management*, **85**, 461–470.

Li, Y., Fan, M. & Li, W. J. (2015). Application of payment for ecosystem services in China's rangeland conservation initiatives: A social-ecological system perspective. *Rangeland Journal*, **37**, 285–296.

Liffmann, R. H., Huntsinger, L. & Forero, L. C. (2000). To ranch or not to ranch: Home on the urban range? *Journal of Range Management*, **53**, 362–370.

Maestas, J. D., Knight, R. L. & Gilgert, W. C. (2003). Biodiversity across a rural land-use gradient. *Conservation Biology*, **17**, 1425–1434.

Malpai Borderlands Group (2016). (http://www.malpaiborderlandsgroup.org/).

McAllister, R. R. J., Gordon, I. J., Janssen, M. A. & Abel, N. (2006). Pastoralists' responses to variation of rangeland resources in time and space. *Ecological Applications*, **16**, 572–583.

Naudts, K., Chen, Y., McGrath, M. J., Ryder, J., Valade, A., Otto, J. & Luyssaert, S. (2016). Europe's forest management did not mitigate climate warming. *Science*, **351**, 597–600.

Netting, R. M. (1981). *Balancing on an Alp: Ecological Change and Continuity in a Swiss Mountain Community*. Cambridge: Cambridge University Press.

Niamir-Fuller, M., Kerven, C., Reid, R. & Milner-Gulland, E. (2012). Co-existence of wildlife and pastoralism on extensive rangelands: Competition or compatibility? *Pastoralism: Research, Policy and Practice*, **2**, 1–14.

Oba, G., Stenseth, N. C. & Lusigi, W. J. (2000). New perspectives on sustainable grazing management in arid zones of sub-Saharan Africa. *BioScience*, **50**, 35–51.

Olsson, P., Folke, C. & Berkes, F. (2004). Adaptive comanagement for building resilience in social-ecological systems. *Environmental Management*, **34**, 75–90.

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge: Cambridge University Press.

Ostrom, E., Janssen, M. A. & Anderies, J. M. (2007). Going beyond panaceas. *Proceedings of the National Academy of Sciences of the United States of America*, **104**, 15176–15178.

Oteros-Rozas, E., Martín-López, B., López, C. A., González, J. A., Plieninger, T. & Montes, C. (2014). Socio-cultural valuation of ecosystem services in a transhumance social-ecological network. *Regional Environmental Change*, **14**, 1269–1289.

Oviedo, J. L., Huntsinger, L., Campos, P. & Caparros, A. (2012). Income value of private amenities assessed in California oak woodlands. *California Agriculture*, **66**, 91–96.

Porensky, L. M. & Veblen, K. E. (2015). Generation of ecosystem hotspots using short-term cattle corrals in an African savanna. *Rangeland Ecology and Management*, **68**, 131–141.

Reid, R. S., Fernandez-Gimenez, M. E. & Galvin, K. A. (2014). Dynamics and resilience of rangelands and pastoral peoples around the globe. *Annual Review of Environment and Resources*, **39**, 217–242.

Sayre, N. F. (2005). *Working Wilderness: The Malpai Borderlands Group and the Future of the Western Range*. Tucson, AZ: Rio Nuevo Publishers.

Sayre, N. F. (2008). The genesis, history, and limits of carrying capacity. *Annals of the Association of American Geographers*, **98**, 120–134.

Sayre, N. F., Carlisle, L., Huntsinger, L., Fisher, G. & Shattuck, A. (2012). The role of rangelands in diversified farming systems: Innovations, obstacles, and opportunities in the USA. *Ecology and Society*, **17**, 43. (http://www.ecologyandsociety.org/vol17/iss4/art43/).

Sayre, N. F., McAllister, R. R. J., Bestelmeyer, B. T., Moritz, M., & Turner, M. D. (2013). Earth stewardship of rangelands: Coping with ecological, economic, and political marginality. *Frontiers in Ecology and the Environment*, **11**, 348–354.

Seeger, R. & Vecchi, G. A. (2010). Greenhouse warming and the 21st century hydroclimate of southwestern North America. *Proceedings of the National Academy of Sciences*, **107**, 21277–21282.

Shannon, G., Thaker, M., Vanak, A. T., Page, B. R., Grant, R. & Slotow, R. (2011). Relative impacts of elephant and fire on large trees in a savanna ecosystem. *Ecosystems*, **14**, 1372–1381.

Smith, A. H. & Martin, W. E. (1972). Socioeconomic behavior of cattle ranchers, with implications for rural community development in the west. *American Journal of Agricultural Economics*, **54**, 217–225.

Starrs, P. F. (1998). *Let the Cowboy Ride: Cattle Ranching in the American West*. Baltimore, MD: Johns Hopkins University Press.

Stokes, C. J., McAllister, R. R. J. & Ash, A. J. (2006). Fragmentation of Australian rangelands: Processes, benefits and risks of changing patterns of land use. *Rangeland Journal*, **28**, 83–96.

Talbert, C. B., Knight, R. L. & Mitchell, J. E. (2007). Private ranchlands and public land grazing in the southern Rocky Mountains. *Rangelands*, **29**, 5–8.

Thompson, C. (2002). When elephants stand for competing philosophies of nature: Amboseli National Park, Kenya. In *Complexities: Social Studies of Knowledge Practices*, J. Law & A. Mol (eds.). Durham, NC: Duke University Press, pp. 166–190.

Utrilla, V., Brizuela, M. & Cibils, A. (2005). Riparian habitats (mallines) of Patagonia – A key grazing resource for sustainable sheep-farming operations. *Outlook on Agriculture*, **34**, 55–59.

Veldman, J. W., Overbeck, G. E., Negreiros, D., Mahy, G., Le Stradic, S., Fernandes, G. W., Durigan, G., Buisson, E., Putz, F. E., & Bond, W. J. (2015). Where tree planting and forest expansion are bad for biodiversity and ecosystem services. *BioScience*, **65**, 1011–1018.

Vetter, S. (2005). Rangelands at equilibrium and non-equilibrium: Recent developments in the debate. *Journal of Arid Environments*, **62**, 321–341.

Williams, D. M. (1996). Grassland enclosures: Catalyst of land degradation in Inner Mongolia. *Human Organization*, **55**, 307–313.