Livestock Grazing and Wildlife Conservation in the American West: Historical, Policy and Conservation Biology Perspectives

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Livestock Grazing and Wildlife Conservation in the American West: Historical, Policy and Conservation Biology Perspectives

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Introduction

Grazing by domesticated livestock, primarily cattle, is the most ubiquitous land use in the western United States. Approximately 70% of the 11 westernmost states in the United States (those including and west of the Rocky Mountains) is grazed by livestock, at least part of the year (CAST 1974; Longhurst et al. 1982; Crumpacker 1984), including approximately 90% of federal land in these states (Armour et al. 1991). Livestock grazing occurs in more than 75% of the ecoregions delineated by the World Wildlife Fund (Ricketts et al. 1999) in the American West. It represents a primary ecological influence in more than half of these ecoregions.

The term *rangelands* is applied to most of the diverse ecological communities in this region – coniferous forests, broadleaf riparian forests, deserts, sandstone canyons and grasslands – if livestock are prevalent. There is no such thing as 'rangelands' in an ecological sense. While the term connotes open grasslands, it is in fact a catchword that implies a predominant form of land use – grazing by domesticated livestock – rather than any type of ecological community.

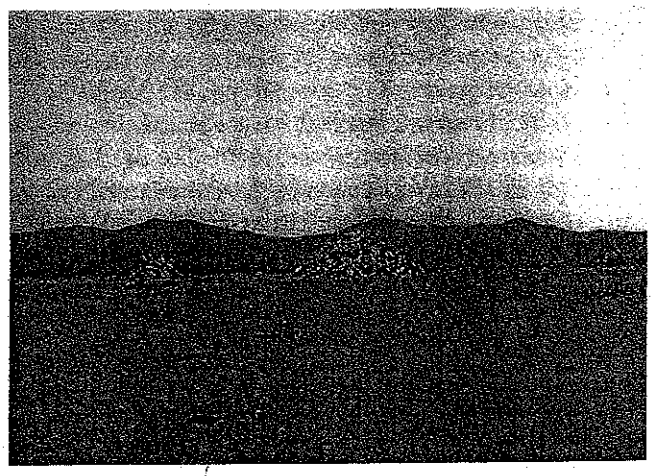
Wild Rangelands: Conserving Wildlife While Maintaining Livestock in Semi-Arid Ecosystems, 1st edition. Edited by J.T. du Toit, R. Kock, and J.C. Deutsch.

While the term *grazing* sometimes is applied strictly to eating grasses, livestock in the arid and semi-arid American West feed on a wide variety of plant life forms – including forbs, shrubs and small trees. In this review, 'grazing' will refer to herbivory in this broader sense.

History and policy of grazing in the American West

Cattle first arrived in what is now the United States in 1540 when the Spanish explorer Coronado came north from Mexico into present-day Arizona, New Mexico, Colorado and as far east as Kansas. He was soon followed by missionaries who extolled the virtues of pastoralism; by 1700, many of these missions were major livestock centres (Stewart 1936; Stoddart & Smith 1943; Brand 1961). The trappings of American ranch culture – brands, seasonal roundups, rodeos and cattlemen's associations – were also imported from Mexico (Brand 1961). The region west of the Rocky Mountains incrementally became American territory in the nineteenth century and livestock interests have been embedded in the political, social and economic fabric of the region ever since. By the 1880s, immense herds of livestock roamed the West, provoking rampant economic speculation in the eastern United States and Great Britain on 'the beef bonanza' (Brisban 1881). By 1880, Utah was home to almost a hundred thousand cattle; New Mexico, a third of a million; Texas, over four million (Stewart 1936). But get-rich-quick schemes abruptly ran up against two hard climatic realities of the American West: aridity and unpredictability. The ecological consequences of aridity became apparent from the dramatic decline of forage plants. Climatic unpredictability traumatized the fledgling livestock industry when severe winter blizzards alternated with hot, dry summers in the second half of the 1880s. As much as 85% of herds perished in some regions; bones littered the ground from the prairies of the north to the deserts of the south (Bahre & Shelton 1996; Fleischner 2002; Figure 9.1).

These ecological events and human tragedies set the stage for eventual reform of livestock grazing practices in the western United States. Faint stirrings about the need for regulation began to be heard in the ranching community in the early twentieth century, but many ranchers remained steadfastly against any governmental role in their industry. As a result, livestock grazing was the last major form of land use in the American West to be regulated by the government. Long after federal oversight of mining and



(a)

(b)

Figure 9.1 **State of Arizona rangelands in 1903: (a) Bones from dead cattle and horses, Robles Ranch; livestock bones were sold for fertilizer; (b) Dead cattle, near Avicaca (Both photographs by D.A. Griffiths, Arizona Experiment Station botanist. Courtesy of the National Archives, Washington, D.C.; 15.1.a – March 21, 1903 – Photograph No. R83-FB-2145; 15.1.b – April 10, 1903 – Photograph No. R83-FB-1760).**

timber harvest were established and national parks and forests were created, range management was essentially non-existent.

Finally, in 1934, amidst continuing controversy, the pivotal Taylor Grazing Act was passed, which asserted the federal government's responsibility to manage livestock grazing (Foss 1960; Stout 1970). The need for range reform became increasingly visible, as evidence of the Dust Bowl began to literally dominate the atmosphere of the country. Passage of the bill was encouraged by what one senator called 'the most tragic, the most impressive lobbyists that have ever come to this capital' – some of the worst dust clouds in history, that had blown over a thousand miles from the overgrazed prairies of the Dust Bowl (Foss 1960). Livestock management practices were radically overhauled in the wake of the Taylor Grazing Act. Formal allotments were established, but because ranges had been seriously overstocked, not all ranchers received the new federal permits. While some ranchers were granted long-term access to the new grazing allotments, others were excluded from their former grazing lands. A new federal agency was established, which soon was named the U.S. Grazing Service and eventually transformed into the Bureau of Land Management (BLM) (Foss 1960; Muhn & Stuart 1988; Klyza 1996).

From the outset, this new agency promoted the ideal of 'home rule on the range', granting extraordinary regulatory authority to ranchers – in effect, allowing ranchers to determine the rules that would govern them. Ranchers representing newly established grazing district advisory boards were formed into a National Advisory Board Council. A member of that council later recollected that ranchers wrote the entire Federal Range Code at the council's first meeting, with government officials polite enough to offer to leave so as not to interfere (Foss 1960). This indicates the uniquely privileged role that livestock interests have played in American politics and policy.

Over a quarter of senators represent western states where livestock grazing is prevalent and tend to be unified in its defense. Quite a few of them have been ranchers themselves. These politicians often are appointed to Congressional committees that oversee livestock grazing policy. Congresspersons from other parts of the nation, where the BLM has no jurisdiction, have nothing to gain politically by contradicting the interests – reliably pro-ranching – of the western delegations. Consequently, a small group of Western politicians have historically exerted disproportionate influence over federal rangeland policy. Political scientist Foss (1960) referred to this as a *special private government*. BLM's most dependable supporters in Congress are those Western representatives who tend to have the strongest agenda to be pushed on it (Klyza 1996).

Similarly, the control of regulatory policy by the very same group it is supposed to regulate, as occurred with district and national advisory boards, is an example of a captured policy pattern. This represents one feature of *interest-group liberalism* – 'a system of self-government in which economic interests, organized in groups, are delegated authority over policy-making in their policy realm' (Klyza 1996). No other interest group has succeeded at this as thoroughly as ranchers. This notion of ranchers' political advantage is echoed by legal historians (Scott 1967; Donahue 1999). According to Scott (1967): 'the American cattle industry is unique in American history.... Because the industry developed and was strong before the law making and enforcement agencies... were developed it made its own law. ... The ranchers sought the benefit of the legislatures and received it. ... Finally, if there was no other way to preserve the needs of the cattle industry, the participants ignored or disobeyed... laws.' Any reflection on contemporary livestock grazing policy must be seen in the light of this long history of political privilege. Moreover, literature, film, and more recently, television have embedded a romantic view of cowboys and ranching into American popular culture as the genre of 'Westerns' developed in the twentieth century.

Land use that had been the last to be regulated by government was also the last to be monitored by citizen groups. Bernard DeVoto, writing in the 1930s, was one of the few early voices to speak critically of livestock grazing and its associated culture in the American West (DeVoto 1936; Stegner 1988). The 1960s and 1970s were a time of great political tumult in the United States of America and out of this unrest a revitalized environmental movement burst forth – its genesis often dated to the first Earth Day in 1970. This movement coincided with a general upsurge in outdoor and wilderness recreation. The more arid portions of the American West, which had generally been ignored by the public, began to be noted for their scenic and recreational values. As more people paid more attention to the canyon and desert country of the intermountain West (the region between the Sierra–Cascades ranges and the Rocky Mountains), they began to notice the omnipresence of livestock. Incrementally, critics began to voice concern about the management of these lands. Writings that questioned the status quo of range management began to appear in the popular media in the 1970s and 1980s (for example, Miller 1972; Ferguson & Ferguson 1983; Fradkin 1979). In what would have been unthinkable a few years earlier, the sportsmen's magazine *Outdoor Life* editorialized in 1985: 'fish and wildlife's biggest enemy is the excessive livestock grazing being done on more than 200 million acres....' (Williamson 1985).

At the same time, more scientists began to pay attention to range management issues. Academic programs in range management within public universities had begun to develop in the 1920s–40s. The first comprehensive textbook (Stoddart & Smith 1943) had appeared in 1943 (its authors stressed that it dealt with range management, not range conservation, because conservation 'implies disuse . . . and disuse is waste') and a professional organization, the Society for Range Management, was founded in 1948. But for several decades most scientific attention came from people affiliated with the livestock industry or agricultural colleges, where livestock production was assumed to be of paramount importance. In the 1980s and 1990s, however, as ecological science became more sophisticated and conservation biology developed a broad focus on biodiversity, more widespread scientific attention began to be paid to 'rangelands'.

Wildlife conservation on rangelands: ecology and conservation biology play a larger role

Effects on ecological integrity

Wildlife and fisheries scientists were among the first to declare disturbing ecological effects of livestock grazing. A federal government symposium in 1977 concluded that livestock grazing was 'the single most important factor limiting wildlife production in the West' (Smith 1977). In 1979, an interagency committee in Oregon and Washington, composed of state and federal biologists, concluded that livestock grazing was the most important factor degrading fish and wildlife habitat in the 11 western states (Oregon-Washington Interagency Wildlife Committee 1979). In the 1990s, three professional scientific societies came out with position statements that enumerated ecological concerns with grazing practices: the American Fisheries Society (Armour et al. 1991), Society for Conservation Biology (Fleischner et al. 1994) and The Wildlife Society (1996). These and other scientists were concerned with what they perceived as the role of livestock in disrupting ecological integrity – an ecosystem's composition, structure, function (Angermeier & Karr 1994; Trombulak et al. 2004).

Livestock grazing affects different species and communities in distinct ways. Failure to recognize these natural differences – and a resulting oversimplified perspective on vegetation change – can lead observers to faulty conclusions concerning the effects of grazing, as 'good' or 'bad'. Not only do different

species of grazers cause different impacts, but plant species, even related ones, can respond dissimilarly to grazing. Some species benefit from grazing-related disturbance, while it is deleterious to others. Often, species that benefit are habitat generalists (Ohmart 1996). For example, populations of the American robin (*Turdus migratorius*), one of the most widespread bird species in North America, increased in heavily grazed riparian habitat, while other species that require dense vegetation declined (Schulz & Leininger 1991). Species that prefer open habitats with lower vegetative density can benefit from grazing (Taylor 1986; Saab et al. 1995). In southern Arizona grassland, birds typical of more xeric habitats were more prevalent on livestock-impacted sites than on adjacent livestock exclosures (Bock et al. 1984). However, in ponderosa pine (*Pinus ponderosa*) forest and savanna in northern Arizona, cattle grazing reduced nesting success of a ground-nesting sparrow (dark-eyed junco, *Junco hyemalis*) by 75%. Livestock grazing created a less favorable microclimate, exposed nests to predators and, in some cases, damaged them directly through trampling (Walsberg 2005). Presumably, a canopy-nesting species in this same forest may have been unaffected by the same livestock grazing activity. In general, understorey bird species are especially impacted by livestock grazing (Krueper et al. 2003).

It has been suggested that livestock can be utilized as a wildlife management tool (Bokdam & Wallis de Vries 1992; Hobbs & Huenneke 1992). Severson (1990) clarified that such applications may be very limited. Because two species in the same community often respond differently to livestock grazing (Hobbs & Huenneke 1992), determination of its success or failure as a management tool depends on which species is used as a criterion. Thus, assessing the possible utility of livestock as a management tool must be context and species specific.

In a study of historic livestock grazing impacts at Chaco Culture National Historic Park in northern New Mexico – one of the longest continuously grazed regions of North America – vegetation at different sites responded differently to long-term (50+ years) protection from grazing, depending on specific site characteristics (Floyd et al. 2003; Floyd et al. In Press). Grasses were favoured in alluvial canyon bottoms, shrubs in upland sites and dense biological soil crusts on certain substrates. This variation reflected the inherent ecological potentials of the different sites – based on edaphic and topographic conditions, as well as residual plant propagules, degree of disturbance and details of land management history. Here, as elsewhere, simplistic conclusions of unilaterally positive or negative effects of grazing could be misleading.

Diverse taxa – including all vertebrate classes, vascular plants and cyanobacteria – have been observed to undergo negative effects from livestock grazing, including decreases in population size of individual species and reduction of species richness (reviewed in Fleischner 1994). Livestock grazing can influence plant communities through removal and structural alteration of vegetation (Krueper 1993; Saab et al. 1995; Dobkin et al. 1998; Krueper et al. 2003); trampling and compaction of soils and consequent effects on water availability and alteration of foraging guilds and disruption of successional patterns and nutrient cycling (Fleischner 1994). These influences on ecosystem composition, structure and function affect animals through direct and indirect effects on food resources, alteration of nesting habitat (including microclimate) and greater exposure to predation (Ammon & Stacey 1997; Walsberg 2005).

Distinct community types also respond differently to livestock grazing. In a review of the effects of grazing on neotropical migrant landbirds, Bock et al. (1993b) found an increasingly negative effect on bird abundances in grassland, riparian woodland and intermountain shrub-steppe community types. Almost equal numbers of grassland bird species had positive and negative responses to livestock grazing, while six times as many shrub-steppe species had negative responses as positive. Grasslands, the more resilient habitat, are much rarer than shrub-steppe in the West (Kuchler 1985).

Functioning and structure of both terrestrial and aquatic communities can also be dramatically altered by livestock grazing. Livestock grazing is considered one of three primary factors (along with fire suppression and logging) involved in changing the structure of ponderosa pine (*P. ponderosa*) forests, one of the most widespread forest types in the West, from open, park-like stands with dense grass cover to communities characterized by dense pine reproduction and lack of grasses (Rummell 1951; Cooper 1960; Covington & Moore 1994). Stand structure and soil dynamics of mixed conifer (*P. ponderosa, Pseudotsuga menziesii*) forests were similarly altered by long-term livestock grazing (Belsky & Blumenthal 1997).

The introduction of non-native grazing mammals to ecosystems usually involves dramatic alteration of soil and geomorphic characteristics (reviewed in Fleischner 1994; Trimble & Mendel 1995; also see Belsky & Blumenthal 1997). Trampling by livestock compacts the soil, decreasing its capacity for water infiltration (Gifford & Hawkins 1978); consequently, heavily grazed habitats have less capacity to hold water, thereby exacerbating the greatest limiting factor in arid and semi-arid ecosystems.

Livestock grazing has been a major contributing factor to stream channel entrenchment ('arroyo-cutting') in the West (Bryan 1925; Cooperrider & Hendricks 1937; Leopold 1946, 1951; Ohmart & Anderson 1982; Hereford & Webb 1992).

The influences of livestock grazing on species composition and on physical habitat characteristics interact to create community-scale alterations. At Capitol Reef National Park in central Utah, paleoecologists determined that the most dramatic vegetation change during the past 5400 years occurred in the past two centuries. They suggested that livestock grazing was the precipitating factor for this historic habitat change (Cole et al. 1997). Further south, climatologists and plant ecologists working along the United States–Mexico border attributed increasing soil surface temperatures and albedo to livestock grazing-related land degradation. They noted a positive feedback loop: grazing-related degradation leading to increases of local temperatures and potential evapotranspiration levels, which in turn reinforces the degradation (Balling et al. 1998).

Changes to forest stand structure and soil dynamics, described above, also altered fire patterns in these ecosystems (Belsky & Blumenthal 1997). By selectively foraging on herbaceous understories, livestock have opened up habitat for young trees, allowing greater recruitment – ultimately leading to much higher tree densities. This replacement of fine fuels with dense stands of small trees has dramatically increased fuel loads and thus, fire intensities. In the mountains along the United States–Mexico borderlands, the frequency of surface fires decreased dramatically between 1870 and 1900 – a change initially caused by livestock grazing and subsequently by a combination of grazing and fire suppression. On the Mexican side of the border, where livestock grazing was less intense and fire suppression more sporadic, surface fires continued well into the twentieth century (Swetnam et al. 2001). Livestock grazing has contributed less directly to increases in fire frequency in riparian habitats. Fire was historically rare in native riparian communities of the Southwest (Bahre 1985; Swetnam 1990), but riparian fire has become more common where the invasive alien tree, tamarisk (*Tamarix*), has become established (Busch & Smith 1993). The spread of tamarisk has been aided by livestock grazing (discussed below), which in turn has increased riparian fire frequency.

The influence of livestock grazing on two ecological features of the region – riparian habitat and biological soil crusts – have special importance for wildlife conservation and will be looked at in detail below.

Riparian habitats – essential to wildlife

Riparian ecosystems are the most critical wildlife habitats in the rangelands of the American West (Thomas et al. 1979). Riparian communities are among the most productive habitats in the American West. This vegetation type covers only 0.1% of the Western landscape (Ohmart 1996), yet provides habitat for more species of birds than all other habitats combined (Knopf et al. 1988). Approximately three-quarters of the vertebrate species in Arizona and New Mexico depend on riparian habitats for at least a portion of their life cycles (Johnson et al. 1977; Johnson 1989). One regional analysis concluded that more than three-quarters of the bird species of Southwestern deserts were dependent in some manner on water-related habitat; over half were completely dependent (Johnson et al. 1977; Chaney et al. 1990; Rich 2002). Riparian areas have been found to harbour more than 10 times the number of migrant birds as adjacent uplands (Stevens et al. 1977). Over 60% of the bird species identified as Neotropical migrants by the Partners in Flight program used western riparian areas during the breeding season or as migratory stopovers (Krueper 1993). In the Interior Columbia River Basin of the Pacific Northwest, over 60% of 132 species of neotropical migrants used riparian habitats – far more than any other habitat type (Saab & Rich 1997). Even xeroriparian habitats – normally dry stream corridors that intermittently carry floodwaters through low deserts – support 5–10 times the bird densities and species diversity of surrounding desert uplands (Johnson & Haight 1985). The critical importance of healthy riparian habitats for wildlife conservation in the region cannot be overemphasized.

But livestock has become concentrated in riparian habitats (Ames 1977; Kennedy 1977; Thomas et al. 1979; Roath & Krueger 1982; Van Vuren 1982; Gillen et al. 1984) for the same reasons as wildlife – the greater availability of water, shade and food than in adjacent dry country. Heavy-bodied herbivores have many impacts on riparian zones, however. In 1990, the U.S. Environmental Protection Agency concluded that riparian conditions throughout the West were the worst in history (Chaney et al. 1990). Several reviews have summarized the effects of livestock grazing on riparian habitats and their wildlife (Platts 1979, 1981; Kauffman & Krueger 1984; Fleischner 1994; Ohmart 1996; Belsky et al. 1999). In a comparison of five southern Arizona streams, Rucks (1984) determined that livestock grazing was the major factor degrading broadleaf riparian forest to scrub. Ohmart (1996) proposed three conceptual stages in riparian habitat degradation that occur over the span of approximately

200 years. Because habitat change continues over a longer time frame than that of human lives, degradation is often imperceptible to casual observers.

Young shoots of riparian trees such as cottonwood (*Populus* spp.) and willow (*Salix* spp.) are foraged by livestock, greatly reducing regeneration and converting riparian forests into even-aged stands of older trees (Szaro 1989). When livestock was removed in the early 1990s from the Fremont River corridor flowing through Capitol Reef National Park, Utah, cottonwood seedlings quickly recolonized sandbars from which they had largely been absent for decades. Livestock foraging in lush riparian vegetation compete with native herbivorous species, often eating the most nutritive elements of the vegetation. Grazers also remove organic debris, which eliminates cover for ground-dwelling species, such as snakes and lizards (Jones 1981, 1988; Szaro et al. 1985). Livestock grazing has been a principal factor contributing to the decline of native fishes in the West (Miller 1961; Armour et al. 1991). Cattle activities, especially damaging to fish habitat, are the removal of vegetative cover and the trampling of overhanging streambanks (Behnke & Zarn 1976; Platts 1981). Reduced vegetative cover leads to increased water temperatures and trampling-induced loss of streamside pools, which provide cover and increases predation risk.

Livestock grazing is the most widespread and pervasive threat to riparian habitats in the arid West. Other threats include water diversion and pumping, the introduction of alien species, recreation and timber harvest (Chaney et al. 1990; Fleischner 1994; Ohmart 1994; Dobkin et al. 1998). Disturbance by domesticated herbivores contributes to increases in non-native plant species (Parker et al. 2006). Livestock spread alien plants by dispersing seeds, opening up habitat for new species and reducing competition from the native species by eating them. Invasions of alien grass species in North America have been most severe in the more arid parts of the West, where invasion by many species (e.g. *Bromus tectorum*, *Bromus rubens*, *Bromus mollis*, *Bromus diandrus*, *Taeniatherum asperum* and *Avena* spp.) was associated with livestock grazing (Gould 1951; Mack 1981; D'Antonio & Vitousek 1992; Belsky & Gelbard 2000). Long-term livestock grazing in riparian areas has promoted establishment of tamarisk (*Tamarix*; Everitt 1980; Ohmart & Anderson 1982; Minckley & Brown 1994). Tamarisk stands have lower species richness of native avifauna than the native cottonwood-willow forests that they often replace (Ohmart & Anderson 1982; Strong & Bock 1990; Rosenberg et al. 1991).

One of the simplest and most effective means of conserving native wildlife in the American West is excluding livestock from riparian corridors. Ohmart

(1996), in a comprehensive review of wildlife conservation in riparian zones, concluded that 'the best way to manage riparian habitats is not to graze them.' The Smithsonian Migratory Bird Center (n.d.) stated that livestock grazing 'remains the single most destructive force that can be practically and significantly reduced' to benefit neotropical migrant birds. A recent synthesis of research in seven riparian ecosystems in five western states concluded that 'reducing cattle grazing is likely to produce the greatest benefits for bird species dependent on western deciduous riparian habitats' (Tewksbury et al. 2002).

It is encouraging to note that riparian habitats begin to recover relatively quickly when grazing disturbance is removed. Studies along several Western streams have reported increases in native wildlife and fish populations in a decade or less after livestock have been fenced out (Winegar 1977; Dahlem 1979; Duff 1979; Keller et al. 1979; Keller & Burham 1982; Krueper et al. 2003). Aquatic habitat often heals more quickly than adjacent riparian vegetation (Knopf & Cannon 1982; Szaro & Pase 1983).

A century ago, the San Pedro River of southern Arizona was unincised and marshy along much of its length (Hendrickson & Minckley 1985), but by the 1970s, it had been severely degraded ecologically. Less than 20 years after removing livestock from the San Pedro, it has one of the highest bird diversities of any area of its size in North America (CEC 1999). The removal of cattle led to rapid, substantial recovery of both vegetation and bird populations, including several species of special conservation concern; the speed and magnitude of recovery was surprising – and encouraging (Krueper et al. 2003; Figure 9.2). However, numerous studies have concluded that such vibrant restoration of riparian ecosystem health requires complete removal of livestock (Ames 1977; Dahlem 1979; Davis 1982; Chaney et al. 1990; Kovalchik & Elmore 1992).

Biological soil crusts

Biological soil crusts provide critical ecosystem functions (Belnap & Lange 2003), including fixing carbon in sparsely vegetated areas. Such carbon contributions help keep interspaces between vascular plants fertile and support other microbial populations (Beymer & Klopatek 1991). The availability of nitrogen is an important factor limiting primary production in arid habitats throughout the world. In the Great Basin Desert of the western United States, nitrogen is second only to moisture in importance (James & Jurinak 1978). In desert shrub and grassland communities that support few nitrogen-fixing

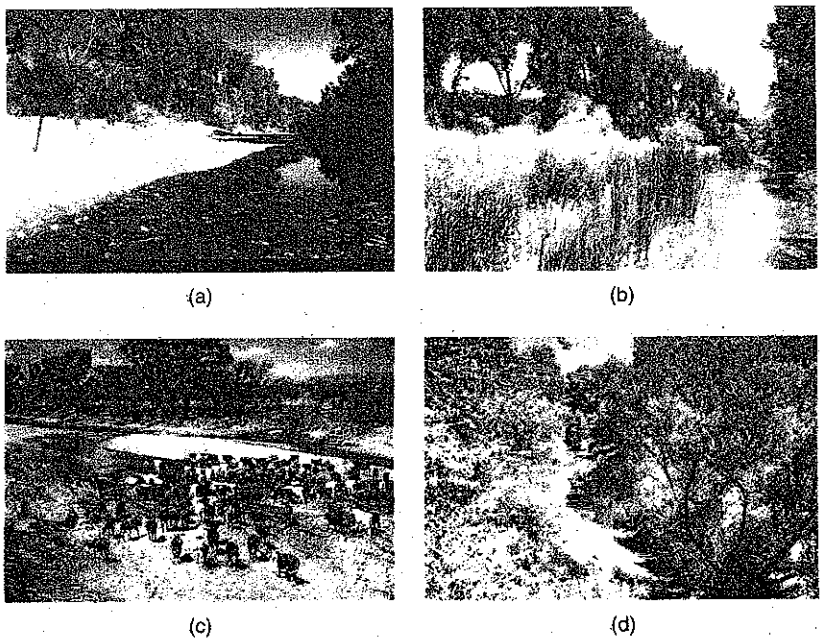


Figure 9.2 **San Pedro River, Cochise Co., Arizona, before and after exclusion of livestock in late 1987. Left and right photo in each pair taken at the same location: (a) June 1987; (b) June 1991 (less than 4 years recovery); (c) 1984; (d) 1997 (10 years recovery) (U.S. Dept. of Interior, Bureau of Land Management files; see Krueper et al. (2003) for more information).**

plants, biological soil crusts can be the dominant source of nitrogen (Rychert et al. 1978; Harper & Marble 1988; Evans & Ehleringer 1993; Evans & Belnap 1999). Nitrogen inputs are highly dependent on temperature, moisture and species composition of the crusts (Belnap & Lange 2003); therefore, both prevailing climate and the legacy of disturbances influence fixation rates (Belnap 1995, 1996). Additionally, crusts stabilize soils (Belnap & Gillette 1997, 1998; Warren 2003), retain moisture and provide seed germination sites. Soil crusts are effective in capturing aeolian dust deposits, contributing to a 2- to 13-fold increase in nutrients in southeastern Utah (Reynolds et al. 2001). The presence of soil crusts generally increases the amount and depth of rainfall infiltration (Loope & Gifford 1972; Brotherson & Rushforth 1983; Harper & Marble 1988; Johansen 1993). Thus, biological soil crusts play critical

roles regarding the two most important limiting factors in arid landscapes: water and nitrogen.

These crusts, however, are easily damaged by livestock, which are heavier and often more abundant and concentrated than most native mammals. Contrary to popular misconception, bison (*Bison bison*) were rare or absent in much of the area west of the Rocky Mountains during most of the Holocene (McDonald 1981). Bison were present in the northern Rockies region and to the east, Northeast and Northwest of the Great Basin (Hall 1981; Mack & Thompson 1982; Van Vuren & Bray 1985; Van Vuren 1987; Zeveloff 1988; Van Vuren & Dietz 1993), but absent altogether from Arizona (Cockrum 1960; Hoffmeister 1986), western New Mexico (Bailey 1971) and most of California (Jameson & Peeters 1988). Soil crusts became established where large, heavy grazing mammals were absent; the Great Plains east of the Rockies hosted enormous herds of bison – and little biological soil crust was left (Mack & Thompson 1982). Thus, the turf-forming grasslands of the Great Plains can support large herbivores more sustainably than can the bunchgrass communities west of the Rocky Mountains.

Not surprisingly, then, livestock grazing has been correlated with the loss of biological soil crust cover and species richness (Johansen et al. 1981; Anderson et al. 1982; Jeffries & Klopatek 1987; Belnap & Eldridge 2003). Crusts can be severely damaged even while they (Belnap 1993) and the more conspicuous vascular plant communities (Kleiner & Harper 1972; Cole 1990) appear healthy. Nitrogenase activity has been reduced by 80–100% in the crust under a single human footprint (Belnap 1994; Belnap et al. 1994) and nitrogen content in the leaves of dominant plant species was lower in trampled than untrampled areas (Harper & Pendleton 1993). If a single foot can grind nitrogen fixation to a halt, the impact of herds of much larger animals for more than a century is easily imagined. In the Chaco Canyon area of New Mexico, the cover of nitrogen-fixing crusts was significantly higher in areas that had been protected from livestock grazing for half a century than in those still being grazed (Floyd et al. 2003).

Other management considerations

The focus on livestock production on such a vast geographic scale has a number of less direct impacts on wildlife conservation. Fencing, which is a fundamental livestock management tool, can functionally fragment habitats

by impeding the movement of native species, such as pronghorn (*Antilocapra americana*). Water diversions and the introduction of alien plants, such as crested wheatgrass (*Agropyron cristatum*; see Menke & Bradford 1992 for an example) are sometimes undertaken as '*range improvements*'. The livestock industry has historically played a large role in the elimination of native predators, including wolves (*Canis lupus*), coyotes (*Canis latrans*) and mountain lions (*Puma concolor*). Some of the most energetic opposition to predator reintroductions, such as those of the Mexican grey wolf (*Canis lupus baileyi*) and Rocky Mountain grey wolf (*Canis lupus occidentalis*), continues to come from livestock interests.

Within land management agencies (especially the BLM and the U.S. Forest Service), livestock production has often been prioritized over wildlife conservation. This has been reflected in budgets and staffing, directed ultimately by Congressional dictates, which are prone to the political influences described above. For example, during 4 years in the late 1980s, the BLM directed only 3% of its total appropriation toward wildlife habitat management, compared to 34% for management of consumptive uses (range, energy and minerals and timber). During the same period the Forest Service allocated 4% of its appropriation to wildlife and fish habitat management and 26% to timber management (USGAO 1991). Moreover, field personnel of land management agencies (especially BLM) often lack faith that their conservation work will be supported by agency management if it is opposed by ranchers (USGAO 1988). Political and agency orientation towards livestock production can lead to contradictory management directions. For example, a U.S. Forest Service analysis of sensitive vertebrate species identified livestock grazing as one of five factors jeopardizing the northern goshawk (*Accipiter gentilis*) in the Southwest (Finch 1992), yet the goshawk management recommendations (Reynolds et al. 1992) released by the same office in the same year did not even mention livestock grazing. Such predilections by agencies reflect similar biases within the range management discipline; a respected 500-page textbook (Holecheck et al. 1989) devotes a single paragraph to nongame wildlife.

Livestock grazing in the American West amounts to a massive experiment without a control (Bock et al. 1993a; Noss 1994). The majority of the region has been devoted to this single land use, with only rare sites left ungrazed to allow comparisons. Not only are such livestock exclosures often too small to illuminate larger landscape effects, but virtually all of them had also been grazed by livestock in the past (thus, more accurately referred to as '*no longer grazed*' rather than '*ungrazed*' sites). Because initial impacts tend to be the most

severe, these formerly grazed exclosures probably underestimate the impacts of livestock grazing (Fleischner 1994). Bock et al. (1993a) called for a system of federal livestock exclosures, whereby 20% of all federal leases would be left ungrazed for comparative study. At present, relatively few large-scale livestock exclosures exist in the southwestern United States – prominent among them being the Audubon Research Ranch (Bock et al. 1984), Buenos Aires National Wildlife Refuge, Canyonlands National Park, Chaco Culture National Historic Park (Floyd et al. 2003), Grand Canyon National Park, Mesa Verde National Park (Smith 2003) and Organ Pipe Cactus National Monument.

In essence, livestock grazing poses two fundamental threats to the health of native wildlife populations in the American West: degradation of riparian habitat and destruction of biological soil crusts. Riparian habitat has wildlife conservation importance that is far beyond its limited geographic area – in many cases, it truly has hemispheric significance. Fortunately, experience over the past quarter century suggests that the restoration of this habitat – which accomplishes crucial wildlife conservation – is possible. The removal of livestock from riparian zones is relatively simple logistically, if not always politically. Damage to soil crusts, however, is less easily healed and has much longer term (and thus less obvious) ecological effects. Nevertheless, with rest from livestock grazing pressures, there are indications that crusts can begin to restore themselves (Floyd et al. 2003).

Current concerns, conflicts and potential

There is general consensus that livestock grazing has exerted enormous ecological influence on landscapes of western North America in the past. But there is significantly less agreement about contemporary grazing practices and about what should happen in the immediate future. Some ecologists and environmental activists insist that livestock grazing should be terminated on public lands, while others defend ranching as the key to the maintenance of open space and traditional cultural values of the region. Environmental groups continue to clamour for major reform of livestock grazing policy (e.g. Williams 2006). Not long ago Bruce Babbitt, former U.S. Secretary of Interior and member of an Arizona ranching family, said 'I am now convinced that livestock do not belong in arid deserts. If it gets less than 10 inches of rainfall, cattle do not belong there. I am here to say the presumption that grazing is the dominant use of our public lands is the artifact of a distant past and must be replaced.'

Many ranch operations have ceased, when children of ranch families have had less interest than their parents and grandparents in maintaining livestock businesses. These social changes occur in the context of shifting local and regional economies in the West (Power 1996). Even with below-market value grazing fees on government allotments, it can be difficult to make a living on ranching alone. Simultaneously, property values in many rural and exurban areas have escalated rapidly in recent years. Thus, selling ranch property for real estate subdivision can be an alluring financial temptation.

Ranchers often contend that any increase in regulatory restriction or grazing fees will force them to sell off their land for real estate development. As a result, 'cows versus condos' has become a primary rallying cry for creating coalitions of landowners and environmentalists concerned about the maintenance of open space (Sheridan 2001). In the face of an onslaught of real estate speculation and exurban development throughout the rural West, it seems self-evident that the habitat fragmentation that accompanies subdivision of ranches works against the conservation of biodiversity (Jensen 2001). Conflicting views abound, however. Some feel that, in certain cases, subdivisions create less of an ecological impact than livestock grazing and other agriculture (Wuerthner 1994). Others insist the reverse – that keeping rural areas inhabited by ranchers and other agriculturalists is essential to protecting wildlife (Brown & McDonald 1995; Knight et al. 1995; Maestas et al. 2003). Both views, however, represent an oversimplified dichotomy (Siegel 1996): subdivision of land *and* livestock grazing can be detrimental to biodiversity. Moreover, there is enormous variation on how both land uses are undertaken, so it can be misleading to think in terms of such a simple choice as 'cows vs. condos'.

A recent study (Bock et al. 2006) in southeastern Arizona teased apart the effects of livestock foraging from that of real estate development/home construction by looking at populations of native rodents, the numerically dominant vertebrates in the region. Contrary to assumptions of the 'cows vs. condos' framing, rodent species richness was completely unaffected by proximity to exurban development. However, rodent species richness and abundance were negatively affected by livestock grazing – whether from typical cattle ranching or from horses on 'ranchettes', where the density of livestock (including horses) is actually often higher than on a ranch. Vegetation and soil change from livestock (cattle and horse) activity, rather than development *per se*, degraded the native faunal diversity. If we are monitoring mammals larger than rodents, we might expect different results. Nevertheless, this

indicates that popular sentiments such as 'cows vs. condos' can obscure ecological complexities.

When reflecting upon such conflicts and controversies, it is useful to consider the psychological and social contexts of stakeholders. Social psychologists, observing cultural conflicts about rangeland issues, interviewed ranchers about a rangeland/endangered species conflict and noted that 'ranchers describe themselves as responsible stewards attuned to and part of nature, while they describe nonranchers as ignorant, irresponsible, insincere, and separate from nature' (Opotow & Brook 2003). While these researchers did not interview 'nonranchers', it is easy to imagine the same biases occurring in reverse. Thomashow (1995) defined a person's ecological identity as 'all the different ways people construe themselves in relationship to the earth as manifested in personality, values, actions, and sense of self'. Each person's ecological identity, he suggests, has three primary roots: childhood memories of special places, perceptions of disturbed places and contemplation of wild places. In a rangeland conflict, a rancher and an environmental activist both consider their lives deeply informed by their experience of, and passion for, nature. Yet their ecological identities might clash dramatically: the rancher's special childhood memory might involve working with family and livestock on a glorious summer day, while the activist's might stem from a remote national park, conspicuously removed from the presence of domesticated animals. Without understanding such fundamentally different human orientations to 'rangelands' – each valid in its own way – we are unlikely to progress towards the understanding and compassion necessary for the resolution of the conflict.

Social (group) identity also plays a key role in environmental conflicts. Social identities, such as 'rancher' and 'environmentalist', can allow individuals to stereotype and vilify those with different views through 'moral exclusion' – the sense that others can be excluded from the normal scope of fairness and civility (Opotow 1990). This moral exclusion can befall human political antagonists or other species considered unworthy of concern. One way some local groups have overcome these sorts of antagonisms is through the creation of a unifying 'overarching identity', such as the common purpose of protecting open space.

Conclusion

Three primary changes are needed to resolve ecological damage and social discord stemming from the legacy of livestock grazing in the American

West – two involving ecological restoration and one social. Two ecological restoration efforts are necessary for long-term conservation of wildlife in the arid and semi-arid regions of the American West. First, riparian areas – the most essential wildlife habitat in the region – must be restored. Abundant evidence suggests that the removal of livestock is necessary for restoration, but that ecosystem health can revive relatively quickly when this occurs. Second, to ensure long-term vitality of the region, biological soil crusts must be allowed to recolonize uplands. Because this involves much larger tracts of land and shows progress much more slowly, this will take greater political will to accomplish.

Finally, to resolve social conflicts on this issue, all parties involved need to strive for greater compassion (literally, 'feeling with') for people holding divergent views. Just as ranchers, environmental activists, land managers and scientists must all acknowledge some validity in each others' perspectives, the fundamental differences must be recognized, rather than pretending that all parties can achieve all their policy goals. Ultimately, difficult decisions must be made. These must be guided by the most accurate information possible, and communication between interest groups must be as honest and clear as possible. I conclude this review as I did an earlier one (Fleischner 1994): the future of livestock grazing in western North America is 'ultimately . . . a question of human values, not of science'. Clear and compassionate communication is needed more than ever.

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