REVIEW AND ANALYSIS OF CATTLE GRAZING EFFECTS IN THE ARID WEST, WITH IMPLICATIONS FOR BLM GRAZING MANAGEMENT IN SOUTHERN UTAH

A Literature Review Submitted to the Southern Utah Landscape Restoration Project

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INTRODUCTION

In 1995 the U.S Department of the Interior issued new Standards and Guidelines for grazing management that were to be applied to all BLM lands (USDI 1995). Each state BLM office then adopted these national guidelines in the form of state manuals that were to direct BLM management at the state level. In Utah, for example, the new national mandate is outlined in the *Utah Standards and Guidelines for Healthy Rangelands* (*USGHR*), which outlines four *Standards*[1] that are to be applied to all rangelands (Utah BLM 1997):

1. "Upland soils exhibit permeability and infiltration rates that sustain or improve site productivity, considering the soil type, climate, and landform.
2. Riparian and wetland areas are in properly functioning condition. Stream channel morphology and functions are appropriate to soil type, climate and landform.
3. Desired species, including native, threatened, endangered, and special-status species are maintained at a level appropriate for the site and species involved.
4. BLM will apply and comply with water quality standards established by the State of Utah (R.317-2) and the Federal Clean Water and Safe Drinking Water Acts. Activities on BLM lands will fully support the designated beneficial uses described in the Utah Water Quality Standards (R.317-2) for surface and ground water.

A key problem with current BLM grazing management in the arid west, and one that has frustrated outside observers and conservationists, is that the BLM will often acknowledge that areas are not meeting these Standards but is unable to definitively state the reasons behind noncompliance. This is problematic because it leads to inaction on the part of the BLM to work to improve conditions on the site. The systems in which the BLM works are highly complex, and it can be difficult to attribute degraded conditions to a specific cause without careful study. In light of these uncertainties, it would behoove the BLM to turn to the scientific literature to better analyze the various reasons behind non-compliance with *USGHR* in the arid west. The BLM has not yet conducted such a survey of the scientific literature, so one is provided for them here.

The following extensive review of the ecological literature was conducted to review the evidence that cattle grazing can impede the BLM from meeting *USGHR*. The vast majority of literature considered in this review comes from studies conducted in the Colorado Plateau and intermountain west, with particular emphasis on lower elevation sites such as those administered by the BLM. In addition to a review of the general literature, we use southern Utah as a "showcase," not only to highlight specific studies in

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[1] These standards can be achieved by meeting numerous objectives tied to each standard. Many of these objectives are discussed throughout this literature review, as they become pertinent under various topics.

the region, but also to analyze certain aspects of BLM grazing management in light of both *USGHR* and the findings of this review.

ECOLOGICAL IMPACTS OF GRAZING ON RESOURCES AND BIOLOGICAL VALUES IN THE ARID WEST

The scientific evidence that cattle grazing impacts arid western landscapes, and the sensitive biota found there, is vast. Yet what is perhaps more disturbing is the pervasiveness of these deleterious effects. Recent estimates on federal grazing lands in the western United States concluded that less than half the vegetation was 50% similar to the presumed climax community (U.S. General Accounting Office 1988b, 1991). The negative repercussions associated with cattle grazing on arid lands such as the Colorado Plateau and southern Utah can be seen in vegetative communities, faunal communities, abiotic systems, ecosystem processes, and streams and riparian/wetland habitats. The following literature review will not only expand on these effects, but will highlight how each Standard, and Indicators for meeting those Standards, can be compromised by cattle grazing.

Effects on Vegetative Communities

Various vegetative indicators required to meet the *Utah Standards and Guidelines* include "sufficient cover and litter [to prevent erosion and promote soil moisture], an appropriately diverse plant community that "sustains…properly functioning ecological conditions," and "diverse age structure and composition." As outlined below, each of these indicators can be severely affected by cattle grazing. Decreases in native plant species diversity, cover and density as a result of livestock grazing have been observed in a wide variety of arid ecosystems in the western U.S, including those of the Colorado Plateau of southern Utah. Moreover, these kinds of alterations to the vegetative community can in turn lead to significant repercussions for successional trajectories, the abiotic environment, and wildlife.

<u>Community composition</u>**:** Grazing affects species composition of plant communities in two ways: 1) active selection by herbivores for or against a specific plant taxon, and 2) differential vulnerability of plant taxa to grazing. Grazing can also delay plant phenology, which in turn can have dramatic effects on communities of pollinators and seed dispersers (Fleischner 1994), thereby further disrupting the composition of a vegetative community. Studies that have documented significantly greater native plant species richness in ungrazed areas compared to those that are grazed include Brady et al. (Arizona - 1989), and Floyd-Hanna et al. (New Mexico - 2000).

While cattle grazing has been shown to decrease species richness in arid communities, it similarly affects species evenness, with considerable secondary effects. Long-term cattle grazing has been shown to decrease the abundance of perennial grasses and forbs and increase the amount of annual grasses and weeds in western deserts (in northern Arizona-

Schmutz et al. 1967; the Great Basin-Rice and Westoby 1978; central Utah-Brotherson and Brotherson 1981; California-Hanley and Page 1981; and Nevada-Medin and Clary, 1990). Studies that have focused chiefly on impacts to perennial grasses have found densities of these grasses to be significantly decreased by grazing (in central Utah-Cottam and Evans 1945; New Mexico-Gardner 1950***;*** Arizona-Blydenstein et al. 1957; Capitol Reef N.P.-Rosenstock 1996). Studies that have shown shrub cover to significantly decrease due to cattle grazing include Bock et al. (Arizona - 1984) and Jones (Nevada - 1999). Any significant grazing-induced changes in cover, densities or relative abundances of certain plant species or guilds can in turn have profound implications at the community level, as these changes can translate into major conversions of community organization, for example, transforming grassland to desert (Schlesinger et al. 1990).

While it is useful to document various studies that demonstrate the deleterious effects of cattle grazing on arid plant communities, previously completed literature reviews comprise the strongest evidence of the impacts cattle have on vegetation in xeric environments. For example, in a quantitative literature review involving 50 independent grazed/ungrazed comparisons from 41 different studies performed in arid environments of the western U.S., Jones (2000) found significant negative impacts of cattle grazing on shrub cover, grass cover, vegetation biomass, and seedling survival. Another extensive literature review by Fleischner (1994) cites numerous cases where grazing was shown to have deleterious effects on vegetative communities.

Proliferation of exotics**:** One particularly insidious result of cattle grazing in arid western ecosystems is the spread of exotic grasses and weeds. Grazing aids the spread and establishment of alien species in three ways: 1) dispersing seeds in fur and dung (2) opening up habitat for weedy species and 3) reducing competition from native species by eating them (Fleischner 1994). Studies that have found increased densities, cover or biomass of exotic plant species in grazed versus ungrazed sites include Green and Kaufman (Oregon -1995), Drut (Oregon - 1994) and Harper et al. (Utah - 1996). It would behoove the BLM to do all in its power to prevent the spread of exotic weeds, especially in light of President Clinton's 1999 executive order that gives federal direction to prevent the introduction of invasive species, as well as providing for their control and/or elimination (EO 11312).

Once they are established (often assisted by cattle grazing), weeds negatively impact western arid ecosystems in numerous ways. Weed infestations reduce biodiversity (Randall 1996), increase fire frequency (Esque 1999, Brooks et al. 1999), disrupt nutrient cycling (Vitousek 1990), alter soil microclimate (Evans and Young 1984), reduce effectiveness of wildlife habitat (Davidson et al. 1996, Knick and Rotenberry 1997), and can expedite loss of topsoil in xeric environments (Lacy et al. 1989).

The BLM claims that "grazing can help prevent the spread of undesirable plant species" and can "minimize, or at least have no effect on, the spread of invasive weeds such as cheatgrass (*Bromus tectorum*) (i.e. BLM 2000a). In both cases the agency cites Sheley (1995), an article that appears in a magazine, not a peer-referred journal. This paper is a

2-page set of grazing recommendations, based on no experimental evidence of its own (or any other studies for that matter), that goes into no detail on the "proper grazing management practices" that can supposedly control weeds. The BLM has also stated that livestock can be used to "control" weed invasions that have already occurred (i.e. USFS and BLM 1997**,** BLM 2000b). These claims are based on observations made in systems already so degraded that they might never improve. However, it is irresponsible for the BLM or anyone else to claim that cattle grazing is in some way neutral or beneficial in fighting weed infestations without backing these claims up with adequate studies from the scientific literature. The reason the BLM is not able to cite the literature on this topic is because evidence to support the use of cattle to avoid or control weed infestations in the arid west is scant. Livestock select bunchgrass over weedy species when given a chance (Gelbard and Belsky, in prep).

The evidence for cattle's implication in spread and establishment of exotic weeds is certainly greater than any "evidence" to the contrary. A recent extensive review of the literature on this topic (Gelbard and Belsky, in prep), illustrates that this relationship is insidious and pervasive. Gelbard and Belsky outline how cattle disseminate weed seeds in their fur/hooves, increase the "invasibility" of sites, and maintain weedy communities by continuing to graze preferentially on natives. The ability of cattle to increase a site's susceptibility to invasion has received the most attention from the scientific community. Sites become invasible due to increased bare soils as a result of grazing, which offer greater opportunity for weed establishment, with less competition (Gelbard and Belsky, in prep, and references within). Evans and Young (1972) found that increased soil erosion [shown to be caused by grazing] also loosens surface soils and helps bury seeds. Exotic seeds adapted to more erosion-prone environments will benefit from this while natives likely won't. Deposition of nitrogen-rich livestock dung also increases invasion of nitrophilous weeds such as cheatgrass by stimulating germination and enhancing growth over that of native plants (Evans and Young 1975, Smith and Nowak 1990, Trent et al. 1994, and Young and Allen 1997). Finally, cattle grazing can further compound the above impacts by creating warmer and drier soil microclimates, through soil compaction, and loss of plant, microbiotic crust and litter cover. The resulting warmer, drier microclimate reduces the competitive vigor of many native grasses (Piemeissal 1951, Archer and Smeins 1991), thus further increasing viability of aggressive exotics.

Examples of cattle impact studies (plants) in Utah's part of Colorado Plateau: An impressive number of studies that document the impacts of cattle grazing on southern Utah's plant communities can be found in the literature. These include:

- A study by Rawlings et al (1997) that found that the part of Canyonlands National Park that had been grazed most intensively prior to 1967 has since been extensively invaded by cheatgrass.
- A study of 530 different rangeland sites in southern Utah, where Gelbard (1999) found that cheatgrass cover was five times greater on sites without cryptobiotic soils (disturbed by either cattle or motorized use) than on sites with undisturbed crusts (and 64% of all sites that were disturbed and lacking crusts were attributed to cattle grazing)

- A study by Bich et al. (1995) involving a "grazing gradient" where independent variables were measured at 4km, 7km, and 9km distant from wells critical for cattle in the Glen Canyon National Recreation Area. The authors found that both density and basal area of Indian ricegrass (*Orzopsis hymenoides*), a native bunchgrass, increased with decreasing grazing intensity, while density and foliar cover of snakeweed (*Gutierrezia spp.*) increased with increasing grazing intensity.
- A study by Kleiner (1983) that found that 10 years of rest from grazing in Chesler Park within Canyonlands National Park led to increases in litter cover from 9.8% to 25.7%, and increases in total vegetative cover from 31.6% to 44.5%.
- A study in the Kaiparowits Basin by Jeffires and Klopatek (1987) that compared a heavily grazed site, a light/moderate winter grazed site, a site10 years into recovery from heavy grazing, and a relict, never-before grazed site. The authors found that the relict site had significantly more herbaceous cover (comprised mostly of perennial grasses) than all other sites. There were no significant differences between the heavily grazed site and the recovering site for any of the measured parameters, leading the authors to conclude that recovery from grazing can take a very long time indeed.
- A study in Capitol Reef National Park (Cole et al. 1997) which used packrat middens to describe vegetation changes in the region over time. The authors found that pre-settlement middens contained abundant macro-fossils of plant species palatable to livestock, such as winterfat (*Ceratoides lanata*) and Indian ricegrass. Their midden analysis demonstrated that drastic vegetation changes, unprecedented during the last 5,000 years, occurred in this part of southern Utah between roughly 1800 and the present. Species typical of overgrazed range, such as snakeweed, rabbitbrush (*Chrysothamnus nauseosus*), and Russian thistle (*Salsola iberica*) were not recorded in middens prior to the introduction of grazing animals.
- Another study in Capitol Reef National Park (Willey 1994) that documented more (and taller) native grasses, more (and taller) shrubs, and more forbs on an ungrazed mesa top compared to a grazed areas within the Park.
- A study in Zion National Park (Madany and West 1983) that documented twice as much forb cover, three times as much grass cover, and more diverse age structure of trees on a set of ungrazed mesas, compared to a nearby grazed area.

Cattle grazing in arid vegetative communities - conclusions: With the considerable evidence of the negative impacts of cattle grazing in arid plant communities like those on the Colorado Plateau, it is surprising that the BLM would claim various beneficial effects of grazing such as "increased seed dispersal, increased carbohydrate root reserves, increased plant vigor and increased probability of plants producing seed" (i.e. BLM 2000a). While the BLM doesn't cite any studies, they are likely referring to "grazing optimization theory," a theory that loss of tissue to herbivores can actually increase total productivity or reproductive fitness of the grazed plant (see Owen and Wiegert 1976, 1981). This theory was chiefly established through studies conducted in highly productive and intensely managed systems, such as the Great Plains or Africa, and has little relevance to the fragile and arid systems of the Colorado Plateau. More importantly, the grazing optimization (or overcompensation) theory was debunked by Belsky (1986, 1993, Painter and Belksy 1993), not only through evolutionary arguments, but also by pointing out that the studies that have shown "evidence of overcompensation" by plants are extremely few, rely on highly managed conditions (i.e. plants are watered, fertilized and protected from competition during experiments), and when replicated, have failed to produce the same results. Furthermore, a local Utah study (Trlica and Cook 1971) found that Utah desert plants exhibit no beneficial effects from defoliation, and that most species defoliated in the spring have significantly smaller carbohydrate reserves than controls by fall quiescence. Regardless of arguments about the existence of overcompensation in plants, the optimization theory is notoriously misapplied to rangeland management. In their landmark book (Saving Nature's Legacy, 1994) Noss and Cooperrider conclude that much of the controversy over the grazing optimization theory is "traceable to confusion over temporal/spatial scales, and to attempts to generalize over vastly different rangeland ecosystems and to equate naturally evolved herbivore grazing [patterns] with current livestock management practices."

In addition to claiming increased plant vigor, compensatory growth and seed production due to cattle grazing, you will recall above that the BLM cited "increased seed dispersal" as a benefit of grazing (BLM 2000a). Dispersal by fur and hooves aside (which incidentally disperse non-beneficial weeds just as well as natives), I came across no studies that cited cattle ingestion of seeds and their subsequent deposition in cattle dung as a favorable environment for native seed germination. While cattle may very well "disperse" native seeds through their feces, this cannot be cited as a beneficial effect unless the seeds actually germinate. Moreover, any progeny that germinates as the result of cattle ingestion is likely to grow up only to be ingested, or destroyed, by cattle as well - often before reaching reproductive maturity. Native desert plant seeds are adapted for dispersal by wind, rodent caching activities (Longland, 1995) or ingestion by certain **native** herbivores. There does not appear to be any literature pertaining to the beneficial role of cattle in native plant seed dispersal and germination in the arid western U.S.

The BLM also claims that "grazing…could improve ground cover, vegetative density and diversity, and plant vigor in some areas better than continuous rest" (i.e. BLM 2000a, BLM 2000c and BLM 2000d). They cite Holechek et al (1989) and Holechek and Stephenson (1983) as proof that rest from grazing is not beneficial. In Holechek's et al's (1989) textbook, the authors cite four other studies as proof that rest form grazing does not improve vegetative conditions. None of these studies were conducted on the Colorado Plateau. Furthermore, one was a confounded experiment (fertilizer was added to the grazing-treated sites), and the other three focused primarily on shrub expansion, an issue that numerous researchers have had difficulty tying one way or another to grazing, and that is probably equally influenced by fire suppression and climate change as it is by grazing (Jones 2000).

The BLM uses Holechek and Stephenson's 1983 study as an example where cessation of grazing in a degraded area did not lead to improvements in forage plants. This is a poor study to use an example of grazing effects (or lack of them), as there were clear confounding factors at work in this study. While total shrub density was significantly greater **outside** the exclosure at the lowland site, it was significantly greater **inside** the exclosure at the upland site. Furthermore, while cover of some grasses (i.e. blue grama, *Bouteloua gracilis*) was greater outside the exclosures, other grasses (i.e. western wheatgrass, *Elymus smithii*) were actually more common inside the exclosures. The authors themselves admit that the timing of grazing was one of the confounding factors in this study - if grazing had occurred in summer rather than spring they would have expected to see the grama and wheatgrass results reversed because of the interaction of the species' phenology with season of use (blue grama does well with spring grazing and western wheatgrass doesn't - Holechek and Stephenson 1983). And lastly, the authors could not even address the influence of rest on forbs because there were no forbs in the study area due to past sheep grazing. Holechek et al (1998), when referring to this study, stated that the authors "considered control of big sagebrush the only feasible means to improve forage production" at the site - not grazing.

The BLM will need to find better scientific proof that long-term rest from cattle grazing does little good for the arid plant communities of the Colorado Plateau. The burden has to be on the BLM since, in reality, "long-term rest" from cattle grazing is the historic and natural condition always known by these communities. In most cases studied by scientists removal of cattle does lead to marked improvements over the long-term. In some cases arid rangelands may take over 100 years to recover (Gardner 1950). Indeed, most of the studies included in this literature review (and there are far too many to cite them all here) that compare an "ungrazed" site to a currently grazed site, are actually comparing a site grazed at sometime in the past (15, 30 50 years ago…) to one that is currently grazed. As most of these studies report significant beneficial effects of what is actually cattle removal over the long-term (as opposed to never being grazed), the positive effects of cattle removal cannot be dismissed. It is irresponsible for the BLM or anyone else to claim that grazing is somehow beneficial to the vegetative components of arid communities without backing these claims up with numerous references from the scientific literature.

Even the following statement from another BLM San Juan Resource Area EA (BLM 2000d), while sounding like a reasonable claim, is suspect: "many studies have shown that grazing can be accommodated without causing irreparable damage to vegetative resources or watershed values, and in fact, forage species and site conditions can be sustained under proper grazing management" (BLM citing CAST 1996). In an extremely thorough review of the 1996 CAST document, renowned ecologist Elizabeth Painter pointed out the document's strong bias and unsupported claims. Among other things, "of the 7 ½ pages of Literature Cited, only 19 citations are from scientific journals." In the same San Jaun EA, the BLM also cites Holechek et al. (1989), claiming that "**light** grazing can be a useful means of improving forage production during the **early stages** of range deterioration when the desirable forages are still present but in low vigor." Most ecologists would be quick to dismiss this careless statement - the principle reason that arid ranges in the western U.S enter into "early stages of range deterioration" in the first place is because of grazing. Studies that suggest otherwise are few and far between.

Effects of cattle grazing on faunal communities

Various faunal indicators required to meet the *USGHR* include habitat connectivity, and "frequency, diversity, density, age classes and productivity of…native species necessary to ensure reproductive capability and survival."

Grazing in arid environments can exert significant impacts on animal populations. The effects range from direct trampling of burrows and nests, to indirect effects on habitat structure and forage availability, to increased competition with other native species for significantly reduced water, cover, and space (Donohue 1999). A thorough review of the literature by Fleischner (1994) documents deleterious effects of grazing on all vertebrate classes and numerous foraging guilds (i.e. herbivores, granivores, insectivores, etc.). As illustrated below, grazing has been shown to have deleterious impacts on desert fauna ranging from lizards (Jones 1981) to large game (Kraussman 1996).

Large mammals: In the most thorough review on this topic (Kraussman 1996), livestock are shown to have insidious effects on large game, chiefly through habitat alteration and behavioral avoidance. Potential competition between elk (*Cervus elaphus*) and cattle is highest on "ecologically compressed habitats" such as winter range, where forage quality and quantity are often limited. If such areas are grazed heavily by cattle in the fall, insufficient forage will remain for elk in the winter (Nogle and Harris 1966) - a problem that is exacerbated in arid sagebrush ecosystems of the Colorado Plateau (Hobbs et al. 1996). It is estimated that perennial grass utilization by cattle of only 25 to 30% in arid western rangelands will trigger forage competition with elk (Kraussman 1996). Many studies have demonstrated that elk avoid or decrease their use of areas grazed concurrently by cattle (Arizona-Wallace and Kraussman 1987; Frisna 1992; Idaho-Yeo et al. 1993). Mule deer (*Odocoileus hemionus*) have been similarly shown to avoid areas with high concentrations of cattle (Wallace and Kraussman 1987, Griffith and Peek 1989, Loft et al. 1991).

Cattle grazing also has deleterious effects on pronghorn antelope (*Antilocapra americana*) and bighorn sheep (*Ovis Canadensis*). Grazing chiefly impacts pronghorn habitat by changing vegetative structure and composition. Secondary effects can include reduced fawn production in modified and degraded habitat (Ellis 1970). Evidence of negative effects of grazing on pronghorn populations has been documented in Idaho (Kindschy et al. 1982), New Mexico (Howard et al. 1990), and Nevada (Ellis 1970). Cattle grazing has also damaged bighorn sheep habitat in many areas of the southwest (Kraussman 1996). One of the most serious effects of cattle grazing on bighorns is transmission of livestock-borne diseases (Menke and Bradford 1992). Whether because of this, or because of habitat degradation, bighorn sheep demonstrate marked "social intolerance" for livestock, which can have serious implications; even seasonal grazing appears to result in effective bighorn habitat fragmentation (Ralph 1984). There are numerous examples of bighorn avoidance of livestock in the literature (see Kraussman 1996 and references within).

The BLM feels that vegetation trend studies that reflect either stable or upward trend conditions (as defined by the BLM) equate to "no impacts" to native game species like deer and elk (i.e. BLM 2000a). These trend studies primarily take long-term viability of plant populations into account, as well as the forage needs of cattle. Yet if an allotment is trending upwards, this does not guarantee adequate forage for elk and deer. In fact, in the San Juan Resource Area in southern Utah, for example, all (ungulate only) wildlife combined receive only 28% of the total allocation of available forage (BLM 1986), virtually guaranteeing that wildlife needs will scarcely be accounted for when rangeland health is assessed. Moreover, by claiming that stable or upward vegetative trends is the only factor that influences health and viability of native game populations, the BLM is seriously discounting negative effects of cattle on game that have little or nothing to do with forage; namely behavioral avoidance, structural alteration of habitat, and competition for water resources.

Small mammals: Cattle grazing can seriously impact small mammal communities in arid environments of the western U.S. Hanley and Page (1981) found that grazing decreased rodent species diversity in California desert grasslands, probably due to a decline in plant species diversity that resulted from the grazing treatment. Rosenzweig and Winakur (1969) also found a negative correlation between grazing intensity and rodent species diversity in arid regions. However, they attributed this to grazing-induced changes in structural aspects of vegetation, rather than changes in plant species diversity. In Utah, Rosenstock (1996) found that both small mammal overall abundance, and species richness, were greater in ungrazed sites in Capitol Reef National Park compared to nearby grazed areas. Researchers have also found changes in relative abundances of certain key desert rodent species due to cattle grazing effects (Glen Canyon NRA-Bush et al. 1995; Nevada-Jones and Longland 1999). And Medin and Clary (Nevada-1990) and Bock et al. (Arizona-1984), found a negative correlation between grazing and overall rodent densities in desert environments. In a quantitative literature review involving 18 independent grazed/ungrazed comparisons from 9 different studies performed in xeric environments of the western U.S., Jones (2000) found significant impacts of cattle grazing on both rodent species diversity, and richness.

Lagomorphs (*Lepus californicus*) are also affected by cattle grazing. Sparks (1968) found evidence of direct competition for forage between cattle and black-tailed jackrabbits in early spring when both species prefer green forage like western wheatgrass and needle-and-thread grass. Jones (in prep) is currently analyzing potential competition between cattle and lagomorphs and other small mammals for limited available forage in the Grand Staircase Escalante National Monument and San Jaun Resource Area in Utah. This analysis is based on fecal pellet content and stomach contents of these native herbivores, and is assessing availability of key plants needed by small mammals but usually allotted to cattle. It is likely that forage competition is driving what has been found to be reduced populations of jackrabbits in grazed areas in New Mexico (Norris 1950) and Colorado (Crouch 1982).

Avifauna: Cattle grazing impacts on bird communities are chiefly manifested through direct effects such as trampling of nest sites for ground-nesting birds, and indirect effects such as alteration of habitat structure (Taylor 1986) and community composition. Researchers have found cattle grazing to cause reduced species richness of all birds (Capitol Reef N.P - Willey 1994), songbirds (northern Utah - Duff 1979), riparian passerines (Oregon - Taylor 1986), and raptors (northern Utah - Duff 1979). Again, comprehensive literature reviews are the most telling in terms of grazing effects. One by Saab et al. (1995) concluded that grazing in the west has led to a decline in abundance of 46% of the 68 neo-tropical migrants that utilize riparian habitats. Another review by Bock et al. (1993) similarly reported that on some western sites up to 40% of riparian birds have been found to be negatively impacted by grazing.

Fish and their habitats: This topic has received perhaps the most research attention in regards to grazing. The effects of cattle on native fish species are almost always the result of indirect effects to physical habitat. Cattle grazing eliminates over-hanging banks (Behnke and Zarn 1976, Duff 1979, Hubert et al. 1985), which are critical for protection from predators. In fact, Clarkson and Wilson (AZ – 1991) found that the amount of ungulate damage to streambanks consistently explained the greatest amount of variation in native fish abundance. Grazing also leads to loss of shrub cover on streambanks (Kovalchic and Elmore 1992, Chaney et al. 1993), which allows water temperatures to increase, which is deleterious to native fish because of reduced oxygen tension-levels in warmer water (Storch 1979).

In addition to researching grazing impacts to fish habitats in the arid west, many scientists have investigated grazing effects on fish populations themselves. Cattle grazing has been shown to reduce total densities or abundances of native fish in Oregon (Lorz 1974), Utah (Duff, 1977, 1979 and 1983), Colorado (Stuber 1985), and the Great Basin (Claire and Storch 1983). In an extensive review of the literature, Platts (1982) concluded that livestock grazing was the major cause of reduced fish populations throughout the western U.S.

In the arid west, effects of grazing on native trout communities has received particular attention. Cattle grazing has been shown to decrease native trout size and abundance (Idaho-Keller and Burnham 1982), standing crop (CO -Stuber 1985), and overall production (Great Basin - Bowers et al. 1979). A review of 21 studies on grazing impacts on salmonids (Platts 1991) revealed that all but one study demonstrated that salmonid habitats were degraded from grazing. And in a position paper published by the American Fisheries Society (Armour et al. 1991) the Society states that, “overgrazing is considered one of the principle factors contributing to the decline of native salmonids in the west.” They feel the most apparent effects of grazing on fish habitats are changes in water quality and stream morphology, addition of sediment through bank degradation and off-site soil erosion, and reduction of shade and cover with resultant increases in stream temperature. These various effects of cattle grazing on native fish habitat will be discussed further in the "Impacts to Streams and Aquatic Habitats" section below.

Effects of cattle grazing on endangered species on Utah's part of the Colorado Plateau

In the Colorado Plateau ecoregion, it is estimated that the negative ecological impacts caused by grazing have contributed to the decline of 41% of all threatened and endangered species listed under the Endangered Species Act (Flather et al. 1994).

Mexican spotted owl: While there have actually not been any studies that have looked at the effects of cattle grazing on Mexican spotted owls (*Strix occidentalis lucida*) (MSOs) themselves, there are studies that have demonstrated impacts of grazing on other raptors (e.g. Duff 1979, Kochert et al. 1988, Kochert 1989). Furthermore, the indisputable impacts that cattle have been shown to have on MSO habitat and prey base on the Colorado Plateau have prompted many ornithologists to voice concern about the potential effects of cattle on MSOs (Howe 1994, Willey 1999, Stacey - in TWP 2000). When assessing the effects of cattle grazing on MSOs, two critical life-requirements must be reviewed. One is quality and quantity of suitable habitat, and the effects that cattle grazing has on these parameters. The other is availability of suitable small mammal prey, and the effects cattle grazing has on these communities. These same two avenues of analysis were used in the Mexican Spotted Owl Recovery Plan (USFWS 1995) to determine possible effects of grazing on owls.

Research has shown that MSOs in Utah require well-developed riparian vegetation (Rinkevich and Gutierrez 1997) with dense understories (Rinkevich 1991), and multi-layered, deciduous habitats (Willey 1991 and 1992, and Willey and Van Riper 1993). Research throughout the Colorado Plateau has revealed that MSOs require high canopy closure, high stand density, substantial vertical and horizontal diversity, and a multi-layered canopy resulting from an uneven aged stand (McDonald et al. 1991, Gutierrez et al. 1995, Zwank 1996, Stacey and Hodgson 1999). Furthermore, Stacey and Hodgson (1999) have identified deciduous understory plants as being particularly important to MSOs, because they offer the greatest vertical riparian vegetative structure and canopy cover. Almost all researchers who study habitat requirements for MSOs agree that structural complexity is paramount. Structural complexity allows MSOs to avoid detection by avian predators such as northern goshawks and great horned owls. It is also important for creating cool microsites for the notably "heat intolerant" MSO (Willey 1991 and 1992, Stacey and Hodgson 1999).

Cattle grazing has been shown to impact all of the structural habitat attributes, outlined above, that are important to MSOs. Long-term grazing can inhibit or retard an area's ability to produce mature trees (USDI 1995). While upper canopy species like large cottonwoods are not directly impacted by grazing, cattle grazing in riparian zones has been shown to eliminate or reduce the upper canopy by preventing the establishment of seedlings, which leads to a loss of the upper canopy over time (Gilinski 1977). In addition, long-term negative effects of cattle grazing on tree seedling establishment can result in decreased stand density, and more open, thermally unfavorable micro-sites (Howe 1994). Age structure of riparian trees also becomes even-aged due to cattle grazing (Kauffman et al. 1983). Reduced seedling establishment due to ingestion and trampling by livestock has transformed a variety of southwest riparian systems into even-aged, non-reproducing communities (Carothers 1977, Davis 1977, Szaro 1989). In general, both vertical and horizontal structure of riparian areas is simplified due to cattle grazing (Taylor 1986, Knopf et al. 1988, Medin and Clary 1989), through ingestion and trampling of seedlings by cattle, and butting/rubbing and browsing shrubs and saplings (Howe 1994). Decreased structural complexity can in turn impact quality and quantity of perches used by MSOs for hunting, courtship and territorial defense (Howe 1994).

In addition to impacting quality of MSO habitat through reduction of structural complexity, there are concerns about cattle's impact on quantity of MSO habitat. The MSO recovery plan voices concern about the decrease in herbaceous ground cover attributed to cattle grazing, and thus increased chances of catastrophic fire in MSO habitat (USFWS 1995), with concomitant effects on MSO foraging/wintering/dispersal/roosting and nesting habitats. The recovery plan also states that grazing can "generally degrade, and in some cases through erosion and lowering of the water table, virtually eliminate some riparian areas, and reduce them to a non-functioning condition, thereby impairing use of riparian areas by owls." The Wildlands Project shares this concern; in a recent publication on a New Mexico/Arizona reserve design project that uses the MSO as a focal species, TWP states that, "loss of riparian areas from livestock grazing may be a major factor in continuing population declines" of the MSO (TWP 2000).

The second critical aspect of determining potential effects of cattle on MSOs is to explore the impacts of grazing on the MSO prey base. It has been suggested that MSOs select habitat based partially on the availability of prey (USDI 1995). Small mammals by far make up the most important component of MSO diets (Howe 1994). In southern Utah, woodrats (Kertell 1977, Rinkevich 1991, Sureda and Morrison 1998) and white-footed mice, or *Peromyscus* species (Rinkevich 1991, USDI 1995, Willey - unpubl data), have been identified as the most important prey species for MSO. Grazing can influence prey availability and diversity by altering various habitat conditions for small mammals (USDI 1995). In terms of *Permyscus* species, a study in southeast Utah (Sureda and Morrison) found that these mice were most often found in areas with heavy brush, a component that is not likely to be present in heavily grazed areas. In New Mexico, cattle grazing has been shown to reduce abundance of Mexican voles (*Microtus mexicanus*) (Ward 1996), another important prey species for MSOs (personal communication, Peter Stacey). West-wide, cattle grazing has been shown to reduce both species density (NV - Medin and Clary 1989 and 1990) and diversity (UT-Duff 1979, NV-Medin and Clary 1989 and 1990) of rodent populations in riparian areas.

MSOs are not by any means “restricted” to riparian or forested habitats. MSOs inhabit relatively open country along the northwest part of the species’ range in southern Utah. Here, the MSO is strongly associated with steep sandstone canyonlands that include relatively open Great Basin desert scrub and woodland communities (Brown 1982, Willey 1995 and 1998). Pinyon-juniper habitat has also been identified as an important component of MSO home ranges during summer and fall (Willey 1992). These mesa/upland habitats contain substantial rodent populations, which can be severely impacted by cattle grazing, via impacts to alterations to vegetative structure and composition (see small mammal section, above). Sureda and Morrison (1998) found that *Peromyscus* species were significantly more abundant in mesa habitats than canyon (riparian) habitats in southeastern Utah.

Gunison sage grouse: While the effects of cattle grazing on this recently designated and separate sage grouse species (*Centrocercus minimus*) have not been thoroughly assessed, it is safe to say that the impacts are comparable to those on sage grouse (*Centrocercus urophasianus*), which has been widely studied.

The impacts of grazing on sage grouse are widely documented (see Yocom 1956, Autenrieth et al. 1977, Klebenow 1982, Dobkin 1995,). The recent petition for federal listing of the species has cited grazing of domestic livestock and its associated operations as likely to be the number one threat to the continued existence of the species (Webb 2000). Even light grazing has the potential to reduce food quality for the sage grouse, as light grazing is known to put stress on the herbaceous plants favored by livestock, and required by sage grouse (West 1996). The reduction of forbs due to cattle grazing is particularly harmful to the sage grouse, not only because of the direct food value to grouse, but also because forbs provide food sources to insects - a critical dietary component for sage grouse chicks during their early developmental period (Webb 2000). Grazing also harms sage grouse by removing sheltering near the nest (Webb 1993), which is known to impact both nesting success and chick survival (Klebenow 1969, Hein et al. 1980) due to increased predation levels.

Perhaps surprising to some, mesic meadows and riparian areas are as important to sage grouse as healthy sagebrush habitats - especially in the summer and fall (Savage 1969, Oakleaf 1971, Autenreith et al. 1982). Unfortunately, these are some of the habitats impacted most heavily by cattle. Cattle prefer gentle slopes near water. These are precisely the same areas needed by sage grouse for nesting and brooding (Klebenow 1969, Hayden-wing and Ostain 1986). Hens with broods have been shown to avoid meadows where grazing has caused poor conditions such as eroded streambanks and low grass/forb availability (Klebenow 1969). Notably, the riparian areas in the Gunnison basin have many heavily grazed riparian areas, and have suffered grazing impacts such as weed encroachment into the riparian zone, and gullying with concomitant secondary effects such as a lowered water table and loss of soil moisture (GSGCP 1997). These effects are probably having considerable impacts on Gunnison sage grouse populations (Webb 2000).

In the Bluff Bench EA in the San Juan Resource Area (BLM 2000c), the BLM stated that "where appropriate, allotments will be managed under a deferred rotation system to maintain and enhance [sage grouse] habitats." While a discussion of the merits of deferred rotation grazing compared to year-long grazing is beyond the scope of this review, I came across no studies that demonstrated the benefits of deferred rotation grazing to sage grouse. Also, while rest-rotation systems have been found to work reasonably well in cooler, wetter areas of the western U.S. they can to lead to continued deterioration in deserts like the Arizona strip that have erratic rainfall and limited water availability (Hughes 1981).

Southwestern willow flycatcher **:** There have been a number of studies that have researched the role of cattle grazing in southwestern willow flycatcher (SWF) (*Empidonax tralii extimus*) habitat degradation, with associated effects on SWF populations. Livestock grazing has been implicated in willow flycatcher habitat loss and habitat changes (Sogge et al. 1997a), reduced quality of willow flycatcher habitat (Taylor 1986, Sanders and Flett 1989) reduced nest productivity (Johnson 1999), and nest failure due to direct impacts by cattle (Stafford and Valentine 1985, Valentine et al. 1988). In light of these considerable impacts cattle have on riparian areas in the southwest, the original petition to list the SWF stated that, "grazing of domestic cattle is probably the single greatest direct and indirect threat to southwestern willow flycatcher habitat" (Suckling et al. 1992).

SWFs are riparian obligates (Paradzick et al. 2000) and require a diverse combination of over - and under-story vegetation (Hubbard 1987). Taylor and Littlefield (1986) also detected a correlation between *Empidonax tralii* abundance and riparian habitat heterogeneity. Knopf et al. (1988) detected a similar correlation, and primarily attributed reduced abundances of sensitive riparian passerines to the impact of cattle on the horizontal patterning of the vegetative community. When willows are "notched" or "highlined" by cattle, they become top heavy with live branches above, with few remaining below. Serena (1982) noted this condition in otherwise suitable habitat in southern California where willow flycatchers were conspicuously absent.

The evidence that cattle grazing reduces SWF numbers is irrefutable. In southern California, Harris et al. (1987) noticed that SWF numbers increased by 50% during a 5-year period in which The Nature Conservancy acquired the area and greatly reduced the intensity of cattle grazing. And SWF appeared on the Brock Canyon allotment in the Gila National Forest the second year after cattle were removed (Suckling et al. 1992). In southeastern Oregon, AUMs on a test plot were steadily lowered from 1973 to 1982, resulting in SWF presence at the site only at the end of the experiment when AUMs had declined by a factor of four (Taylor and Littlefield 1986). In fact, many of the locations where SWF still occur (i.e. Rio Grande Conservancy land outside Albuquerque, the New Mexico Game and Fish wildlife enclosure, Grand Canyon National Park), are areas from which cattle have been excluded or dramatically reduced.

Livestock grazing can also increase parasitism by brown-headed cowbirds (*Molothrus ater*) (Kimball 1993), an exotic nest parasitizer that has been shown to be a factor in willow flycatcher nest failure (Whitfield 1990, Sogge et al. 1997b, and Sedgewick and Iko, unpublished manuscript) and population declines (TWP 2000). Brown-headed cowbirds, formerly associated with bison (*Bison bison*), are now followers of cattle and are attracted to the grass stubble they leave behind (Suckling et al. 1992). Not only do cattle bring cowbirds into riparian areas, they can increase fragmentation of willow habitat, thus creating more edge habitat which makes SWFs susceptible to cowbird parasitism.

Threatened/Endangered plants in Utah: While most research attention usually focuses on federally listed animal species, its important not to discount the adverse effects of cattle grazing on threatened and endangered plants on Utah's part of the Colorado Plateau. Southern Utah actually contains far more T/E plants than one would expect. This is partly the result of intrinsically high rates of endemism in the Colorado Plateau due to climate, the intersection of different ecological provinces on the plateau, and distinctive geologic formations and substrates (Welsh 1978). This results in very small populations of unique plants that have evolved in relative isolation and are adapted to specific habitats.

Utah currently has 29 plant species that are either federally listed under the ESA, or are candidates for listing (UDWR 1998). Because 86% of rare Utah endemics occur in arid and semi-arid regions of the state (where most BLM holdings exist), a majority of federally listed plants occur on BLM lands. Groupings of the state's T/E and sensitive plants according to vegetation type illustrate that a majority of those species occur in vegetative communities that typically characterize Utah BLM holdings (Table 1, next page).

One reason for the preponderance of T/E plants in southern Utah is high intrinsic rates of endemism; the other is that the habitats for these plants have been threatened by many human activities. One of these activities is cattle grazing. With ranges as narrow as those occupied by these rare species, it is conceivable that a whole population of the rarest species could be decimated if it existed within one or two poorly placed grazing allotments. Detrimental impacts of cattle grazing have been documented on Townsend's aprica (*Townsendia aprica*), Wright's fishook cactus (*Sclerocactus wrightii*), and Winkler's pincushion (*Pediocactus wrinkleri*) cactus in Capitol Reef National Park (San Juan College 1994). These impacts primarily consisted of death and damage to plants due to trampling. While trampling may not necessarily kill plants, it often destroys the meristem, and the plant fails to produce flowers, fruit, and seeds. The highest percentage of damaged T/E plants in Capitol Reef were found near water sources.

Discussion and conclusions - cattle and wildlife on BLM land

This section has outlined the pervasive and insidious effects that cattle grazing can have on native wildlife on arid rangelands such as those on the Colorado Plateau. The U.S. Department of the Interior agrees with these findings, as outlined in Rangeland Reform ’94 (USDI 1994): “if grazing were discontinued on western rangelands 75% of degraded…fish habitat would be restored, waterfowl populations would increase,…[and both] game and nongame species would benefit from improved riparian habitat and from increased vegetation for winter food/cover.”

Changes to physical structure of ecosystems

Various indicators required to meet the Standards and Guidelines for physical structure of ecosystems include the appropriate kinds of vegetative habitats for wildlife, “sufficient cover and litter to protect the soil surface from…erosion,” and “the absence of indicators of excessive erosion such as rills, soil pedestals, and actively eroding gullies.”

Vegetation structure: Intact physical structure of arid ecosystems is very important to native wildlife on large and small scales. Because of grazing, shrub components have appeared where none were before (Archer 1989, Schlesinger et al. 1990), and extensive willow stands have been removed from streamcourses (Oregon - Kovalchik and Elmore 1992), with profound effects on native wildlife. Grazing structurally changes habitat for ground-dwelling vertebrates, such as snakes and lizards, through the loss of low-height vegetation (Jones 1981, Szaro et al. 1985). Grazing similarly affects shrub and woodland riparian forest structure, with impacts on birds who require diverse habitat structure (Taylor1986, Knopf et al 1988). Cattle grazing also removes soil litter from the system (Four Corners region-Orodho et al. 1990, Capitol Reef National Park-Willey 1994 and Rosenstock 1996, and review by Jones 2000 and references therein), which can impact ground-nesting animals that require litter for their nests.

Soil stability/erosion: Grazing also contributes to the deterioration of soil stability in deserts (Warren et al. 1985), thus leading to increased soil erosion. Soil erosion is further exacerbated by increased surface runoff triggered by loss of vegetative cover and litter (Ellison 1960), both of which have been shown to be reduced by cattle grazing (see references above). As soils take 5,000 to 10,000 years to naturally re-form in arid regions such the Colorado Plateau (Webb 1983), accelerated soil loss caused by grazing is an irreversible loss. The steep slopes with little to no vegetal cover underlain by highly erodible rock that are common in the rugged landscape of southern Utah are particularly susceptible to cattle-induced erosion.

Numerous studies have observed severe erosion when comparing heavily grazed to ungrazed sites in the arid west (Cooperrider and Hendricks 1937**,** Croft et al. 1943, Gardner 1950, Kauffman et al. 1983). In a particularly well-designed study (Lusby 1979), a federal inter-agency committee chose Badger Wash, just over the border from Utah in western Colorado, as a representative Colorado Plateau site to assess grazing effects on erosion. The BLM was one of the five agencies cooperating in this 20-year study, initiated in 1953, which compared four entire ungrazed watersheds to four others left open to grazing. The findings indicated that runoff was reduced by 40%, and sediment yield by 63%, on ungrazed watersheds compared to grazed watersheds. There are a number of good reviews on this topic that describe the indisputable impact of livestock grazing on soil stability and erosion (see Gifford and Hawkins 1978, Fleischner 1994, Trimble and Mendel 1995, and Jones 2000).

Presence of cryptobiotic crusts: Cryptobiotic crusts, which were historically widespread in western arid lands, are being rapidly depleted across rangelands today. These crusts increase the stability of otherwise easily erodible soils, increase water infiltration in a region that receives limited precipitation, and increase fertility of xeric soils often limited in essential nutrients such as Nitrogen and Carbon (Johansen 1993, Belnap et al. 1994).

Cattle are highly destructive to these fragile cryptobiotic crusts that exist within many BLM lands on the Colorado Plateau. Cryptibiotic crusts are only prominent components of ecosystems where large-bodied herbivores have been absent from recent evolutionary history; such as in the Colorado Plateau and many other regions of the arid west. Under these circumstances, cryptobiotic crusts are easily damaged by livestock (Navajo National Monument, AZ - Johansen et al. 1981 and Brotherson et al. 1983; Utah - Anderson et al. 1982; northern AZ - Beymer and Klopatek 1992; northwest New Mexico - Floyd-Hanna et al. 2000). While the previously cited studies were conducted on the Colorado Plateau, the majority of studies that have investigated the impacts of cattle grazing and other disturbances on cryptobiotic soils have actually been conducted in southern Utah and have found:

- that heavy grazing reduced crusts by 98.5% and light grazing reduced crusts by 52.3% at the Desert Experimental Range in southern Utah (Marble 1990)

- that cryptobiotic crust cover was seven times greater in an ungrazed part of Canyonlands National Park compared to a grazed area (Kleiner and Harper 1972)

- that Nitrogenase activity levels in cryptobiotic crusts decreased anywhere from 30% to 100% in disturbed plots relative to undisturbed plots, and that threshold friction velocities (the force required to detach soil particles from the surface) were significantly higher in undisturbed cryptobiotic crusts than in disturbed plots (Moab area - Belnap 1996, Belnap and Gillete 1997)

- that a relict, never-grazed site in the Kaiporwits Basin had significantly more cryptobiotic crust cover than both a light-moderately winter grazed site and a site that had not been grazed for 10 years (Jeffries and Klopatek 1987)

- that cryptobiotic crust cover more than doubled over a ten year period of rest from grazing in Canyonlands National Park (Kleiner 1983)

- and Jayne Belnap, the respected authority on cryptobiotic soils, reports that cattle grazing has greatly impacted cryptobiotic crust integrity within the new Grand Staircase Escalante National Monument (Belnap 1997).

The deleterious effects of cattle on cryptobiotic crusts are not easily repaired or regenerated. The recovery time for the lichen component of crusts has been estimated at about 45 years (Belnap 1993). At this time the crusts may appear to have regenerated to the untrained eye. However, careful observation will reveal that the 45 year-old crusts will not have recovered their moss component, which will take an additional 200 years to fully come back (Belnap and Gillette 1997).

There are numerous secondary effects once crusts are trampled by cattle. Destruction of crusts increase wind and water erosion of surface soils that were previously protected by the crusts (personal communication with Howard Wilshire). This can in turn trigger rapid loss of the underlying topsoil (Webb 1983). The destruction of cryptobiotic soils by cattle can reduce nitrogen fixation by cyanobacteria, and set the nitrogen economy of these nitrogen-limited arid ecosystems back decades. A severe loss of nitrates to plants is a significant threat in typically Nitrogen poor arid environments, and may even eventually lead to desertification (Belnap 1995). Once crusts are destroyed, ecosystem structure can be furthered altered when bare ground is available for colonization by exotic weeds (see Gelbard, in review, and references within). In addition, the breaking up of physical and microbiotic soil crusts increases surface roughness, which favors cheatgrass germination (Tisdale and Hironaka 1981, Stohlgren in press). The relationship of crust destruction and weeds is further supported by evidence that intact cryptobiotic crusts reduce or prohibit weed establishment by preventing weed seed germination (Eckert et al. 1986, Mack 1989). Even small reductions in crusts can lead to diminished productivity and health of the associated plant community, with cascading effects on plant consumers (Davidson et al. 1996).

The BLM has stated numerous times that grazing and cryptobiotic crusts are compatible. In many of their EAs accompanying term permit renewals in the San Juan Resource Area (i.e. BLM 2000a), the BLM states that "properly managed grazing [does] not damage crusts to the point that ecological processes associated with the crusts…would be negatively affected." Yet, instead of citing studies that examine the effects of grazing on ecological processes associated with crusts, the BLM simply cites (first) a study that documented slightly more microphytic cover in a single grazed versus ungrazed comparison (Anderson 1994), and (next) a conclusion by one author (Schofield 1985) that reduction of grass cover by cattle results in greater moss coverage. Both of these studies are weak at best if being used to argue for cattle's compatibility with cryptobiotic crusts. There are far more studies (cited above) that have shown the indisputable severe effects that cattle have on cryptobiotic soils. In terms of the Anderson study, one of the comparisons was a paired comparison where there was "no measurable difference in…microphyte cover" (Anderson 1994). The other paired comparison revealed that there was 73% percent more microphyte cover in the grazed area than in the exclosure….or, in other words, about 4% cover versus about 2.5% cover. It is not surprising that Anderson et al. detected such minute effects of grazing; they compared an ungrazed area to a lightly grazed area. As for the Schofield study, an increase in mosses does not necessarily mean there is a concomitant increase in cryptobiotic soils. Moss is only one of many components (algae, lichen, soil particles, cyanobacteria..) that comprise crusts. Also, the BLM goes on in the San Juan EAs to point to studies (McIlvanie 1942, Hacker 1984 and 1987 – both studies conducted in Australia) that document more successful germination of grass seedlings in grazed areas where crusts have been destroyed than in ungrazed areas where crusts are intact. This is a very odd point to use when arguing that grazing is compatible with cryptobiotic crusts; all three of these studies prove the contrary.

Interestingly, the BLM states in some of the San Juan Grazing Permit Renewal EAs: "possible impacts associated with continuous rest may include increased **soil crusting** *(emphasis added)* as a result of the loss of hoof action…" The BLM does not include any references from the literature that explain why crusting is deleterious. Indeed, this "crusting" of the soil is a necessary and important precursor to the cryptobiotic soils that will eventually establish, given enough long-term rest from grazing. The crusting will create "platforms" that will enable the moss, algae, lichen and cyanobacteria components of the microphytic crusts to become established. The BLM has acknowledged the ecological importance of fully developed cryptobiotic soils - yet the previous statement indicates they are unaware of how long these take to reform after being released from grazing, and how this process works.

When citing "crusting" as a deleterious effect of continuous rest, the BLM is likely referring to Allan Savory's theory that grazing, and associated "hoof action" is necessary to "till the soil," resulting in purported enhanced water retention and seedling germination (Savory 1988). However, the literature (referenced below in Hydrology section) citing the deleterious effects of livestock trampling on soil compaction, infiltration, and moisture far outweighs any studies claiming the contrary. In fact, virtually none of Savory's claims have been verified through reliable scientific methods (Noss 1991). Savory claims that hoof action will distribute seeds and establish seedlings by grinding seeds into the ground. But studies of the effects of cattle hoof action upon seedling success have found that the quantity and timing of precipitation is the most important factor affecting seedling survival – not increased seed-to-soil contact (Bryant 1989). Furthermore, a study in Juab County, Utah that emulated Savory's recommended grazing practices, found that seedling survival was drastically reduced in the sites grazed by cattle (Salihi and Norton 1987). Savory also claims that breaking up "soil crusts" is necessary in arid lands in order to provide germination sites for new plant growth, thus advancing succession. If this is true, then all arid environments that used to be grazed but have been protected for a number of years should theoretically be suspended in some earlier successional state, with reduced species diversity, etc. (Donohue 1999). This is clearly an absurd theory. Many other well known and respected range ecologists have criticized Savory's theories, including Richard Miller, Donald Dyer, Joy Belsky, Rex Pieper, John Buckhouse, Tony Svejcar, Tom Fleischner, and Neil West. Many feel that Savory's theories, which are significantly premised on the importance of herding (and often migratory) ungulates in highly productive systems such as the Great Plains and Africa, are misplaced in the arid west.

Disruption of critical ecosystem processes

The second Fundamental of Rangeland Health, developed by the Secretary of the Interior in 1995, states that the following condition must exist on BLM lands: “Ecological processes, including the hydrologic cycle, nutrient cycle, and energy flow, are maintained.”

Cattle grazing can disrupt fundamental ecosystem functions involved with nutrient cycling and energy flow. Ecosystems can lose nutrients because they are tied up in livestock feces, which in some deserts cannot be recycled due to lack of appropriate decomposers (for example, dung beetles). Also, in the Great Basin Desert nitrogen is the most important nutrient limiting biomass production (James and Jurinak 1978). Cryptobiotic soil crusts perform the major share of nitrogen fixation in desert ecosystems (Rychert et al. 1978). The damage suffered by cryptobiotic crusts at the hands of livestock grazing (cited above) results in decreased nitrogen fixation (Belnap et al. 1994).

Grazing also can disrupt ecological succession. Long-term, continuous disturbance by livestock maintains early seral vegetation in many arid areas (Longhurst et al. 1982). Or, it can serve to “hold” a system in a displaced seral stage; livestock grazing has been credited with transforming parts of New Mexico from a grassland to a cresote-dominated landscape (York and Dick-Peddie 1969).

Impacts to Hydrology

One of the chief hydrological impacts attributed to grazing in the arid west is increased storm runoff caused by an interaction of two chief factors: 1) greater soil compaction and thus decreased soil infiltration caused by trampling (Colorado-Rauzi and Smith 1973, southeastern Utah-Gifford et al. 1976**,** central Utah-Achouri and Gifford 1984, Four Corners region-Orodho et al. 1990), and 2) less vegetation, litter, and cyptobiotic soils on the surface to absorb rain (Ellison 1960). Evidence of increased storm-runoff on grazed versus ungrazed watersheds is considerable (Lusby 1979, Meehan and Platts 1978, Stevens et al. 1992). Increased storm runoff indirectly triggered through grazing can in turn cause further soil erosion, and flooding (Ohmart and Anderson 1982). There are a number of good reviews on this topic that describe the indisputable impact of livestock grazing on soil compaction, infiltration and runoff (see Gifford and Hawkins 1978, Kauffman and Krueger 1984, Fleischner 1994, Trimble and Mendel 1995, Jones 2000, and Carter 2000).

In addition to triggering increased runoff, cattle grazing can indirectly lead to a lowered water table, thereby reducing the capacity for water storage in the system, and ultimately reducing or eliminating perennial flows (Chaney et al. 1993, EPA 1993). The mechanism for this hydrologic alteration (lowering of water table) is discussed in more detail below.

Impacts to streams: channel morphology and aquatic habitats

Various stream/channel/aquatic indicators required to meet the Standards and Guidelines include intact stream banks, “channel width [and] depth appropriate to landscape position,” and water quality that’s in compliance with state standards. Below, the literature that pertains to these indicators is reviewed, but other reviews have already summarized much of these findings (i.e. Belsky et al. 1999).

Bank stability: Because of cattle grazing, bank stability along stream channels is reduced due to fewer plants and roots to anchor the soil, less plant cover to protect the soil from wind and rain erosion, and direct trampling of banks (Carter 2000). Studies that have shown that grazing reduces streambank stability include Behnke and Zarn (various locations - 1976), Winget and Reichert (UT – 1976), Duff (UT – 1983), Kauffman et al. (OR – 1983), and Stuber (CO - 1985).

Channel morphology: Because of the effects of cattle grazing on bank stability, banks essentially “retreat” back, (Platts 1991), thus leading to channel widening (Duff 1979**,** Kauffman et al. 1983, Stuber 1985). In a review of the effects of livestock grazing on salmonids, Platts (1991) reported that grazing can change channel morphology through accrual of sediments, alteration of channel substrates, transformation of pools to riffles, and widening of the channel. This type of loss in stream channel integrity and diversity is a deleterious modification of aquatic habitat (EPA 1993), with potentially profound effects on aquatic organisms.

Grazing can also lead to “gullying” (Winegar 1977) and channel incision (Kovalchik and Elmore 1992), due to a combination of bank instability and downcutting from higher flood energy. The water table is effectively lowered in an incised channel, with associated negative impacts such as a distinct narrowing of the riparian zone. Most reviewers conclude that livestock have been a contributing factor to the entrenching of stream channels in the southwest (Leopold 1951, Hereford and Webb 1992, Betancourt 1992).

Health of aquatic habitats**:** Livestock have been shown to decrease water quality of streams through changes in the chemical, physical, and bacteriological characteristics of the water column (EPA 1993). Grazing-induced changes in water chemistry, temperature, and clarity can in effect create an entirely new aquatic ecosystem (Kennedy 1977, Kauffman and Krueger 1984, Jeffries and Klopatek 1987), with impacts for biodiversity (Rinne 1988).

In particular, cattle can increase nutrient and bacteria concentrations through direct deposition of urine and manure into the stream, fecal material present in runoff, sediments containing buried micro-organisms that are churned up by hoof action, and nutrients concentrated in reduced quantities of water (Belsky et al. 1999). Numerous studies have shown that livestock grazing increases amounts of bacteria in western streams, including Johnson et al. (CO - 1978), Stephenson and Street (ID - 1978), and Tiedmann and Higgins (OR - 1989).

Cattle grazing can also physically decrease water quality through increased sediment loads in the water column (Winegar 1977, Behnke and Raleigh 1978, Johnson et al. 1978, Stevens et al. 1992). This occurs through a combination of cattle-induced effects - namely disturbance to and erosion from denuded streambanks, reduced sediment trapping from reduced riparian and instream vegetation, and instream trampling (Carter 2000).

Cattle grazing indirectly leads to an increase in stream temperatures through lower summer flows, widening of the stream channel (thus exposing more water surface to solar radiation), and increased solar exposure due to reduced shade from streamside vegetation and to loss of undercut streambanks (Belsky et al. 1999). Studies that have documented temperature increases between grazed and ungrazed reached includes Duff (1977), Van Velson (1979), and Claire and Storch (1983). Increased temperatures can in turn impact fish populations, because of decreases in dissolved oxygen levels triggered by the higher temperatures. “Rangeland Reform ‘94” (DOI 1994) states that, “water quality conditions would improve to their maximum potential if livestock were removed from western rangelands.”

Impacts to wetlands and riparian zones

Various riparian/wetland indicators required to meet the Standards and Guidelines include adequate “vegetative cover to protect stream banks, [dissipate floods], protect against accelerated erosion, capture sediment, and provide for groundwater recharge,” and “vegetation reflecting…soil moisture,…diverse age structure and composition, ….and providing food, cover and other habitat needs for dependent animal species.”

Because livestock spend a disproportionate amount of their time in riparian communities (which are the most productive habitats in arid lands generally, and in the Colorado Plateau specifically), the ecological stakes are highest here, and many of the adverse impacts of grazing are magnified. Life forms relying on western aquatic habitats include invertebrates, reptiles, amphibians, fish, birds, and mammals. Birds are often referenced as one of the significant suites of species relying on healthy riparian zones. The stability of populations of various avian species has been used to determine the effects of grazing on riparian vegetation (Knopf et al. 1988, Fitch and Adams 1998). Participants in studies at the High Desert Ecological Research Institute state that “the loss of riparian habitats has been suggested as the most important cause of population decline among landbird species in western North America” (Dobkin et al. 1998).

The negative impacts of cattle grazing on wildlife in riparian zones is manifested through impacts to the animals’ habitats (i.e. riparian vegetation). Grazing can reduce or totally eliminate vegetation bordering a stream (Szaro and Pase 1983**,** Platts 1991). Numerous studies have found greater riparian species richness in ungrazed areas compared to grazed riparian zones (USGAO 1988a, Armour et al. 1994, Popolizio et al. 1994, Green and Kaufman 1995). Other studies have found that grazed riparian areas suffer increases in exotics, upland species, and sub-dominant species that are released from competition when dominant wetland plants are grazed down (Great Basin-Schulz and Leininger 1990, eastern Oregon-Green and Kauffman 1995). The spread of wetland exotics, namely tamarisk, has been aided by grazing throughout the west (Ohmart and Anderson 1982, Hobbs and Huenneke 1992). Furthermore, prevention of seedling establishment due to grazing and trampling has transformed a variety of southwest riparian systems into even-aged, non-reproducing vegetative communities (Fleischner 1994). The combination of these influences on vegetation structure and composition is detrimental to wildlife. A review by Skovlin (1984) concluded that grazing results in adverse impacts to both small mammals and birds within riparian areas.

The most well-documented effects of grazing on riparian zones are reviewed by Platts (1982), Fleischner 1994, Ohmart (1996), and a most extensive analysis by Belsky et al. (1999) who reviewed over 150 separate studies on grazing effects on western riparian areas. In their review, Belsky et al. reported that they found no systematic investigations showing positive impacts or ecological benefits that could be attributed to livestock activities when grazed reaches were compared to protected areas.

While the BLM touts overall rangeland health improvements over the last century, the U.S. Department of the Interior (in its DEIS: "Rangeland Reform '94") clarifies that these asserted rangeland improvements have for the most part occurred only in upland areas, not in riparian areas. The DEIS further concedes that western riparian areas "have continued to decline and are considered to be in their worst condition in history." Livestock grazing is identified in the DEIS as the chief cause of this deteriorated condition. The reason that riparian zones continue to degrade while upland areas improve is simple; cattle spend anywhere from 5 to 30 times longer in riparian habitats than upland habitats (Skovlin 1984). Moreover, most BLM allotments operate under management plans that were designed to meet the phenological growth requirements of **uplands** (Ohmart 1996). In fact, one of the more recent manuals on inventorying and monitoring rangelands (NRC 1994) only devoted five sentences to riparian areas. Simply reducing overall livestock numbers on an allotment has proven in multiple cases not to be a solution to riparian degradation (Dahlem 1979, Olson and Armour 1979). Unless fencing, cattle removal or other profound management changes are made, riparian habitats will continue to be degraded under most of the current BLM RMPs.

Associated effects of cattle grazing: range improvements

Range improvement projects, such as fences, water developments, salt stations and vegetation treatments, are seldom if ever designed to restore or enhance native biodiversity. In fact, they usually have the opposite effect, whether intentional or inadvertent (Donohue 1999).

Fences: Fences are a fundamental cattle management tool, but they create obstacles for many native wildlife species, therefore effectively fragmenting habitat. Also, both livestock and other uses, including maintenance, often cause trails to form along the fence line. These trails can provide travel corridors for predators, increasing the risk to ground nesting birds such as sage grouse (Braun 1998). Ground nesting birds can also be impaled on barbed wire fences (Webb 2000). Fence posts also provide perches for raptors, thus possibly increasing predation pressure in the area above normal levels.

Stock Tanks and other water developments: Most water developments for cattle divert or gather water from other, natural sources. Drilling wells to provide stock water can deplete aquifers or disrupt hydrologically connected surface flows (Donohue 1999). Any diversion of water away from riparian areas, seeps, springs and other wetland areas is ecologically damaging: these projects reduce the size of the original wetland, as well as its productivity. Indirect effects similarly ensue in these areas; for example a reduction in surface water area caused by water diversion can lead to a decrease in insect populations, thereby decreasing the wetland's value as potential habitat for bats (RRCS 1999).

The BLM often claims that by providing water to cattle in upland areas, they can reduce detrimental grazing impacts along streams and wetlands by luring cattle away from these sensitive areas and into the uplands. However in doing so, the BLM only assures that the negative impacts of cattle will be shifting from one area to another. Further, the condensed density of cattle near a stock tank can contribute to pollution of surface waters in the region (Donohue 1999), through storm run-off that will eventually make it back to the wetlands/riparian areas that the BLM was trying to protect in the first place.

Land management agencies and wildlife professionals often claim that man-made water sources in arid habitats inherently benefit wildlife, but these perspectives on benefits are primarily based on game bird and ungulate studies. In light of this, Burkett and Thompson (1994) investigated effects of "human-altered water units" on small mammals, herpetofauna, and invertebrates in New Mexico. After comparing species richness of these guilds in 20 paired comparisons of watering units versus sites without water, they found that animal richness did not differ between water units and non-water units across vegetation communities.

Few people understand the extent of stock tanks and other water improvements in Southern Utah. Exotic weed expert Jon Gelbard, while conducting graduate research near Canyonlands National Park, counted 115 water improvements in Hatch Point Allotment alone (personal communication with Jon Gelbard). He said, "there are probably tens of thousands of these [water improvements in southern Utah]. They are islands of degraded habitat that are favorable to weedy plants and probably act as conduits for spread."

Vegetation treatments**:** Vegetation treatments are used by the BLM to increase forage for livestock. Large scale vegetation treatments, whether mechanical (i.e. bulldozing, chaining and cabling) or chemical, can be deleterious to desert soils, microbiotic crusts, plant communities and wildlife.

Treatments that use bulldozers, or involve cabling and chaining, can directly affect the physical characteristics of the soil, alter the types and abundance of vegetation that serves to anchor the soil and prevent erosion, and can alter the presence and abundance of micro-organisms that contribute to overall soil quality (BLM 1991). Removing large perennial vegetation from a system can negatively impact soils. Large shrubs such as sagebrush continually add organic nutrients to the soil when their large root masses die and decompose (Peterson 1995). This influx can sometimes double the thickness of the soil profile that is actively involved in mineral cycling, in addition to adding litter and humus which is important in maintaining soil moisture (Daubenmire 1970). Sagebrush in particular appears to play an important role in maintaining soil moisture. Because of its deep taproot and shallow, diffused root system, sage can bring deep soil moisture to the upper layers of the soil, providing normally unavailable moisture for use by both the sagebrush and neighboring plants (Caldwell and Richards 1989). Large scale mechanical treatments also destroy microbiotic crusts, leading to many of the negative consequences outlined in earlier sections of this review.

Many studies of the effects of chaining and cabling focus on the herbaceous community that tends to increase after such treatment. Indeed, this effect, and its presumed benefit for game animals, is the chief justification for vegetation treatments on BLM lands. While it is true that the removal of trees and shrubs will open up habitat for a variety of grasses and forbs to move in, the species that will come into the site are the ones that were present in some capacity before the chaining. In the case of thousands of acres of BLM lands in Utah, exotics such as cheatgrass are certainly present to some extent. Clearing large tracts of land and leaving them open for invasion by the more aggressive species in the area can exacerbate the already alarming weed infestation on Utah's public lands.

Large scale mechanical treatments, while perhaps benefiting one or two targeted species of game, are detrimental to many other wildlife species. Fish in nearby streams may be impacted by increased sediment runoff immediately following chaining. Bulldozers used in these treatments can result in soil compaction, which damages the subterranean habitat used by burrowing animals. Furthermore, the destruction of trees and shrubs results in loss of both thermal cover and protective cover for a variety of organisms, and loss of nesting areas for birds. For example, Sedwick and Ryder (1987) found that native bird diversity is lower on chained plots than nearby unchained plots. The loss of shrubs in a system can indirectly affect animals as well. The thick canopy of shrubs protect the shrub's understory from livestock grazing, and this vegetation can be important for wildlife. Also, the crowns of shrubs tend to break up and weaken hard crusted snow on winter ranges, making it easier for native ungulates to access understory plants for foraging (Peterson 1995).

There are similar negative repercussions of large-scale chemical treatments on the lands of the Colorado Plateau. Non-target plant and animal species can be adversely affected in spraying applications, especially if it is windy, or if application area is large (i.e. chemical is sprayed from a vehicle or dropped from helicopters or fixed-wing aircraft). There are concerns with chemicals entering surface water through accidental direct application or drift, or post-treatment through surface or subsurface runoff. These situations could harm a variety of aquatic organisms. There is also a danger of herbicides reaching groundwater if the chemicals move with infiltrating water through the soil profile and into the water table. In addition, any chemical treatment that leaves an area completely devoid of all trees and shrubs will tend to have the same consequences as the mechanical treatments described above. In particular, any area of newly opened habitat is particularly inviting to aggressive exotics (e.g., brome grasses). Lastly, the impacts of removing vegetation needed by wildlife are considerable; Klebenow (1970) reported cessation of nesting by sage grouse in newly sprayed areas, and in virtually all documented cases, herbicide application to blocks of sagebrush result in declines in sage grouse breeding populations (Connelly et al. 2000).

Summary of grazing effects - an evolutionary perspective

Nearly all of the studies cited in this literature review were conducted in arid western states, with most emphasis on the intermountain region, Colorado Plateau and the southwest. One critical common factor among these studies is that they were conducted in places that are free of large, native grazers. American bison occurred very rarely in the arid west (Mack and Thompson 1982, Berger and Cunningham 1994, Kay 1994). In a worldwide review of effects of grazing by large herbivores, Milchunas and Lauenroth (1993) concluded that an evolutionary history involving grazing animals and the local environment was the most important factor in determining negative impacts of grazing on productivity. Western arid rangelands lack such an evolutionary history. Until Europeans introduced cattle and other grazers to our arid rangelands, the western range was relatively free of large grazing mammals for 10,000 years (Berger 1986, Berger and Cunningham 1994).

Because there was no evolutionary history involving sustained grazing in this region, the introduction of livestock to the Colorado Plateau has resulted in widespread changes in ecosystem function throughout this region (Belnap 1997). Intermountain grasses do not readily replace leaf area lost to grazers, and usually fail to reproduce if heavily trampled (Mack and Thompson 1982) because they are unable to store enough carbohydrates to flower and set seed under heavily grazed conditions (Grayson, 1993). Furthermore, the intermountain west lacks native annual grasses that can aggressively colonize areas denuded of vegetation after a grazing incident. Therefore, native grasses and forbs of the Colorado Plateau were at a distinct disadvantage when cattle were first introduced. The results of this generally failed experiment can be seen today; it is clear to biologists who visit many parts of southern Utah that nonnative grasses and forbs (a.k.a. weeds) are faring better than unpalatable (and often non-native) bunchgrasses on most grazing allotments.

In summary, its critical that only grazing impact studies conducted in the low-elevation lands of the Colorado Plateau be used to argue for the effects grazing really has (or doesn't have) on BLM lands in southern Utah. Grazing proponents who compare systems that were historically or are currently grazed by native, hooved ungulates (such as the Great Plains, or Africa) with arid western ecosystems run a serious risk of losing scientific credibility. Arguments that the plant communities of the arid west are adapted to grazing because they supported a diverse herbivore fauna during the Pleistocene (Burkhardt 1996) are probably irrelevant to this issue, as the plant communities have most certainly changed in the intervening time and there have been few selective agents favoring the retention of grazing tolerance. The BLM often cites studies that demonstrate neutral, or even beneficial, effects of grazing. These studies are largely inappropriate because they are often conducted outside southern Utah, in regions subjected to different ecological and evolutionary forces. When dealing with low-elevation systems as fragile as those of southern Utah (which only receives 12 inches or less of precipitation a year), the inappropriateness of those comparisons is even more obvious.

ANALYSIS OF BLM GRAZING MANAGEMENT IN SOUTHERN UTAH, IN LIGHT OF A REVIEW OF THE LITERATURE

In light of the many deleterious effects of cattle grazing outlined above, an ecologist could certainly point to some problems with current BLM grazing management in arid ecosystems, such as those of the Colorado Plateau. These problems not only involve digression from accepted science, but also indicate that the BLM may not really be serious about meeting Standards and Guidelines in these fragile environments.

Compliance with Standards and Guidelines, and the tools to do so

There are two chief tools used to assess compliance with the *Standards and Guidelines*: Properly Functioning Condition (PFC) assessments for riparian areas, and upland range health - or visual - assessments. These assessment procedures were developed to be used at a national scale, and the Utah *USGHR* were adapted from these National Guidelines. Yet the extremely arid and fragile ecosystems which occur in southern Utah, and which are particularly subject to cattle grazing impacts (as shown above), may require more stringent guidelines and assessment tools in order to adequately protect these lands from the rigors of grazing. Moreover, under the current *USGHR* and its assessment procedures, it is possible for BLM allotments to be in "compliance" with *USGHR* (which can include failing to meet the standards, but making progress towards meeting the standards), yet still be in poor health. Furthermore, as long as an allotment is in "compliance," grazing will continue, causing further degradation. While it is beyond the scope of this review to analyze the effectiveness of the *USGHR* as a policy, we can use the scientific literature reviewed above to make observations on the scientific rationale behind the PFC assessments and upland range health assessment procedures.

Properly Functioning Condition assessments of riparian areas**:** An important component of the BLM's PFC assessment process is a field survey checklist that focuses on three chief parameters: hydrology, vegetation characteristics, and erosion/sediment deposition. While these are good indicators to use in a PFC determination, there are other important indicators that BLM chose either to not include or fully represent in the PFC assessment process. These omitted indicators include existence of wetland soils, channel substrate characteristics, wildlife indicator species, wildlife habitat features, seed establishment and germination, and cover and frequency of exotics (Catlin et al. 2000). As some of these indicators are clearly outlined in *USGHR*, the current BLM PFC procedure can conceivably result in stream reaches labeled as functioning, but still being out of compliance with *USGHR*. Moreover, all of these omitted parameters can be seriously affected by cattle grazing, especially in very arid regions. By not including these indicators in the PFC assessment process, the BLM reduces its chances of accurately attributing riparian degradation to what is likely to be its true cause - cattle grazing.

There is one very key component of the BLM's PFC analysis process that is missing. To effectively assess ecosystems, one must be able to define attributes of healthy systems and habitats as a baseline or model. Otherwise, objective assessment is not really possible. Both the hyrdogeomorphic (HGM) model (Brinson 1993) and the (IBI) model (EPA 1998) are examples of evaluative systems that use references areas or benchmarks. A reference area allows an assessor to, for example, compare presence and abundance of indicator species in the riparian study area against a well-studied reference area in the same region. The reference reach can allow the assessor to define "normal integrity" of the system being studied, and measure deviations from these expectations (Meffe and Carrol 1994), which will likely be the consequence of human actions (Karr and Chu 1999). Additionally, the comparison method helps define protective approaches to improve habitat in the study reach, and can evaluate performance of restoration and protection techniques. It is crucial that reference sites used in these types of comparison studies be disturbance-free, and definitely **ungrazed** (preferably never grazed). The use of such reference sites allows for quantifiable changes in habitat resulting from human-altered regimes in the study reach. The BLM's PFC method does not include the use of undisturbed reference sites.

Upland range health - or visual - site assessments: Ironically, the chief problem with the upland range health assessments is the BLM's use of Ecological Reference Areas (ERAs) as benchmarks that are compared against assessment plots in visual assessments of allotments. As described in *Interpreting Indicators of Rangeland Health: Draft Handbook* (BLM 1998), an "ERA is a landscape unit in which ecological processes are functioning and the vegetation complex has adequate resistance to and resiliency from major disturbance." Yet it is fine if the ERA is sited within a grazed area (BLM 1999). From an evolutionary perspective, in rangelands never historically grazed by large herbivores, grazing can certainly be considered a major disturbance. If the ERA is within the allotment under scrutiny, it is probably suffering various impacts of grazing, even if it is the healthiest representative patch of that particular vegetative community at the site. Any Reference Area that is compared to another grazed area will probably not suffer too much by comparison. BY using this method of comparison, the BLM assures that the true effects of grazing suffered by allotments will never truly be realized. Only by using ungrazed areas (and preferably, an ungrazed watershed) as benchmarks or reference areas, can one isolate the true relationship between cattle grazing and degraded conditions.

In addition to the reference area problem, the BLM's upland assessment process is lacking indicators which should be present if the assessment methodology was firmly tied to *USGHR*. This includes wildlife indicators, measurements of infiltration rates, and better accounting of condition, coverage and frequency of **all** plant species. While the BLM's procedure calls for consideration of all plant species in the assessed area, in practice, BLM limits analysis to principally the dominant species (personal communication, Jim Catlin). As a result, some plant species which may be most impacted by grazing are not adequately assessed, including rare and sensitive special-status species.

Determination of capability

Historically, the BLM evaluated the use of the public lands under its jurisdiction based on whether the lands were capable of supporting livestock use. The factors that are included in the determination of the capability of the lands for grazing included the slope of the land, and the distance to water sources.

Sound ecological theory dictates that the BLM should consider more than just slope and distance to water when determining rangeland capability. For example, all allotments with highly erodible soils (i.e. soils that have a moderate to high erosion hazard) should not be considered capable of sustaining livestock grazing (Bane-Gaston and Carlson 2000). There should be a minimum percentage of perennial grass cover that an allotment must have before it can be deemed capable of supporting livestock grazing. And areas with less than 12 inches of annual rainfall should not be considered capable of supporting livestock (Bane-Gaston and Carlson 2000).

Season of use / timing of grazing

A substantial number of grazing allotments in southern Utah are grazed during the growing season. For example, in the Grand Staircase Escalante National Monument, forty-six out of 76 allotments (over 60%) are grazed during some part, or all, of the growing season. While there is evidence that grazing during the growing season can lead to some compensatory growth in plants that co-evolved with large, hooved ungulates, grazing is damaging to vegetation of the intermountain west, especially during the growing season (Painter and Belsky 1993, and references therein).

The BLM seems to understand some of the problems associated with warm-season grazing; the Bluff Bench, Laws and Brown Canyon EA in the San Juan Resource Area (BLM 2000c) states that “recommended grazing practices focus on use when biological crusts are least vulnerable to shear and compaction forces; i.e. when the crust is moist, frozen or snow covered” (i.e. winter). Even so, winter grazing by cattle can not guarantee that no harm will come to fragile cryptobiotic soils. In fact, the study that the BLM cites in these EAs (Marble and Harper 1989) was conducted with sheep, which weigh substantially less than cattle. Because sheep cause limited damage to soil crusts in the winter does not necessarily mean the same for cattle.

There is actually considerable evidence that winter grazing can impact xeric communities. Dormant woody riparian species are known to be especially negatively affected by browsing and trampling (Elmore and Kauffmann 1994). In upland communities, decadent plants with standing dead or dormant growth are unattractive to native herbivores (Ganskopp 1993), but will be readily eaten by cattle in winter. The removal of this natural protective barrier can result in heavy grazing of the new growth on the plant by numerous herbivores, which can lead to increased plant mortality (Elizabeth Painter, unpublished MS). In Utah, a study by Rasmussen and Brotherson (1986) compared a winter-grazed site to a ungrazed site between the Paria river and the Arizona state line in southern Utah. The ungrazed site had higher species diversity, significantly greater litter cover, significantly greater shrub cover, significantly greater winterfat cover, greater coverage of Indian ricegrass, and ten times less Russian thistle cover than the winter-grazed site. They attributed the lower coverage of Indian ricegrass in the winter-grazed site to the fact that Indian ricegrass actively grows during the late winter months.

Timing of grazing in relation to drought months/years is also an issue with cattle grazing management. In the Little Boulder and Peters Point Allotments Permit Renewals EA, the BLM states, “in areas where degradation has occurred, amount and timing of precipitation has more of an effect than livestock grazing in terms of recovery” (BLM 2000a). It seems that the BLM believes that, as long as a normal winter follows a particularly bad drought year, then its fine to graze at normal levels the following year. However, numerous authors have posed that overgrazing during drought years can have lasting negative effects on range health, which cannot be overcome during years of increased precipitation (Fleischner 1994, and references cited therein).

Grazing during certain seasons can also be detrimental to wildlife. For example, the dates that cattle are released in the Gunnison basin, which is home to the imperiled and soon to be listed Gunnison sage grouse, conflict with the nesting and early-brood rearing period for the grouse (Webb 2000).

Forage utilization

Most AMPs that exist for southern Utah allotments allow up to 60% of the forage to be utilized by cattle. It is clear that the BLM is only considering the needs of cattle, and the ability of enough preferred forage plants to set seed to sustain forage cover into the following year. As such, the needs of numerous native herbivores, including ungulates, lagomorphs, small mammals, and insects are not being taken into account. If this results in population declines of native species (through both lack of forage and cover) to a level that can be shown to be “inappropriate for site and species involved,” then this allotment will be out of compliance with USGHR. It is also evident that 60% utilization is not compatible with drought conditions, as we saw last season when numerous allotments in the southeast part of the Grand Staircase Escalante National Monument were so heavily degraded that cattle needed to be removed prematurely.

Holechek et al.’s (1998) well-respected range management text estimated acceptable levels of grazing use for most major range types in western North America. These estimates were based on the premise that moderate livestock use of key forage species would maintain vegetation species composition, plant vigor, and overall productivity. They determined that acceptable utilization levels ranged from 40% to 60% on more productive rangelands, and from 20% to 40% on more arid rangelands. Furthermore, C. Wayne Cook (in NWF vs. BLM 1993) stated that, “in order to allow for plant reproduction and viability [on the Colorado Plateau], 25% is considered a maximum allowable utilization.” As both of the previous estimates are undoubtedly conservative as they do not take forage needs for native herbivores into account, the BLM should consider reducing the maximum acceptable utilization levels everywhere in southern Utah. The BLM has actually already reduced utilization levels in the Glen Canyon NRA, where spring utilization of key forage plants such as native bunchgrasses, winterfat and four-wing saltbush does not exceed 25% (NPS 1998).

When considering the ecological implications of forage utilization levels in the arid west, its important to also consider how forage utilization is being measured by the BLM. Most agencies use stubble height estimates to measure utilization. However, since different plant species can have different levels of grazing tolerance, no single utilization threshold will be appropriate for all vegetation types, plant taxa, and seasons. This is especially true in light of the fact that forage production in xeric environments can vary by up to 500% (Valentine 1990), meaning that a set utilization value can have differential impacts to the land, depending on whether its a wetter or drier year. Also, sometimes the BLM will choose to measure plants that are somewhat palatable to cattle, and extrapolate that utilization level to the entire allotment (personal communication, John Carter). If the most palatable plants are overlooked in these measurements, the utilization level for that allotment will imply lower levels of use than are actually occurring. Lastly, **where** the utilization estimates are conducted can affect the findings. For best accuracy, utilization estimates should be conducted within about ¾ of a km from water, and should never be conducted more than about 1½ km from water (Stuth 1991) Estimates conducted further away than this are simply not receiving the same level of cattle grazing as the rest of the allotment, and as such are conveying unrealistic levels of utilization for that allotment.

CONCLUSIONS

This review of the ecological literature, with subsequent analysis of BLM grazing management in light of the scientific evidence of the impacts of cattle grazing in arid landscapes, clearly reveals that cattle grazing can impede the BLM from meeting *Utah's Standards and Guidelines for Healthy Rangelands*. Indeed, the state of Utah currently ranks lowest of all western states in terms of compliance with the National Fundamentals of Rangeland health (BLM 2001). The BLM would go far towards meeting *USGHR* if they took a more calculated and informed look at exactly how cattle grazing can negatively impact the many and various environmental indicators required to meet the four Standards.

It will be problematic if the BLM continues "business as usual" in light of the abundant literature that outlines the many problems with cattle grazing in xeric lands. I fear that we may see an example of "business as usual" this year in southern Utah as the BLM writes the EIS for proposed grazing management in the newly created Grand Staircase-Escalante National Monument. If the BLM goes about writing this document as they have the term permit renewal EAs in the San Jaun Resource Area, we will expect to see the BLM present purported positive or neutral effects of cattle grazing that are not only unsupported by either scientifically collected data or references to the scientific literature, but are contrary to the best available science. Without supporting evidence, these purported positive or neutral effects can be treated as no more than speculations by or opinions of the BLM. Speculation or opinion is not a strong enough base on which to build a management plan that might have significant, long-lasting (or irreversible) negative effects on Utah's BLM lands and the organisms that depend on them.

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